THE INTERSECTION BETWEEN ICT AND CLIMATE SMART AGRICULTURE IN ADAPTING TO THE IMPACTS OF CLIMATE CHANGE ON FOOD PRODUCTION BY uMSINGA'S SMALLHOLDER FARMERS: IMPLICATIONS FOR CLIMATE CHANGE EDUCATION

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MARCH 2020

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By

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Thesis submitted in fulfilment of the academic requirements for the degree of Doctor of Philosophy of Education in the Cluster of Science and Technology Education
School of Education
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March 2020

ABSTRACT

This study drew on community based participatory action research (CBPAR) and living theory (LT) to explore the intersection between information and communication technology (ICT) and climate smart agriculture (CSA) in enhancing the ability of smallholder farmers (SHFs) to adapt and mitigate the impacts of climate change in uMsinga, an impoverished rural area in KwaZulu-Natal. As action research, it included a preliminary and main phase. At the preliminary phase, the study aimed to identify SHFs' existing agricultural practices in relation to climate change adaptation, as well as their perceptions regarding the possible integration of ICT and agricultural practices. In the main phase, the study aimed to assess the existing ICT literacy and the required ICT literacy if SHFs are to integrate smartphones with their agricultural practices. It explored the kind of functionalities that SHFs wished to see in a possible weather app.

In order to address these research questions, a sequential transformative mixed method approach guided by community based participatory action research (CBPAR) and living theory (LT) approach was employed. In the study, 35 uMsinga SHFs were engaged through community forum meetings. Two frameworks were employed to make sense of the findings in the study, namely: the theory of planned irrigators' behavior (TPIB) as well as unified theory of acceptance and use of technology (UTAUT). The theories were used to explore the nature of relationship which exist in the intersection between ICT and CSA.

The findings, from the preliminary phase, show that the uMsinga SHFs practise seven CSA practices. The findings further revealed eight unintended challenges resulting from the SHFs' choice of CSA practices. These challenges affirmed that the deployment of ICT alone is insufficient to solve the threats posed by climate change for food production by SHFs. As such, the findings further show that an overwhelming majority of the SHFs has a positive regard for the integration of ICT with CSA practices. However, two unintended problems appeared to be limiting the realisation of their intentions: inadequate ICT literacy skills and the absence of agro-weather application that is appropriate and suitable for this rural indigenous community.

The CBPAR intervention thus focused on improving the SHFs ICT literacy skills and their ability to use an existing "Demo" weather app through their smartphones, to enhance their CSA practices. The findings, arising from this main phase of the study, highlight the "importance of context" in helping SHFs to mitigate the threats posed by climate change to food production, an issue that is completely ignored in curriculum policies and policies aimed at integrated national adaptation responses to climate change impact and vulnerability. The

contributions to knowledge as well as the implications of findings are discussed within the context of the criticality of interfacing between ICT and SHFs CSA practices.

DECLARATION

I, **Olusegun Ojo Bakare** declare that:

i. The research reported in this thesis, except where otherwise indicated is my original work;

ii. This thesis has not been submitted for any degree or examination at any other university;

iii. This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons;

iv. This thesis does not contain other persons' writing, unless specifically acknowledged as being sourced from other researchers. Where other written sources have been quoted, then:

   a) Their words have been re-written, but the general information attributed to them has been acknowledged;

   b) Where exact words have been used, their writing has been placed within quotation marks, and referenced.

v. The work described in this thesis was carried out in the School of Science and Technology Education, University of KwaZulu-Natal, from 2016-2018 under the supervision of Prof. Busisiwe Precious Alant (Supervisor); and

vi. The Ethical Clearance No. HSS/1648/017D was granted prior to undertaking the fieldwork.

Signed: ______________________________ Date: 16th of March 2020.

As the candidate's Supervisor, I, Prof. Busisiwe Precious Alant, agree to the submission of this thesis.

Signed: .... Date: 17 March 2020

ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

13 February 2018

Mr Olusegan Bakare (216077049)
Scool of Education
Edgewood Campus

Dear Mr Bakare,

Protocol reference number: HSS/1648/017D
Project Title: The intersection between ICT and Climate Smart Agriculture (CSA) in adapting to the impacts of Climate Change on food production: Implications for Climate Change Education (CCE) in Capacity Building amongst uMsinga's smallholder farmers (SHFs)

Approval Notification – Expedited Application

In response to your application received 04 September 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shamila Naidoo (Deputy Chair)

/ms

Cc Supervisor: Dr Busisiwe P Alant
Cc Academic Leader Research: Dr SB Khoza
Cc School Administrator: Ms Tyzer Khumalo

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1910 - 2010
100 YEARS OF ACADEMIC EXCELLENCE

Founding Campuses: Edgewood, Howard College, Medical School, Pietermaritzburg, Westville

DEDICATION

This thesis is dedicated to God, the only wise God.

ACKNOWLEDGEMENTS

I thank God Almighty, to whom alone be glory, honor and adoration for His infinite love, favor, courage, wisdom and strength for making this dream a reality. Faithful is He who has promised and fulfilled His promise.

My profound and sincere appreciation to my able supervisor, **Prof. Busisiwe Precious Alant** for her seasoned scholarly support throughout this research journey. She is a dear mother and mentor indeed, whose meticulous guidance and constructive instructions has been used by God to greatly reshape my research capacity within the shortest possible time. I want to appreciate your love, motherly care, donations and patience to coin out best out of my worst state to making this project a success. May the blessing of God never depart from your life and family.

I would like to thank those who have helped in making this work possible, and to apologize in advance if I have left anyone out.

I owe an immeasurable gratitude to my beloved wife, Grace Abosede Olusegun-Bakare for her love, prayers, support, encouragement, understanding, patience, perseverance and motherly care to my family during the period of pursuing this programme. You are beloved indeed, I sincerely appreciate you, may God bless you.

I like to appreciate my lovely children, Oluwasesan, Obed and Obadiah for their patient, prayers and encouragement during long absence from home. May God bless your future in Jesus name. Also, other family members like mummy and daddy Aborode, late pastor Adewumi, mummy Adewumi and the entire family members, sister Jumoke, Buhlebuyeza and Pulma. I appreciate your prayers and encouragement.

I appreciate all my participants from uMsinga, because this research would not have been possible without your cooperation and love. More so, my special appreciation goes to Miss Nompilo for her great assistance in invitation of the participants. She was so committed to seeing that this project succeeded many thanks.

I would also specially thank Mr and Mrs Linda Kowa for their sincere contributions to ensure nothing hinders the successful completion of this study. To Dr Ezekiel Omotoso, Dr. Kehinde Omotoso, Dr. Peter Merisi, Dr. Williams Dagogo, Dr. Joseph Yacim, Dr. Jonathan Fatokun, Dr. Nike Wojuola and Bro. Wale Mobolaji for helping in proofreading of this work.

I would like to appreciate Bro. Minenhle, Bro. Xola, Sister Ntokozo, Sister, Andele, Sister Precious, Sister Minenhle and Wandile for their supports and assistance in translation of data from IsiZulu to English language.

Dr. Asheena Singh Pillay, I am sincerely grateful to you, for your words of encouragements and contributions during presentations of my work.

I would like to sincerely appreciate Bro. and Sister Miracle Amoni for their financial assistance during this programme.

I cannot but express my gratitude to the past and present Vice Chancellor, Obafemi Awolowo University (OAU), for approving my study leaves with pay and TETFUND to fund this programme. My appreciation also goes to all the past and present chairman/person of TETFUND at both national and OAU level. Likewise, my appreciation goes to all the past and present Deans of Faculty of Education, OAU, all the past and present Directors of Institute of Education, OAU. I cannot but appreciate all the professors and associate professors, senior colleagues in the Institute of Education, namely: Prof. O. J Adeyanju, Prof. F.O, Aladejana, Prof. P.O Jegede, Dr. C.O Odejobi, Dr. T.O Bello, Dr. Oribabo, Dr. B.A Adeyemi, Dr. E. Ojedokun, Dr. Adelodun, Dr. H.O Ajayi, Dr. O.S Agboola, Dr. Iroegbu, Dr. A.G Adeleke, Dr. J.O Okewole, Dr. Adediran, Dr. S.O Olajide, Dr. Omiyefa, Miss Fawole Mr. Akingbade and Mr. J.O Salami for their love and care to have released me for the numbers of years which I spent to face rigor of this study whilst they combined my work with theirs, may God bless you all.

I would like to appreciate the National Overseer of South Africa and Zambia, Pastor John Amoni for his consistent prayers for the success of this project. I also appreciate the DLCF National Coordinator, Pastor Joseph Adesina, the KZN Provencal Pastor, Pastor Michael Olusanya, Adeleke, Edgewood Associate Coordinator and host of other Pastors for their prayers. I would also extend my appreciation to all members of the Deeper Life Campus Fellowship (DLCF), UKZN and UP for your supports in prayers and words of encouragements which kept me going.

I appreciate the great assistance of the Region Overseer (RO), Pastor Fola Ajala, all group Coordinators, Region Coordinator (RC), Pastor P.O Jegede and all Associate Coordinators (AC) of DLCF, OAU for their prayers, encouragement and financial assistance during this programme. I want to specially thank Pastor S Itakpe, R.O Salawu and P. Obayemi for their concerns, encouragements and prayers. May God bless you.

LIST OF ABBREVIATIONS

App	Computer Software Application
AR	Able to Recognize
AST	Adoption/Adaptation Strategy Tools
BMP	Basic Mobile Phone
BMP	Basic Mobile Phone
CBPAR	Community Based Participatory Action Research
CC	Climate Change
CCE	Climate Change Education
CH4	Methane
CO2	Carbon Dioxide
CSA	Climate Smart Agriculture
CSIR	Council for Scientific and Industrial Research
C-TAM-TPB	Combined TAM and TPB
DEA	Department of Environmental Affairs
DTPB	Decomposed Theory of Planned Behaviour
EE	Effort Expectancy
FAO	Food and Agriculture Organization of the United Nations
FC	Financial Capital
FCD	Facilitating Conditions
F-gases	Fluorinated Gases
FREQ	Frequency
GHG	Green House Gas
GIS	Geographical Information Systems
GPS	Global Positioning System
HC	Human Capital
HM	Hedonic Motivation
ICT	Information and Communication Technology
ICTnCSA	Intersection Between ICT and CSA
IDT	Innovation Diffusion Theory
ILAT	ICT Literacy Assessment Tool

IPCC	Intergovernmental Panel on Climate Change
LT	Living theory
MM	Motivational Model
MPCU	Model of PC Utilization
N2O	Nitrous Oxide
NAD	Not Able to Demonstrate
NAR	Not Able to Recognize
NC	Natural capital
PBC	Perceived Behavioural Control
PCA	Physical Capital
PD	Partially Demonstrated
PE	Performance Expectancy
PEOU	Perceived Ease of Use
PMT	Protection Motivation Theory
PSFMP	Preliminary Study Forum Meeting Protocol
PU	Perceived Usefulness
PV	Price Value
RS	Remote Sensing
RSA	Republic of South Africa
RuTAM	Rural Technology Acceptance Model
SADC	Southern African Development Community
SC	Social Capital
SCT	Social Cognitive Theory
SD	Satisfactorily Demonstrated
SHFIDP	SHFs' ICT Literacy Development Protocol
SHFFIDP	SHFs' Functionalities Inclusion Discussion Protocol
SHFs	Smallholder Farmers
SI	Social Influence
SIT	Social Identity Theory
SMS	Short Message Service

SP	Smartphone
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TPIB	Theory of Planned Irrigators' Behaviour
TRA	Theory of Reasoned Action
TV	Television
UKZN	University of KwaZulu-Natal
UNFCCC	United Nation Framework Convention on Climate Change
UTAUT	Unified Theory of Acceptance and Use of Technology

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CHAPTER 1

CONTEXTUAL BACKGROUND TO THE STUDY

> *Climate change is now affecting every country on every continent. It is disrupting national economies and affecting lives, costing people, communities and countries dearly today and even more tomorrow. Weather patterns are changing, sea levels are rising, weather events are becoming more extreme and greenhouse gas emissions are now at their highest levels in history. Without action, the world's average surface temperature is likely to surpass 3 degrees centigrade this century. The poorest and most vulnerable people are being affected the most (UNFCCC, 2019a).*

We can all agree with the United Nations Framework Convention on Climate Change (UNFCCC) that Climate Change is the defining issue of our time and we are at a defining moment (UNFCCC, 2018). The world's first climate conference was convened 1979 in Geneva by a group of scientist to discuss four key issues, namely: climate data, identification of climate topics, integrated impact studies, and research on climate variability and change (UNFCCC, 2014; Wikipedia, 2018). The meeting lead to the creation of the Intergovernmental Panel on Climate Change (IPCC) which was set up in 1988 by the World Meteorological Organization (WMO) to *provide policymakers with consistent scientific assessments on climate change, its implications and potential future risks, as well as to suggest adaptation and mitigation options* (IPCC, 2019, p. 1). In 1990, the

Facts and Figures

As of April 2018, 175 parties had ratified the Paris Agreement and 168 parties had communicated their first nationally determined contributions to the UN framework convention on Climate Change Secretariat.

As of April 2018, 10 developing countries had successfully completed and submitted their first iteration of their national adaptation plans for responding to climate change.

Developed country parties continue to make progress towards the goal of jointly mobilizing $100 billion annually by 2020 for mitigation actions.

Thanks to the Intergovernmental Panel on Climate Change we know:

From 1880 to 2012, average global temperature increased by 0.85°C. To put this into perspective, for each 1 degree of temperature increase, grain yields decline by about 5 per cent. Maize, wheat and other major crops have experienced significant yield reductions at the global level of 40 megatons per year between 1981 and 2002 due to a warmer climate.

Oceans have warmed, the amounts of snow and ice have diminished and sea level has risen. From 1901 to 2010, the global average sea level rose by 19 cm as oceans expanded due to warming and ice melted. The Arctic's sea ice extent has shrunk in every successive decade since 1979, with 1.07 million km² of ice loss every decade.

Given current concentrations and on-going emissions of greenhouse gases, it is likely that by the end of this century, the increase in global temperature will exceed 1.5°C compared to 1850 to 1900 for all but one scenario. The world's oceans will warm and ice melt will continue. Average sea level rise is predicted as 24 – 30cm by 2065 and 40-63cm by 2100. Most aspects of climate change will persist for many centuries even if emissions are stopped.

Global emissions of carbon dioxide (CO2) have increased by almost 50 per cent since 1990.

Emissions grew more quickly between 2000 and 2010 than in each of the three previous decades.

It is still possible, using a wide array of technological measures and changes in behavior, to limit the increase in global mean temperature to two degrees Celsius above pre-industrial levels

Major institutional and technological change will give a better than even chance that global warming will not exceed this threshold (UNFCCC, 2019b).

second international climate conference was held in Geneva to consider the first IPCC assessment report. The technology experts and scientists at the conference urged a global commitment to combating the risk of climate change. Some developments at the conference led to formulation of UNFCCC. In 1992, at "Earth Summit", the UNFCCC was formulated as a first step in addressing issue of climate change around the globe. Climate change was then recognised as a global threat that faces humanity and it is "attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods" (UNFCCC, 1995, p. 3). In this regard, 197 countries representing the entire globe in 1994, under the platform of UNFCCC, adopted and implemented an international environmental treaty to address climate change issue. In addition, the objective of UNFCCC in article 2, states that:

> "*stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner"*(Likkasit, Maroufmashat, Elkamel, Ku, & Fowler, 2018; Limayem, Hirt, & Cheung, 2007; UNFCCC, 1995, p. 5).

The third UNFCCC conference was held on 11th of December 1997 in Kyoto, Japan for an international treaty that extended the 1992 agreement. This treaty is called the Kyoto Protocol. The Kyoto Protocol was adopted and entered into force on 16th of February 2005, and 192 parties have ratified the treaty to date (Darragh, 1998; UNFCCC, 2011). The Kyoto Protocol commits industrialized nations to abide by the agreement to reduce GHG emissions (UNFCCC, 2011). In addition, the Kyoto Protocol is committed to help nations adapt to climate change (ibid). Similarly, to combat the climate change threat, both developing and industrialized nations (195) were brought into a common place for the first time on 12th of December 2015 for what is known as the Paris Agreement (Global Forum on Sustainable Energy, 2016). The main aim of the Paris Agreement is to keep the global temperature rise below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels (UNFCCC, 2015). This 1.5-degree Celsius limit is a relatively harmless defense line against the worst risks of changing climate. As such, the IPCC was mandated to come up with a report in 2018 on how this goal can be attained (Global

Forum on Sustainable Energy, 2016). However, global emissions of GHG are reaching record levels that show no sign of abating (UNFCCC, 2019c). UNFCCC reported that the last four years were the hottest on record, while Arctic winter temperatures have increased by 3°C since 1990. In addition, sea levels are on the increase and coral reefs are dying due to the life-threatening risk of climate change on health, via air pollution, heatwaves and risks to food security (ibid). In this regard, the UN Secretary-General, António Guterres, is inviting all leaders in nations to come to New York on 23 September, 2019 with concrete, realistic plans to enhance their nationally determined contributions by 2020. This with the aim of reducing GHG emissions by 45 per cent over the next decade, and by 2050 attain a net zero emissions (ibid). According to the Secretary General speech, the world's richest nations are the most blamable for the threats, however the impacts of the climate change are being felt first and worst by the most vulnerable peoples, communities and poorest nations (UNFCCC, 2018). Climate change threatens to have a devastating effect on plants, animals and man IPCC (2007).

According to the report of Food and Agriculture Organization of the United Nations' (FAO), that impact of climate change resulted in low food production, insecurity, high prices of food materials and poverty among developing countries (FAO, 2013). A number of studies (Makeleni, Tournaire, Grwambi, & Troskie, 2018; Masud et al., 2017; Wahab & Popoola, 2018; Williams, Crespo, & Abu, 2019) in Nigeria, Malaysia and South Africa have shown that the increasingly unpredictable nature of weather patterns affects food production and insecurity. For example, Nhamo et al. (2019)'s study revealed that the production of maize, the staple food in the Southern African Development Community (SADC) region, is reducing due to the impact of climate variability. Similarly, the report of the IPCC indicates that SADC countries will experience a 50% loss in crop production by the year 2020 (IPCC, 2007). This prediction was made over a decade ago and reports from literature appeared to be pointing towards such direction in South Africa today. A recent study by Gluckman (2017) shows that there are recurring water crises in Cape Town that not only affect people directly but also have a negative impact on the economy of the country, especially on food production. Likewise, Shi and Tao (2014) report that South Africa has suffered a large (30%) reduction in maize (*Zea mays)* yield due to drought. In addition, the recent report of Department of Environmental Affairs, Republic of South Africa, (DEA) predicted that production of the two staple crops in the Republic, maize (*Zea mays)* and wheat *(T. aestivum),* will reduce by 3.5% and 4.3% in 2050 respectively (Republic of South Africa, 2018). The impact of climate change is on every provinces and municipality (like uMsinga) in RSA.

1.1. Study area

uMsinga is a local Municipality in the Mzinyathi District in KwaZulu-Natal (KZN) Province of South Africa located at 28°10'S 30°15'E. It is a rural area characterized by hot and dry weather (Wettasinha & Waters-Bayer, 2010) as shown in Figure 1.1. According to Cousins (2012), the mean annual precipitation of uMsinga is 600-700 mm, with high summer temperatures reaching about 44°C. uMsinga is vulnerable to the elements of climate change like high rise in temperature, pests and diseases, decrease in volume of water bodies, increase in drought and flood among others (Alexandratos & Bruinsma, 2012; Hinz, Frickmann, & Krüger, 2019; IPCC, 2014). This fact was established in a number of studies (Drought Information Bulletin, 2004; Hitayezu, 2016; Rukema & Simelane, 2013), showing data regarding stark drought spells on uMsinga in years such as 1992, 1999, 2001, 2003, 2004, 2007, 2008, 2010, 2014 and 2015. According to Vanderhaeghen and Hornby (2016), uMsinga has been experiencing drought for a very long time but it became severe from year 2010. The authors revealed the experience of the people as the explained that "the weather has changed from the old days. It's a different kind of weather. With that change, the real problems have come" (p. 4). With the climatic nature of uMsinga, agricultural activities have been negatively affected by climate change (IPCC, 2007). Studies therefore regard uMsinga Municipality as a hotspot for climate change (Sinyolo, Mudhara, & Wale, 2014; Wettasinha & Waters-Bayer, 2010). Thus, the means of livelihood of smallholder farmers (SHFs) have been negatively affected and challenging, as depicted in Figure 1.2 and 1.3.

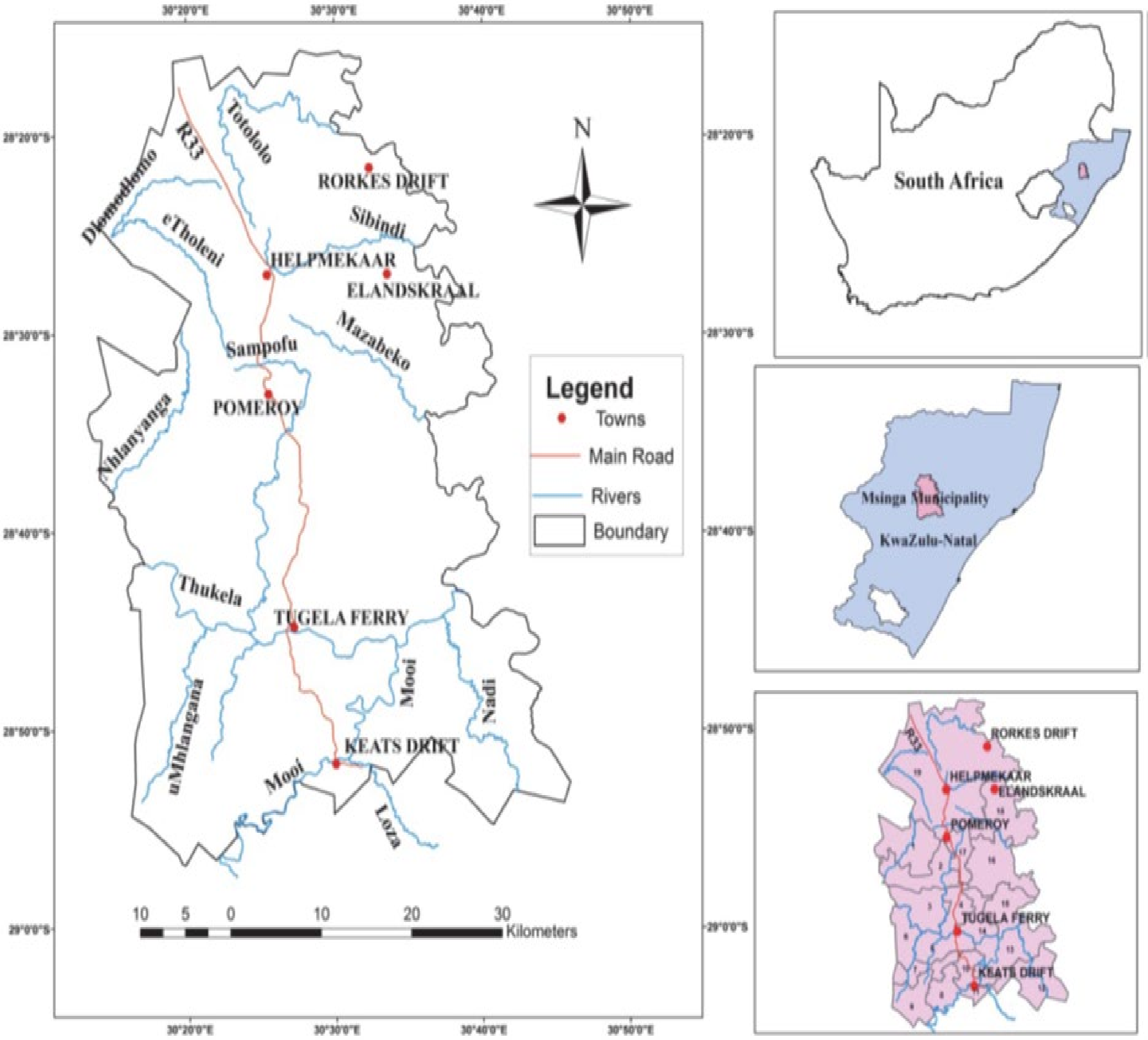


Figure 1. 1: Research site

(Sinyolo et al., 2014)

Figure 1. 2: Effect of drought on plants and animals in uMsinga

(Vanderhaeghen & Hornby, 2016)

Figure 1. 3: Effect of drought on crops in uMsinga

Most inhabitants of uMsinga are involved in subsistence farming activities to sustain their livelihoods (Sinyolo et al., 2014). Previous studies have shown that most farmers engage in irrigation systems of farming for food production and sustenance (Cousins, 2012, 2013; Fanadzo, 2012; Wettasinha & Waters-Bayer, 2010). The implication is that most uMsinga SHFs can only farm along the banks of the uThukela river whilst larger parts of the land remain unfarmed. This means that the non-irrigator farmers in uMsinga spent much income buying food to sustain their families (Sinyolo et al. (2014). This is a huge challenge to SHFs in uMsinga. As such, Sinyolo et al. (2014) concluded that irrigation farming "is not enough on its own to eradicate poverty" in uMsinga (p.154). This suggests that there is a need for the inclusion of other practices, apart from irrigation, like climate smart agriculture (CSA). This may involve early planting, planting improved varieties, utilising ICT in farming and so on. This might positively influence the farmers' adjustment to the adverse effects of climate change on agricultural practices in uMsinga.

1.2. Classification of climate change mitigation

On the basis of the negative impacts of climate change all over the world, this study classified means of mitigating the threats into two prominent approaches, namely, using scientific and education approaches.

The first is the scientific approach to mitigating climate change. A number of studies (FAO, 2010; Sullivan, Mwamakamba, Mumba, Hachigonta, & Majele Sibanda, 2012) have shown that concerted efforts have been made to combat this menace among rural dwellers by introducing CSA as a sure way to mitigate climate variability. For example, studies reviewed in Chapter 2 of this study indicate that 35 different strategies of CSA are being practised in Africa, America and Asia amongst farmers. Despite these practices of CSA among farmers, Sullivan et al. (2012) found that the adoption of CSA alone among SHFs is inadequate to mitigate impacts of this changing climate. This may possibly be due to the complex environment where these SHFs live and farm (Ospina & Heeks, 2010).

1.2.1. Information and communication technologies (ICTs) approach

It is essential to note that the nature of our environment is becoming unpredictable to SHFs as such traditional methods of predicting and adapting to the changing climate appears to be failing, possibly because of the complexity brought by climate change (Ackom, 2014). It is in this regard that a number of studies (Aleke & Nhamo, 2016; Ospina & Heeks, 2010;

Shabajee, Preist, Fairbrother, & Dewsbury, 2014) have recognised the roles being played by ICT, describing them as being helpful in (1) providing early warning systems for climate change, (2) sharing knowledge of adaptation among concerned people, (3) raising climate-related risks awareness, (4) coordinating disaster recovery information, (5) supporting consultation and participation in developing adaptation policies, (6) providing training in flood and risks management, (7) providing data to aid adaptation decision-making as well as (8) collecting and analysing information for vulnerability assessments. In addition, ICT is found useful in the adaptation, monitoring, mitigating and strategizing of climate change related matters in Africa, Asia and Latin America (Aleke & Nhamo, 2016; Ospina & Heeks, 2010; Shabajee et al., 2014; Thapar Kapoor, 2014). ICT has been deployed into agriculture in Tanzania and India to perform functions like agro information dissemination (Churi, Mlozi, Mahoo, Tumbo, & Casmir, 2013), and to gain access to market (Beza et al., 2017; Kacharo, 2016). Despite these key roles played by ICT, studies (Misaki, Apiola, & Gaiani, 2016, p. 12; Yohannis, Wausi, Waema, & Hutchinson, 2019, p. 36) have argued that the deployment of ICT alone is unlikely to be able to combat the menace of climate change among SHFs. As such, Sinyolo et al. (2014) in their study suggested "rural micro-projects and development initiatives" to support irrigation farming to mitigate the impacts of drought which have plunged uMsinga SHFs into poverty (p. 145). Therefore, since adoption of CSA and ICT separately have inadequately helped SHFs to mitigate impacts of climate change, this study therefore proposes the intersection between ICT and CSA practices as an adaptive tool.

1.2.2. Education as an approach

The second approach uses education to mitigate the impacts of changing climate. Uncertainty over the changing climate has been considered a major global threat that requires attention of scholars in the field of education to consider climate change education as a viable method of mitigation (Anderson, 2012). Climate change education is defined as a deliberate inquiry-based and interactive teaching and learning procedure that advances learners' scientific knowledge about climate change (Ratinen, 2016, p. 12). Two distinct divisions appeared to be prominent in the concept of CCE. These are, the 'climate' as well as the 'change' (McKeown & Hopkins, 2010, p. 18). These authors argue that the concept of 'change' in CCE depicts "educating for change" (p.18). This implies that the 'change' is a "thought provoking" phenomenon when concerned individuals like uMsinga SHFs engage with it effectively (p.18). McKeown and Hopkins further claim that the education is meant to predict future occurrences to prepare people for the impacts of climate change (ibid). It can be deduced that pedagogical expertise is required to prepare the citizenry in schools. For this to happen, there is need for collaboration between researchers and members of indigenous communities who are regarded as custodians of indigenous knowledge, so teachers can acquire adaptive knowledge. This is because a number of studies (Berger, Gerum, & Moon, 2017; Herman, Feldman, & Vernaza-Hernandez, 2017; Vujovic, 2013) have identified inadequate knowledge and misconceptions concerning climate change among teachers. Though it appears that many teachers around the world are confused, "there is much that scientists can learn from indigenous people," (Simonelli, 2008, p. 18) to resolve some of the challenges identified about educating for change. The scientist (teacher) could learn from indigenous people like uMsinga SHFs to clear their doubts about climate change issues and be adequately informed to transfer adaptive knowledge to their learners. In addition, teachers as scientists can learn how to help learners and acquire adaptive knowledge through collaboration with indigenous farmers in the rural area, in order to improve practice (Lotz-Sisitka, 2009).

1.3. Problem statement

In recent time, climate smart agriculture (CSA) and ICT have been found to be effective means of adaptation to climate change risk among vulnerable communities of the world. CSA has been adopted in many part of the world by farmers and has been proven as well to be a sure way to mitigate climate change (FAO, 2010; Sullivan et al., 2012). Research has since then shown that CSA alone is inadequate to effectively help SHFs adjust to the changes climate has brought to humanity (Sullivan et al., 2012). In like manner, ICT has been deployed into the field of climate change for use in weather monitoring, weather forecasting and weather information dissemination tools. Research has also shown that the deployment of ICT alone to solve the risk of climate change is inadequate (Misaki et al., 2016; Yohannis et al., 2019). Therefore, scholars (Sinyolo et al., 2014) have suggested intersection of both technology (like ICT) and the use of CSA among rural farmers for effective climate change mitigation and adaptation. This study therefore proposed the intersection between ICT and CSA as an effective way to mitigate climate change. If this will happen among SHFs in the rural communities of developing countries like South Africa, ICT literacy needs to be developed to enable the SHFs to interface between ICT tools and CSA. This is because research has shown that rural farmers have low ICT literacy to effectively use ICT (Angello, 2015; Chikaire, Anyoha, Anaeto, & Orusha, 2017; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016).

1.4. Purpose of the study

The purpose of this study is to explore the intersection between ICT and CSA in order to understand the nature of this relationship in adapting to the impacts of climate change on existing agricultural practices among the small-holder farming community in uMsinga. This research is thus seen to provide a space to explore the development of knowledge, skills and competence required for climate change adaptation. In other words, it is seen as the basis upon which capacity could be developed and derived for climate change education policy and practice. To achieve this aim, the study is divided into two parts with the following preliminary and main study objectives.

Preliminary study objectives are to:

a) Establish the current agricultural practices among smallholder farmers (SHFs) in uMsinga;
b) Get community buy-in into interfacing ICT and CSA; and
c) Confirm the need for interfacing ICT and CSA among uMsinga SHFs.

Main study objectives are to:

a) Determine the uMsinga's SHFs ICT literacy levels, by:

    i. assessing the level of ICT literacy held by SHFs in uMsinga;
    ii. determining the level of ICT literacy that SHFs in uMsinga need so they can combine the use of ICT devices and CSA in adapting to the impacts of climate change on food production;

a) explore the ways ICT literacy levels in i) and ii) above could be developed to incorporate the integrated use of ICT devices and CSA using CBPAR[1];

    i. know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool;
    ii. understand how uMsinga SHFs would use these functionalities and the reasons for this.

[1] Community based participatory action research (CBPAR) (Burns & Grove, 2003)

1.5. Critical research questions

Research questions help to create boundaries in a study, thereby structuring its framework (Pryor, 2010). This section presents the research questions underpinning this study, which is divided into two phases, namely: the preliminary and main study.

Preliminary study research questions

a) What are the uMsinga SHFs' existing agricultural practices in relation to climate change adaptation?
b) Do SHFs in uMsinga regard the integration of ICT and CSA into existing agricultural practices as crucial for adequate food productivity and livelihood in the face of climate change?

   i. If so, what informs their perception?
   ii. If not, what informs their perception?

Main Study Research Questions

b) What level of ICT literacy do:

   i. SHFs in uMsinga have?
   ii. SHFs in uMsinga need, so that they can combine the use of ICT devices and CSA in adapting to the impacts of climate change on food production?

c) How can the ICT literacy levels in i) and ii) above be developed to enable the integrated use of ICT devices and CSA using CBPAR?

   iii. What kind of functionalities would uMsinga SHFs include in the ICT-based agro-weather tool, interfaced with CSA to adapt to the impacts of climate change on food production?
   iv. How would they use these functionalities and why?

1.6. Significance of the study

The significance of this study centres on the point that it will produce guidance to the government, SHF communities, educational system, and software developers. To the government, the findings of this study will inform policy formulation and improvement with regard to the ICT literacy development of SHFs to boost adaptation to climate change in the Republic of South Africa. Furthermore, the finding will fill the gap identified in the South African White Paper which promised to develop a "list" of the basic skills that citizens need to participate in the digital society" (Republic of South Africa, 2016, p. 125). In addition, the findings will help the community members to improve their agricultural practice through the intersection between ICT and CSA. This is rather than adopting ICT separately or CSA alone as observed in Misaki et al. (2016) and (Sullivan et al., 2012). More so, this study as a subset of main project of Council for Scientific and Industrial Research (CSIR) will provide the basis for the development of an indigenous weather ICT agro app to enable uMsinga SHFs to access the market for sales of farm produce and to disseminate agro information.

With regard to the educational system, the findings will provide insight to policymakers and curriculum designers to enable them to formulate policies regarding CCE curriculum for all. This might therefore provide adaptive capacity building for the citizenry. The software developers, on the other hand, will gain insight from the findings of this study to understand further benefits of users' involvement in software designs rather than imposing designed applications on clients without their participation. Such involvement may possibly reduce the tendency of producing apps that are non-indigenous and that thereby become useless to SHFs because key areas needed by the users might have been omitted in the design.

Finally, it is envisaged that the findings of this study will promote further research in the field of ICT education in relation to the teaching of climate change education in South African schools. Given that there is a "paucity of research on CCE" in RSA (Anyanwu, Le Grange, & Beets, 2015, p. 3), it is anticipated that the findings of this study will offer be of value for both scholars and practitioners in the field of ICT and CCE, at international as well as national level.

1.7. The research methodology

This study employed a mixed methods approach to generate data, using sequential transformative strategy (Creswell, 2013). In addition, the study engaged the indigenous community of uMsinga, using community forum meeting as indigenous method of data collection (Wilson, 2001). The data generation procedures were divided into two parts namely:

preliminary and main study. The preliminary study has two phases, both of which produced textual data using the community forum method. Whilst the main study consists of two phases also, the first phase also collected numerical data and the second phase used non-numerical data, using questionnaire and community forum methods.

In this study, four instruments were constructed, namely: a preliminary study forum meeting protocol (PSFMP), an ICT literacy assessment tool (ILAT), SHFs' ICT literacy development protocol (SHFIDP), and SHFs' functionalities inclusion discussion protocol (SHFFIDP). The PSFMP was used to generate data for the preliminary study research questions while the ILAT was employed to produce quantitative data for the main study, research question 1. Likewise, SHFIDP and SHFFIDP were used to generate data to answer the second main study research questions. SHFIDP was used to facilitate the community forum meeting set up to understand how the uMsinga SHFs regarded ICT literacy development. This was guided by CBPAR and living theory (LT). Similarly, SHFFIDP was used to facilitate data generation regarding functionalities to be added into existing standard app like a demo app used for the intervention programme.

In addition, the instruments were validated using content validity (Creswell, 2008) as well as the consistent involvement of the uMsinga SHFs in the study (Breu & Peppard, 2001; McNiff & Whitehead, 2006). The split-half reliability test was used to check the consistence of the ILAT.

Furthermore, the study adopted purposive sampling of size 35 irrigation SHFs and one extension officer. The sample size was small because of the nature of the study participants. In addition, the preliminary study was analysed thematically, whilst the unified theory of acceptance and use of technology (UTAUT2) and theory of irrigators' planned behaviour (TIPB) were used to make sense of the findings. Research question 1 of the main study was analysed using descriptive and inferential statistics. On the other hand, research question 2 of the main study was analysed thematically.

1.8. Ethical issues

It is of great importance to consider several ethical issues in this study since the lived worlds of a university researcher and participatory community members differ. Thus, the rules of conducting this research were clearly stated and followed, from the point of entry to the presentation of results, data usage and dissemination. According to Creswell (2013), a code of ethics is the "ethical rules and principles drafted by professional associations that govern scholarly research in the disciplines" (p. 261). Similarly, ethics involves demonstrating the behaviour that will respect the person of the participants as well as not to harm them (Whitehead & McNiff, 2006). In this study, the ethical rules were observed and allowed to guide the conduct of the research. In other words, since other people were involved in this study, their permission for participation was sought (ibid). This was done by obtaining gatekeeper consent, which was granted, to enable access to the group of the SHFs in uMsinga before data collection began. In addition, the intended SHFs were told that they have the right to withdraw from the study at any time without been intimidated.

1.9. Limitations of the study

Limitations in research are regarded as factors inhibiting the successful attainment of set goals of a study (Addo, 2016). According to Addo (2016), there is no research without limitations, though the limitations vary based on the context of the studies. There are some factors that have limited the scope of this study. These include: the small sample size selected, the finances, and methodological challenges resulting from conflict between the frameworks adopted in this study and the ethical clearance. It was therefore challenging to produce evidences showing how the uMsinga SHFs were influenced in learning to use ICT to improve their CSA practices.

1.10. Theoretical frameworks

A framework provides the needed structure and support that a researcher requires for the entire study (Osanloo & Grant, 2016; Tamene, 2016). It also makes the research credible (Adom, Hussein, & Agyem, 2018) and serves as a strong basis for the methods and analysis of the study (Osanloo & Grant, 2016). This study adopted three frameworks: CBPAR, living theory and adoption/adaptation strategy tools (AST) which consists of two theories. These AST theories are, unified theory of acceptance and utilisation of technology II (UTAUT2) (Venkatesh, Thong, & Xu, 2012) and the theory of irrigators' planned behaviour (TIPB) (Wheeler, Zuo, & Bjornlund, 2013). CBPAR and living theory were used to guide data generation in this study. This is because indigenous people are involved in the data generation, as such approaches that support indigenous research must be adopted (Wilson, 2001, 2008). The UTAUT2 evolved after carefully considering the strengths and weaknesses of seven different models and theories, namely: theory of reason action (TRA), theory of planned behaviour (TPB), technology acceptance model (TAM), TAM2, TAM3, rural area technology acceptance model (RuTAM) and UTAUT. The UTAUT2 consists of seven constructs, namely: hedonic motivation, price value, habit, performance expectancy, effort expectance, facilitating conditions and social influence. These constructs of UTAUT2 were used to make sense of the findings related to uMsinga SHFs' ICT adoption.

Similarly, TIPB evolved after carefully considered strengths and weaknesses of protection motivation theory (PMT), and TPB. The TIPB consisted of five variables, namely: financial, natural, physical, human and social capital. The constructs of TIPB were used to make sense of findings related to CSA adoption in uMsinga. All these constructs are discussed extensively with relevant related literature in Chapter 3.

1.11. Definition of key contextual concepts

There are nine key contextual concepts in the title of this study, namely: intersection, information and communication technology (ICT), climate smart agriculture (CSA), adaptation, climate change (CC), food production, climate change education (CCE), capacity building and smallholder farmers (SHFs). These are briefly discussed below.

1.11.1. Intersection

The term intersection is used in this study to mean interface, combination or combining, and joining. The concept is used to refer to the joining of two autonomous systems (strategies) together in a single project. The two systems in this study are ICT and CSA. In previous studies (Ismail, 2016; Misaki et al., 2016; Yohannis et al., 2019), the idea of using ICT alone by SHFs has been considered. However, this use of ICT "alone" amongst SHFs was found to be insufficient (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36) to mitigate impacts of climate change. Similarly, CSA was described by Sullivan et al. (2012) as a way to mitigate the effects of climate change on agriculture. There are a few studies that try to use intersection between ICT and rural women (Kwapong, 2007). Similarly, Thapar Kapoor (2014) used ICT with precision agriculture for information dissemination. Likewise, Estrada-Flores (2010) described some of the ICT components like geographical information systems (GIS), global positioning system (GPS) and remote sensing (RS). GIS entails joining "computer hardware, software, and geographic data developed to capture, store, manipulate, analyse, and display data" targeted to specific locations on earth's surface (Estrada-Flores, 2010, p. 8). RS, on the other hand, could be used to understand fitness of crops, evolving issues on vegetal, insect plagues, and the likes (ibid). However, there is a paucity of study on the intersection between ICT and SHFs' CSA practices.

1.11.2. Information and communication technology (ICT)

ICT is defined as the 'electronic means of capturing, processing, storing, and communicating information' (Heeks, 1999, p. 3). This concept, ICT, has three components: computer hardware, software and communications equipment (Anastasia & Sherzod, 2016; Heeks, 1999). Each of these components cannot work independently without the other. Furthermore, the application of the three components is required to help SHFs take effective decisions to mitigate and adapt to climate change.

SHFs' adoption of ICT in farming practices in recent time cannot be overemphasised. This is because they need ICT to understand the complexity that the changing climate has brought to their environment. The SHFs who specializes in crop production could use ICT to get to know the health condition of their crops, emerging issues about plants, insect infestations brought as a result of climate change, accidental damage by herbicides used, uniform application of fertilizer and water utilisation (Estrada-Flores, 2010).

Furthermore, attempts have been made in previous studies to deploy ICT into the field of agriculture to help farmers in information dissemination (Ismail, 2016) as well as searching for markets for crops (Wawire, Wangia, & Okello, 2017). Similarly, it is believed that the roles of ICT (Aleke & Nhamo, 2016; Ospina & Heeks, 2010; Shabajee et al., 2014) are inadequate to help SHFs adapt to impacts of climate change (Misaki et al., 2016, p. 12). One of the reasons behind the limitations of using ICT among SHFs in rural areas is a deficiency in ICT literacy (Churi, Tumbo, Mahoo, Casmir, & Mlozi, 2014; Nzonzo & Mogambi, 2016, p. 310). This limited understanding of ICT usage has largely restricted SHFs (Angello, 2015) to mere basic utilisation of technology. They thus do not use it in their daily farming as a tool. This lack in ICT literacy among rural SHFs has been identified in studies (Chisango & Lesame, 2014; Hlatshwayo, 2017a), but how this could be developed remained unexplored. According to Xaba and Urban (2016), farmers' ICT literacy development is problematic in the Republic of South Africa.

1.11.3. Climate smart agriculture (CSA)

The concept CSA is regarded as "an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change" (Lipper et al., 2014, p. 1068). In other words it is a mechanism for "strengthening farmers' resilience to climate change, while at the same time reducing agriculture's climate imprint through curbing greenhouse gas (GHG) emissions by limiting deforestation and increasing carbon storage, included in the soil" (Saghir, 2014, p. 66).

In this study, CSA is referred to as a farming approach that reduces the impacts of climate change in order to improve the productivity and livelihood of uMsinga SHFs. CSA has been proven and recommended to be a sure approach to reduce climate change threats among SHFs (FAO, 2010). This was achieved by using the three pillars upon which CSA stands, namely: sustainable agricultural productivity and income, adaptation and building resilience to climate change, and reducing/removing greenhouse gas emission where possible (FAO, 2013, p. 290; 2017, p. 388; Taneja, Pal, Joshi, Aggarwal, & Tyagi, 2014). These three pillars have been targeted to build the sustainability of SHFs' livelihood in the face of climate change.

1.11.4. Adaptation

Adaptation is regarded as a key pillar in CSA (FAO, 2013, p. 290; 2017, p. 388; Taneja et al., 2014). According to the Intergovernmental Panel on Climate Change (IPCC), adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2001, p. 72; 2007). This concept, 'adaptation', involves a shift in responding to vulnerability with the aim of minimising the threat to farming activities (Arbuckle, Morton, & Hobbs, 2013). According to Saravanan and Change (2011), adaptation is required to ensure the sustainability for susceptible individuals in the face of climate variability. Adaptation involves a response process that enables smallholder farming communities to survive the menace of climate variability. In this study, adaptation is required in the intersecting use of ICT and CSA to reduce the impacts of climate change on agricultural production among SHFs.

1.11.5. Climate change (CC)

Climate is defined as "the average weather condition of a place over a period of 30 years as shown by temperature, wind velocity and precipitation" (Brace & Geoghegan, 2011; Hulme, Dessai, Lorenzoni, & Nelson, 2009, p. 197). Climate change, in the UNFCCC report, is defined as "a change of climate that is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and that is in addition to natural climate variability over comparable time periods (UNFCCC, 1995, p. 3)”. However, the Intergovernmental Panel on Climate Change (IPCC) defines CC in a more specific terms as “any change in climate over time whether due to natural variability or as a result of human activity” (IPCC, 2007, p. 6). These definitions point to the fact that CC is triggered by natural or human activity that changes the weather condition of the environment over the years. Some of the human activities in recent times that have aggravated CC are deforestation and the industrial revolution (Wares, Hasan, Islam, & Saleh, 2018) that has led to an increase in the use of fossil fuels (Likkasit et al., 2018). It has been argued that CO_2 is the main greenhouse gas emission and fossil fuels contribute the greatest share of CO_2 emissions (Likkasit, Maroufmashat, Elkamel, Ku, & Fowler, 2018; Saini, Sharma, & Kumar, 2018). This invariably makes the weather and the environment where SHFs live and farm unpredictable, thereby affecting their decisions on when to plant as well as what crop to plant. This has thus impacted negatively on livelihood of many SHFs in the rural areas of developing countries like South Africa and renders them jobless, as well as immigrant with limited or no food production.

1.11.6. Food production

Food production is regarded as all activities related to the growing of crops and the raising of livestock (Zeuli & Nijhuis, 2017). The essence of farmers engaging in farming activities is to guarantee food security for the livelihood of the immediate family as well as the populace. This has been largely affected by the impact of climate change. In India, for example, Paroda, Jat, Gautam, Stirling, and Mal (2018) report that climate change is a huge threat to food production. Similarly, about a decade ago (2007), the IPCC predicted that food production will be reduced by 50% in year 2020 in Southern African countries as a result of climate change (IPCC, 2007). Based on this, various strategies have been employed to improve food production in the region. These include; changing planting dates, crop diversification and mixed cropping, conservation agriculture, rainwater harvesting and seed varieties that are drought tolerant and early maturing (Senyolo, Long, Blok, & Omta, 2017; Ubisi, Mafongoya, Kolanisi, & Jiri, 2017), irrigation (Sinyolo et al., 2014) as well as farming near rivers (Nethavhani, 2013) as shown in section 2.3.2, Chapter 2. Such strategies have been adopted by SHFs for effective food production in the face of climate change.

1.11.7. Climate change education (CCE)

Climate change education (CCE) is a new field of study that is evolving in recent time due to the unpredictable nature of weather conduction being witnessed generally in the globe (Anderson, 2012; Læssøe et al., 2009). This uncertainty regarding the future climate (Anderson, 2012) has been considered a major global threat that requires the attention of scholars in the field of education. This therefore gave rise to CCE. Climate change education is defined as a deliberate inquiry-based and interactive teaching and learning procedure that advances learners' scientific knowledge about climate change (Ratinen, 2016, p. 12). This concept contains two distinct divisions, the 'climate' as well as the 'change' (McKeown & Hopkins, 2010, p. 18). The 'climate' aspect of CCE has been discussed in most climate change related studies by different scholars. It addresses how climate is being taught in natural science subjects, like Geography, in most countries of the world, including the Republic of South Africa (RSA) (Anyanwu et al., 2015; Læssøe & Mochizuki, 2015; Læssøe et al., 2009; McKeown & Hopkins, 2010; Vujovic, 2013). However, the concept of 'change' in CCE depicts "educating for change" (McKeown & Hopkins, 2010, p. 18). This means learning how to adapt to climate variability, which is a major concern in this study.

In the Republic of South Africa, one of the objectives of the National Climate Change Response White Paper is to "effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity" (RSA, 2011, p. 11). To achieve this objective, the document stipulates that early warning systems that predict and give "timely warnings of adverse weather and possibly related pests and disease occurrence" will be provided. In addition, "up-to-date information and decision support tools to assess the vulnerability of farmers and inform farm management decisions" will be given (ibid). The White Paper document also planned to "educate subsistence and small-scale farmers on the potential risks of climate change, and support them to develop adaptation strategies with on-farm demonstration and experimentation" (RSA, 2011, p. 23). However, there is very limited literature that documents government achievements on educating and developing the rural populace with regard to climate change adaptation in the Republic (Anyanwu et al., 2015). This present study fills the gap.

1.11.8. Capacity building

Capacity building means different things to many people, but, in general, it refers to investment in people, institutions and practices that will, together, enable countries to achieve their developmental objectives (World Bank, 1997). It also means strengthening or improving the assets of organisations. Furthermore, capacity building is synonymous with organisation development (Eade, 2007). To many other people, capacity building refers to training or human resource development (Wakely, 1997). According to McGinty (2002), this development in people, institutions and practices requires knowledge, time and finance. On this note, the RSA recognized the role capacity building role that citizenry plays in mitigating the impacts of climate change by keeping to UNFCCC agreement of Article 4.7 (RSA, 2011). In a similar report, the Department of Environmental Affairs (Republic of South Africa, 2018), reveals that climate change education and training amongst others are the main gap that exist in the current South African climate change capacity building . The document suggested training as a way forward. This therefore provides the basis for this study, in order to understand how uMsinga SHFs' ICT literacy capacity could be developed in order to improve on their agricultural practices.

1.11.9. Smallholder farmers (SHFs)

The term 'smallholder farmers' (SHFs) include small-scale farmers, resource-poor farmers, peasant farmers, food-deficit farmers, household food security farmers, land-reform beneficiaries and emerging farmers (Machethe et al., 2004). In the South African context, a SHF is regarded as a low-value producer (Chisasa & Makina, 2012). Similarly, Aditto, Gan, and Nartea (2012) define SHF as a farmer who has a farming area less than 4.8 hectares. In this study, SHFs are regarded as peasant or subsistence farmers who engage in agricultural activities for livelihood sustenance.

1.12. Outline of the study

Chapter 1 of this research presented the contextual background to the study, namely: the background of the study, definition of key contextual concepts, problem statement, purpose of the study, critical research questions, significance of the study, the research methodology, ethical issues, limitation of the study, frameworks, operational definitions of terms, and outline of the study.

In **Chapter 2** the issues outlined are the context of the study; factors influencing SHFs' adaptation to climate change; factors influencing farmers' adaptation of ICT tools; and summary of studies reviewed.

In **Chapter 3**, the frameworks guiding this study were discussed. These include CBPAR, living theory and AST. The AST consisted of two theories, namely: the unified theory of acceptance and use of technology (2) (UTAUT2) as well as theory of irrigators' planned behaviour (TIPB).

Chapter 4 presents the research design and the methodology employed to respond to the research questions set for this study. The methodology was guided by using two frameworks, namely: CBPAR and living theory. On this premise, the chapter is divided into three major sections, pre-intervention, during intervention and post intervention. In addition, **Chapter 5** presents the analysis of findings of the first phase of the preliminary study which aimed to report on the CSA practices uMsinga SHFs engaged in. TIPB was used to make sense of the findings.

Chapter 6 presents the analysis of the second phase of the preliminary study, which addresses the intersection between ICT and CSA practices. UTAUT2 was used to make sense of the findings.

Chapter 7 presents the analysis of findings of the first phase of the main study, which concerns what ICT literacy the uMsinga SHFs have and need in order to interface between ICT and CSA practices. UTAUT2 was used to make sense of the findings. Similarly, **Chapter 8** presents analysis of findings of the second phase of the main study, which is on the ICT literacy development of the uMsinga SHFs. The intervention programme was guided by using two frameworks, CBPAR and living theory. UTAUT2 was used to make sense of the findings.

Chapter 9 of this study presents the discussion of findings stemming from the analyses of data generated in this study. Lastly, **Chapter 10** presents the conclusion of the study, implications of the findings and its contribution to body of knowledge.

CHAPTER 2

LITERATURE REVIEW

The previous chapter, Chapter 1, presented the background of uMsinga in terms of its relevance to climate change. Against this backdrop, the concern of this study is to explore an adaptive tool to mitigate the impacts of climate change on uMsinga SHFs. The concern of this chapter is therefore to study the existing body of knowledge on adaptation to climate change, in order to gain insight into what could be done better to mitigate impacts of climate change. To address this concern, this chapter is divided into six sections based on Creswell (2003, 2008) model of writing literature review, namely: (1) introduction, (2) the research independent variable(s), (3) the research dependent variable(s), (4) studies conducted on the independent variable(s), (5) studies conducted on the dependent variable(s), and (6) summary of findings that relate to research being conducted (Creswell, 2003). Therefore, this study adopted this model by dividing this chapter into six sections, namely:

- Section 2.1 will provide the context of the study;
- Section 2.2 will explore impacts of climate change on agricultural practices;
- Section 2.3 will identify factors influencing adaptation to climate change;
- Section 2.4 will explain the adoption of ICT devices among rural farmers for agricultural practices in the face of climate change;
- Section 2.5 will identify factors influencing farmers' adaptation/adoption of ICT tools; and
- Section 2.6 will provide summary of studies.

The detail is discussed below.

2.1. Context of the study

This study is situated in uMsinga community. uMsinga is a local Municipality in the Mzinyathi District in KwaZulu-Natal (KZN) Province of South Africa located at 28°10'S 30°15'E as shown in Figure 2.1. The Municipality is a rural area characterized by a hot and dry climate (Wettasinha & Waters-Bayer, 2010). According to Cousins (2012), the mean precipitation of uMsinga is 600-700 mm/a with high summer temperatures of about 44°C. A report presented by Mdukatshani Rural Development Programme (2012), indicating the total rainfall in uMsinga from January to December, 1975 to April, 2010, shows a record of relatively high rainfall from 1975 to 1976 but a drastic decrease from 1977 till 1995. Furthermore, the document revealed that there was increase in rainfall in 1996 (944.75) above that of 1976 (854.7mm), but a decrease from 1997 to 2005. However, the volume of rainfall increased in the following year, 2006 (910.25mm), but decreased sharply till year 2009 (565.1mm) (ibid). The analysis of this data shows that the highest rainfall since 1975 to 2009 in uMsinga occurred in 1996 with total volume of 944.75mm, followed by year 2006 (910.25mm) and 1997 (897mm). The most severe drought in uMsinga in the years between 1975 and 2009 occurred in 1989 with rainfall of 189.5mm, followed by 2003 (302.5mm) and year 1982 (384.5mm). A later study by Rukema (2014) revealed that drought in uMsinga became severe from year 2010 till 2015. In 2015, SHFs found it difficult to plant their crops because of severe drought in uMsinga (Vanderhaeghen & Hornby, 2016). The authors further report that the drought became worse each year from 2010 till 2015 (ibid). Most inhabitants of uMsinga are involved in subsistence farming activities due to drought and financial constraints (Sinyolo et al., 2014). Based on this natural occurrence in uMsinga, agricultural activities have been negatively affected by climate change (IPCC, 2007). This means that the livelihoods of the SHFs are likely to have been negatively affected by climate threat. It can therefore be said that uMsinga SHFs are facing a huge challenge of climate change that must be mitigated.

In this regard, previous studies (Cousins, 2012, 2013; Fanadzo, 2012; Wettasinha & Waters-Bayer, 2010) have shown that most farmers engage in irrigation farming due to the impacts of climate change in uMsinga for food production and sustenance. The implication is that, most uMsinga SHFs can only farm along the coast of uThukela River whilst larger parts of the land remain unfarmed. This means that, the non-irrigator farmers in uMsinga spent much of their income buying food to sustain their families Sinyolo et al. (2014). These authors conclude that the irrigation farming "is not enough on its own to eradicate poverty" in uMsinga (p.154). This suggests that there is need for inclusion of other practices apart from irrigation like climate smart agriculture (early planting, planting improved varieties), utilising ICT in farming and so on. This might positively influence the farmers' adjustment to the adverse effects of climate change on agricultural practices in uMsinga.

2.2. Impacts of climate change on agricultural practices

The change in climate is regarded as a natural phenomenon that has been inflicting negative impacts on people, animals and plants IPCC (2007). According to Food and

Agriculture Organization of the United Nations' (FAO) report, the impact of climate change on agriculture in recent time has gained global concern (FAO, 2013). This is because the negative impacts have led to low food production and insecurity, high price of food materials, and poverty among developing countries (FAO, 2013). Similarly, some SHFs are losing their jobs in search for livelihood due to the prevalent menace of climate change in vulnerable environments (FAO, 2013). Likewise, the report reveals that the increase in unpredictable nature of weather pattern especially among developing countries affects food production in Nigeria, Malaysia and South Africa (Makeleni et al., 2018; Masud et al., 2017; Wahab & Popoola, 2018; Williams et al., 2019). Similarly, the IPCC (2007) report predicted that Southern African countries will experience a 50% loss in crop production by year 2020. This is becoming apparent as we move closer to the predicted year in the continent. The impacts of climate change increase on yearly basis due to drought and shortage of rainfall in Southern African countries like South Africa.

Furthermore, a recent study has shown that the water crises in Cape Town of South Africa (Gluckman, 2017) will not only affect the people directly but economy of the country especially food producers. In addition, the report by the Department of Water Affairs (DWA) shows that RSA has over stretched the limit of developing surface-water sources, thus, more dams might not be built to raise level of water supply in the country for domestic and agricultural use (Chami & Moujabber, 2016; DWA, 2013). Likewise, Shi and Tao (2014) claim that RSA is reported to have suffered a major reduction in maize (*Zea mays)* yield due to drought. Similarly, the study by Sinyolo et al. (2014) argues that uMsinga SHFs face the challenge of drought due to the hotness of the location. Although irrigation farming has been adopted by farmers in uMsinga to adjust to the impact of drought on food production (Sinyolo et al., 2014), this impact is still major on food production. It is therefore necessary to search literature to understand factors informing SHFs' adaptations to climate change.

2.3. Factors influencing adaptation to climate change

Adaptation is defined as the "process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (Field, Barros, Stocker, & Dahe, 2012, p. 5). To adjust to the menace of climate change, there are factors that could possibly inform SHFs, namely: climate change education (CCE); climate smart agricultural (CSA) technologies and approaches or climate change adaptation strategies

(CCAS); awareness of climate change adaptation strategies; practice of climate smart agricultural (CSA). These are discussed in greater detail below.

2.3.1. Climate change education (CCE)

Climate change education is a new field of study which is recently evolving due to the unpredictable nature of weather conditions across the globe (Anderson, 2012; Læssøe et al., 2009). This uncertainty regarding the future climate has been considered a major global threat that requires attention of scholars in the field of education (Anderson, 2012). Climate change education is defined as a deliberate inquiry-based and interactive teaching and learning procedure that advances learners' scientific knowledge about climate change (Ratinen, 2016, p. 12). Two distinct divisions appeared to be prominent in the concept of CCE. These are the 'climate' as well as the 'change' (McKeown & Hopkins, 2010, p. 18). Frist, the 'climate' aspect of CCE is taught under natural science subjects like geography in most countries of the world like Republic of South Africa (RSA) (Anyanwu et al., 2015; Læssøe & Mochizuki, 2015; Læssøe et al., 2009; McKeown & Hopkins, 2010; Vujovic, 2013). According to McKeown and Hopkins (2010), 'climate' involves knowing about atmospheric composition and processes. This part can easily be acquired under natural science subjects in schools.

On the other hand, McKeown and Hopkins (2010) argue that the concept of 'change' in CCE depicts "educating for change" (p.18). This means that the 'change' is a "thought provoking" phenomenon when it is effectively raised with concerned individuals like SHFs (p.18). The authors further claimed that the change is meant to predict future occurrences to prepare people for the impacts of climate change (ibid). It can be deduced that pedagogical expertise is required to prepare the people to invoke the thinking capacity of community members. For this to happen, there is need for collaboration between the researcher and the community representatives to acquire adaptive knowledge.

However, research has shown that proper adaptive knowledge is lacking to address the impacts of climate change (McKeown & Hopkins, 2010). This is because adequate adaptive pedagogy or andragogy (Knowles, Holton, & Swanson, 1998) is required to solve the changing climate threats. The knowledge is to empower individuals like SHFs to adjust to the menace of climate change to improve productivity and practice. Research has however suggested learning for change, rather than just awareness education, as a means to address limited adaptive pedagogy (Gaillard, 2012). The author also argued that this might be realised through in-depth climate change education that involves discussion between educators and the community members like uMsinga SHFs (ibid).

A number of studies (Chang & Pascua, 2017; Læssøe & Mochizuki, 2015; Noah, Musonda, & Chakanika, 2016) have shown that CCE is evolving and steps are being taken to educate both young and adult learners about climate change. For example, in Singapore (Chang & Pascua, 2017) CCE is now included in the school curriculum, though without a strong policy guiding its implementation in the schools. In addition, the Chinese government has developed plans to educate its populace with the knowledge of climate change (Læssøe & Mochizuki, 2015). Thus, climate change education will be taught in "basic education, higher education and adult education with focus on awareness and participation in relevant activities" (p. 14). Furthermore, Noah et al. (2016) claim that climate change education is a major content of non-formal adult education programmes in Zambia that are being offered to develop the literacy level of the adults.

In the RSA context, CCE is relatively new. According to the Republic of South Africa (2011), "*climate change is a relatively new issue that has cross-disciplinary and cross-sectoral implications in South Africa. Understanding the concept as well as the options to mitigate it and adapt to it is fundamental to future development pathways and the wellbeing of South African society* (p. 45). As such, the White Paper, stated that CCE "should be part of the broader framework of education for sustainable development, and should equip South African citizens to re-orient society towards social, economic and ecological sustainability" (p. 45). Thus, CCE is being taught under the domain of natural science subjects like Geography in South African schools (Læssøe & Mochizuki, 2015; Republic of South Africa, 2011; Vujovic, 2013), unlike Singapore and China where specific curriculum provision has been made for CCE. Despite this, Feinstein, Jacobi, and Lotz-Sisitka (2013) argue that CCE is narrowly understood as climate science education. The authors opine that CCE should be addressed independently in the South Africa educational system (ibid).

It is crucial that people have and in-depth knowledge of climate change. This is because our environment is becoming more complex and climate change causes variations from place to place (Tripathi & Mishra, 2017). However, studies reveal that teachers' knowledge and perspectives on CCE pose further threats to learners' knowing. A study by Bozdogan (2011) shows that teachers have misconceptions about some relevant concepts relating to CCE. A number of studies (Berger et al., 2017); Herman et al. (2017) in Ontario and Florida show that teachers had inadequate knowledge of climate change. Conversely, in the United States (US), Virginia teachers had adequate knowledge, expertise and confidence to teach climate change in their schools (McNeal, Petcovic, & Reeves, 2017).

Research has shown that there is a "paucity" of empirical research on "climate change education" in RSA (Anyanwu et al., 2015, p. 3). There are a few studies (Anyanwu et al., 2015; Vujovic, 2013) which investigated teachers who teach climate change related subjects in schools. These demonstrated a high level of literacy on climate change but the teachers misconceived some basic climate change issues. For example, Anyanwu et al. (2015) reveal that teachers thought that "water vapour is the most abundant greenhouse gas" (p. 7); and greenhouse gases occurred as a "layer in the atmosphere" (Vujovic, 2013, p. 158). In addition, Vujovic's study found shortfalls in the Geography textbooks used by the teachers to teach climate change education (p. iii). The author suggested that these flaws and shortfalls should be rectified for ultimate success of climate change education in schools. Further, Vujovic claims that "the teachers stated that mass media was a key source from which information on climate change is obtained" (p. 155).

Although the challenge of inadequate knowing and misconceptions of climate change were identified in the studies reviewed in this section, how to solve them was unclear. It appears that many educators are confused but "there is much that scientists can learn from indigenous people," (Simonelli, 2008, p. 18) to resolve some of the identified misconceptions. The scientist (teacher) could learn from indigenous people like SHFs to clear their doubts about climate change issues and be adequately informed to transfer adaptive knowledge to their learners. In addition, teachers as scientists can learn how to help learners and acquire adaptive knowledge through collaboration with indigenous farmers in the rural area in order to improve practice (Lotz-Sisitka, 2009).

In summary, it was clear from these studies (Berger et al., 2017; Herman et al., 2017; Vujovic, 2013) that teachers around the world who teach climate change related subjects in schools need adequate understanding of climate change to educate learners so as to take the right adaptive measures in their environment. Though there is a "paucity of research on CCE" in RSA (Anyanwu et al., 2015, p. 3), this study is set to know how SHFs mitigate climate change and develop knowledge from them for CCE capacity building in South Africa.

2.3.2. Adoption of indigenous knowledge systems to mitigate climate change

Indigenous in this study means “something natural or innate which is an integral part of culture” (Odora-Hoppers (2002, p. 8). It could be regarded as native or inborn of a place (Fortuin, 2017). Indigenous knowledge systems (IKS) are defined as those systems that “abide in the hearts and minds of Elders and specialist knowledge keepers and are regarded as a heritage for practical and survival purposes” (Khupe, 2014, p. 12). In this regard, it can be said that IKS was deeply involved in the mitigation of climate change before the advent of science. It also implies that science only captures IKS and repackage it in a different form. The IKS indicators used amongst the Indigenous people of Kenya, Swaziland, Tanzania, South Africa (Mwaura, 2008), Zambia (Kasali, 2011) and Zimbabwe (Kihupi et al., 2002) reveal the richness and relevance of indigenous knowledge in providing the early warning needed to mitigate impacts of climate change. In Kenya for example, the early warning system indicators used by the some communities are in the behaviour of substances like animals, birds, reptiles, amphibians, insects, spiders, plants, trees and their fruiting patterns, winds, temperatures as well as celestial bodies such as moon and stars displaying shapes and signs (Mwaura, 2008, pp. 65-66). In some communities, the signs of rain are indigenously captured in the flowering or leaves of certain indigenous species of tree (like setiot), the flow of wind in a certain direction, as well as the migration of birds and insects (Songok, Kipkorir, & Mugalavai, 2011).

Furthermore, in Zambia, the study by Kasali (2011) revealed such early warning indicators as use of flying insects and the movement of wind in specific directions. Excessive flowering of mango and wild fruit trees might indicate a bad rainy season for food production. Similarly, in Swaziland, the indigenous indicators employed to prepare for impact of climate change like drought, include the appearance of abundant butterflies in farming season, army worms, the dropping off of immature avocado fruits and fruiting of wild trees in between the months of December and February of a year (Mwaura, 2008, p. 67). The certainty of flooding in a year is captured by observing rivering birds making their nests at top of trees. However, when the nests are made at the lower part of trees, it means flood is unlikely in Swaziland (p. 64).

In Tanzania, the indigenous people capture early warning indicators through divining from use of goat intestines by specialized Masai elders to understand drought and famine, social conflicts, diseases, childbirth, peace or battle (Mwaura, 2008, p. 69). According to the author, if the small intestine was found unfilled, this indicates drought or famine or hostility and war.

Otherwise, it indicates abundance of rain, plenty and peace (ibid). Likewise in Zimbabwe, the indigenous people predict weather by the observation and monitoring of certain behaviours in some animals, birds, plants and insects (Kihupi et al., 2002). According to Enock (2013), other indicators used include these; the fruiting time of specific local trees, the volume of water in streams and ponds, bird nesting behaviour and the behaviour of insects in the environment.

Similarly, in South Africa, using the Northern Limpopo for instance, it is a belief that drought is an act of God as such, the early warning indicators are captured by elders through ancestors who was known to be intermediaries between nature and God and who prevent drought from occurring (Mwaura, 2008). According to Mwaura (2008), the indigenous people believe that floods and drought are acts of God, that the rape of elderly women or minors brings floods, appearance of a “red” moon indicates the imminence of floods and drought, appearance of solar eclipse brings drought and the cry of the ‘vlera bird’ indicates floods (Mwaura, 2008, p. 66). In uMsinga, the prevalent early warning indicators include these; the specific behaviour of some animals, revelations from ancestors, crying of birds and migration, wind movement in certain direction as well as the appearance of vegetation (Rukema, 2014). According to the author, trees shedding leaves is an indicator of drought (ibid). Rukema’s findings show four ways by which the indigenous people of uMsinga have been mitigating drought, namely: (1) praying to ancestors, (2) growing drought resistant crops, (3) migration of men and young women to urban area in search for work, and (4) grazing arrangements with distant communities (p. 137).

In summary, a numbers of studies (Enock, 2013; Kasali, 2011; Kihupi et al., 2002; Mwaura, 2008; Rukema, 2014; Songok et al., 2011) in Kenya, Swaziland, Tanzania, Zambia, Zimbabwe, and South Africa have shown that IKS is used to provide early warning systems by indigenous people in different parts of the globe. In addition, IKS has been successfully used by indigenous people to mitigate and adapt to impacts of climate change. However, (Mwaura, 2008; Rukema, 2014) point out that the role of IKS as early warning system was limited by inadequate and inaccurate sources of weather information. Mwaura (2008) therefore suggested integration of IKS with modern knowledge as the way forward to strengthen the weaknesses of IKS. The findings in Rukema (2014) show that IKS was used by uMsinga farmers to mitigate impacts of climate change by growing drought resistant crops. Since the planting of drought resistant crop is a form of climate smart agriculture (CSA) strategy, therefore, this current study meets the suggestion of Rukema (2014) and Mwaura (2008) by interfacing between modern knowledge (using ICT) and indigenous people' agricultural practices.

2.3.3. Climate smart agricultural (CSA) technologies and approaches

The international community has been making concerted efforts on how to adapt and mitigate climate change impact globally through the use of climate smart agricultural (CSA) technologies and approaches (Taneja et al., 2014). According to Lipper et al. (2014), CSA is "an approach for transforming and re-orienting agricultural systems to support food security under the new realities of climate change" (p. 1068). Similarly, Saghir (2014) defines CSA as a mechanism for" strengthening farmers' resilience to climate change, while at the same time reducing agriculture's climate imprint through curbing greenhouse gas (GHG) emissions by limiting deforestation and increasing carbon storage, included in the soil" (p. 66). Based on these definitions, this study views CSA as climate change adaptive strategies that reduce GHG emissions in order to improve food productivity and livelihood.

A number of studies (FAO, 2010; Sullivan et al., 2012) have proven and recommended CSA to SHFs as a sure approach to reducing climate change threats. CSA has three pillars upon which it stands (FAO, 2013, p. 290; 2017, p. 388; Taneja et al., 2014), namely: sustainable agricultural productivity and income, adapting and building resilience to climate change, and reducing/removing greenhouse gas emissions where possible (FAO, 2013). These three pillars contribute to the main goal of sustaining farmers' livelihood in the face of climate change. In addition, CSA improves farmers' adaptive capacity (Lipper et al., 2014).

There are diverse climate smart agriculture strategies which have been adopted in different countries of the world. A large number of studies in India, Ghana, Uganda, South Africa (Borden, Anglaaere, Adu-Bredu, & Isaac, 2019; Bukomeko, Jassogne, Tumwebaze, Eilu, & Vaast, 2019; Mthembu, Everson, & Everson, 2019; Senyolo, Long, Blok, & Omta, 2018; Tripathi & Mishra, 2017) have shown how farmers have practised agroforestry. Likewise, changing cropping pattern is been practised in Indian, Nepal, Bangladesh, and Nigeria (Ayanlade, Radeny, & Morton, 2017; Kabir, Alauddin, & Crimp, 2017; Khanal & Kattel, 2017; Tripathi & Mishra, 2017); changing farming location in Malaysian (Masud et al., 2017). In addition, in India, South Africa, Malaysia, Bangladesh, and Ghana (Abdoulaye, Bamire, Akinola, & Etwire, 2017; Kabir et al., 2017; Masud et al., 2017; Senyolo et al., 2017, 2018;

Tripathi & Mishra, 2017; Ubisi et al., 2017) farmers practise changing planting dates. Furthermore, the practice of compost, and farmyard manure are common among farmers in Malaysian, Zambia, Mozambique, and Malawi (Makate, Makate, & Mango, 2017; Masud et al., 2017). Further examples are contour terraces in Kenya and Bangladesh (Farouque & Takeya, 2007; Mutuku, 2017a); crop diversification in South Africa, Bangladesh, and Ghana (Abdoulaye et al., 2017; Denkyirah, Okoffo, Adu, & Bosompem, 2017; Kabir et al., 2017; Senyolo et al., 2017; Ubisi et al., 2017). Similarly, early maturing is practised in India, South Africa, Ghana, and Kenya (Abdoulaye et al., 2017; Agesa, Onyango, Kathumo, Onwonga, & Karuku, 2019; Senyolo et al., 2017; Tripathi & Mishra, 2017; Ubisi et al., 2017).

Furthermore, in the Midwestern US (Mase, Gramig, & Prokopy, 2017) farmers employ new technology. Similarly, farmers in Ghana (Abdoulaye et al., 2017) engage in off-farm jobs. Additionally, studies in Malaysian, Ghana, South Africa (Abdoulaye et al., 2017; Masud et al., 2017; Nethavhani, 2013) have shown farmers practising farming near water bodies. In Zambia, Mozambique, Malawi, and Nigeria (Makate et al., 2017; Wahab & Popoola, 2018) farmers practise grain legume rotations to mitigate climate change. Likewise, improved animal husbandry is practised in Bangladesh (Kabir et al., 2017). Studies in Ghana, South Africa and Zimbabuwa (Denkyirah et al., 2017; Didarali & Gambiza, 2019; Guodaar et al., 2019) have shown practice of increasing pesticide. Infield conservation practices in Midwestern US, and Ghana (Mase et al., 2017); inorganic fertilizers in Zambia, Mozambique, Malawi, and Ghana (Denkyirah et al., 2017; Makate et al., 2017); inter-cropping in India and South Africa (Senyolo et al., 2018; Tripathi & Mishra, 2017); irrigation system in India, Malaysia, Nepal, Ghana and South Africa (Abdoulaye et al., 2017; Khanal & Kattel, 2017; Masud et al., 2017; Sinyolo et al., 2014; Tripathi & Mishra, 2017). Among the practices are mixed cropping in South Africa and Ghana (Abdoulaye et al., 2017; Senyolo et al., 2017; Ubisi et al., 2017); open ridges in Kenya and Bangladesh (Farouque & Takeya, 2007; Mutuku, 2017a); planting of improved varieties in Bangladesh and Ghana (Abdoulaye et al., 2017; Denkyirah et al., 2017; Kabir et al., 2017; Senyolo et al., 2018); planting tolerant and drought resistant crops in South Africa and Nigeria (Ayanlade et al., 2017; Senyolo et al., 2017; Ubisi et al., 2017). Furthermore, planting trees for shade and shelter are practised in Ghana (Abdoulaye et al., 2017; Denkyirah et al., 2017) as is purchasing additional crop insurance in Midwestern US (Mase et al., 2017). Rainwater harvesting is practised amongst farmers in South Africa, Ghana, and Uganda (Abdoulaye et al., 2017; Kiggundu et al., 2018; Senyolo et al., 2017; Ubisi et al., 2017); small reservoirs and Zai Pits in Kenya (Agesa et al., 2019; Sullivan, Mumba, Hachigonta, Connolly,

& Majele Sibanda, 2013) and terrace improvement and direct seeded rice (DSR) adoption in Nepal (Khanal & Kattel, 2017). Likewise, studies in Kenya and Bangladesh (Farouque & Takeya, 2007; Mutuku, 2017a) show that the use of tied ridges is practised among the farmers to mitigate impacts of climate change.

In South Africa (Kassam, Friedrich, & Derpsch, 2018; Senyolo et al., 2017, 2018; Ubisi et al., 2017) farmers practise conservation agriculture, crop rotation (Makeleni et al., 2018), drought early warning detection (Senyolo et al., 2018), agro-ecology (Senyolo et al., 2018) and Bio-char (Senyolo et al., 2018), in-field rain water harvesting (IRWH) (Goitsemodimo, 2015; Sullivan et al., 2013), changing planting dates, crop diversification and mixed cropping, conservation agriculture, rainwater harvesting and seed varieties which are drought tolerant and early maturing, (Senyolo et al., 2017; Ubisi et al., 2017) irrigation farming (Sinyolo et al., 2014), site-specific nutrient management (Senyolo et al., 2018) and farming near rivers (Nethavhani, 2013).

Conclusively, considering the range of CSA being practised among 14 countries in the studies reviewed from Asia, Africa, and the Americas, it could be assumed that farmers are aware of CSA practices in these countries. In addition, the analysis of the studies shows that out of the 35 CSA being practised as reviewed in this study, 18 are practised amongst South African farmers. However, since climate change varies from region to region (Tripathi & Mishra, 2017), this study investigates the strategies adopted by uMsinga SHFs to face the challenges of changing climate.

2.3.4. The challenges facing SHFs' agricultural practices in developing countries

SHFs are facing various categories of challenge resulting from climate change in recent time. The term challenge is defined as barriers (Azhoni, Holman, & Jude, 2017), limits (Dow, Berkhout, & Preston, 2013), obstacles (Bedsworth & Hanak, 2010), and constraints (Agard et al., 2014). In my study, challenge (Fünfgeld, 2010) is used synonymously with barriers, limits, obstacles and constraints. Agard et al. (2014) claimed that adaptation constraints/challenges are factors "that makes it harder to plan and implement adaptation actions or that restricts options" (p. 2). It should therefore be noted that challenges hinder, restraint or stop SHFs from using some agricultural practices that respond to the new situation created by unpredicted changing weather. However, these constraints differ from one location to another depending on environmental factors (Tripathi & Mishra, 2017).

The identified challenges restraining the adoption or adaptation of CSA in previous studies include; limited information on climate change and adaptation strategy (Azhoni et al., 2017; Denkyirah et al., 2017; Makate et al., 2017), inadequate credit facilities and agricultural subsidies (Denkyirah et al., 2017; Islam, Sallu, Hubacek, & Paavola, 2014; Masud et al., 2017; Yameogo, Kabore, Bontogho, Torou, & Barry, 2017), high cost of farm input (Denkyirah et al., 2017; Masud et al., 2017), insufficient water resources (Masud et al., 2017; Yameogo et al., 2017), uncertainty over market conditions (Descheemaeker et al., 2016; Islam et al., 2014; Yameogo et al., 2017), lack of relevant knowledge (Azhoni et al., 2017; Descheemaeker et al., 2016; Islam et al., 2014; Makate et al., 2017), inaccurate weather forecasting (Islam et al., 2014; Masud et al., 2017), lack of skills (Islam et al., 2014; Makate et al., 2017), policy implementation gaps (Azhoni et al., 2017; Islam et al., 2014), weak inter-institutional networks (Azhoni et al., 2017; Islam et al., 2014), poor technological tools (Descheemaeker et al., 2016; Islam et al., 2014), and climate risk (Masud et al., 2017; Yameogo et al., 2017). Other challenges are: inaccessibility of inputs (Yameogo et al., 2017), inadequate labour (Denkyirah et al., 2017), insecurity of land holdings (Descheemaeker et al., 2016), land tenure issues (Descheemaeker et al., 2016), unhelpful normative attitudes (Azhoni et al., 2017), poor radio signals (Islam et al., 2014) and the high cost of climate change adaptation (Denkyirah et al., 2017).

Similarly in South Africa, less rainfall results into lack of access to water from rivers and dams (Blignaut, Ueckermann, & Aronson, 2009; Shisanya & Mafongoya, 2017; Ubisi et al., 2017), and perceived protracted droughts (Ubisi et al., 2017). These challenges limit adoption of CSA among farmers. The implication of these challenges is that CSA alone is inadequate to combat the impacts of climate change because of the complex environmental changes, as pointed out in Sullivan et al. (2012, p. 1). Thus, other approaches like information and communication technology (ICT) could be considered as alternative way to reduce the impacts of climate change.

2.4. Adoption of ICT devices among rural farmers for agricultural practices in the face of climate change

Research on the adoption of ICT device like mobile devices among rural dwellers had been an ongoing debate in recent time. For example, Asif, Uddin, Dev, and Miah (2017) claim that farmers in their study are low mobile phone users. However, other researchers argue that ICT devices appear to be largely embraced in rural community of most developing countries

(Arunrat, Wang, Pumijumnong, Sereenonchai, & Cai, 2017; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016; Olaniyi, Adetumbi, & Adereti, 2013). This might possibly be because of portability of the mobile devices (Clough, Jones, McAndrew, & Scanlon, 2009; Nzonzo & Mogambi, 2016) and benefits like the ease of communication in remote areas (Khan, 2016). A study on the impact of ICT-based service delivery systems on agricultural production, in Bangladesh (Das, Munshi, & Kabir, 2017), used mixed methods to elicit data from ICT-based farmers and non-ICT dependent farmers. Das et al. (2017) found that the farmers used ICT tools like radio, television, mobile phones and computers. In addition, the study reveals that the ICT-dependent farmers were able to increase farming production to yields higher than the yields of non-ICT-based farmers (ibid). However, the study is uncertain on how these farmers attained the increase in the yields using ICT tools. Further, the study is silent on the ICT skills that the farmers possessed to enable them to use mobile devices and computers to improve farm productions.

Similarly, in Nigeria, the study of Chikaire et al. (2017) focused on the effects of ICT use on farming practices. The study targeted ICT users only among farmers using quantitative methods. Chikaire et al. (2017) found radio and mobile phones were mostly used by the farmers (ibid). Likewise in Kenya, Nzonzo and Mogambi (2016) conducted a study to understand how SHFs used ICT to source for agricultural related information using blended methods. The study reveals that SHFs used ICT to receive agro-climatic information (ibid). Furthermore, in Rwanda, a study by Rugege and Vermeulen (2017) found that farmers use ICT to disseminate weather information. However, a study in Bangladesh (Asif et al., 2017) found factors affecting farmers' use of mobile phones. According to the study, the majority of the farmers were low mobile phone users.

In South African context, rural dwellers, who are predominantly subsistent farmers (Nkuna, 2017) use mobile devices (such as mobile phones) to varying degrees of activity, like their counterparts in the cities (Republic of South Africa, 2016). This assertion has been verified in many studies, that mobile technology has empowered rural dwellers in South Africa and that their traditions support the use of mobile technology (Dalvit, 2015). The author also argues that there are high numbers of mobile phone users in South Africa (ibid). Similarly, Tubbs (2012) reports show that 59% of South African populace have access to the Internet. The study further claims that out of the people that used Internet, 27% percent used mobile phones to access the Internet (ibid). In addition, the estimate of Jones (2010) reveals that by 2014 most mobile phones would have changed to smartphones. These findings show that the meaning of ICT is understood by rural dwellers in RSA. The rural dwellers must have seen or used ICT for one activity or the other. However, this study plans to confirm the studies of Tubbs (2012) and Jones (2010).

In summary, it is apparent from the studies reviewed in this study, that, at both international and local level, rural farmers use ICT devices in many developing countries of the world.

2.5. Factors influencing farmers' adaptation/adoption of ICT tools

There are some factors which are likely to influence farmers' adaptation of ICT tools, namely: the effectiveness of ICTs in reducing the impacts of climate change; ICT literacy; ICT literacy acquisition; ICT adoption/adaptation; software design and transfer; users' participation in software design and use; ICT infrastructure and awareness; and ICT policy plans for climate change adaptation in rural locations. The details are discussed below.

2.5.1. Role of ICT in addressing the impacts of climate change

ICT is known to play a vital role in many fields of studies like agriculture, health, information system, and climate change among other. A number of scholars have recognised the roles of ICT and described them as being helpful in (1) providing early warning systems for climate change; (2) sharing knowledge of adaptation among concerned people; (3) raising climate-related risks awareness; (4) coordinating disaster recovery information; (5) supporting consultation and participation in developing adaptation policies; (6) providing training in flood and risks management; (7) providing data to aid adaptation decision-making, as well as (8) collecting and analysing information for vulnerability assessments (Aleke & Nhamo, 2016; Ospina & Heeks, 2010; Shabajee et al., 2014). In this study, ICT is used to provide forms of early warning systems for smallholder farmers regarding the impacts of climate change on their crops. Also, the research uses ICT as a means of information sharing among selected uMsinga SHFs. However, the roles of ICT are ongoing among subsistent farmers. Thus, this research explored the nexus of agricultural practices with ICT for better understanding or improved practice.

Additionally, ICT applications have been found playing significant roles to combat menace of climate change globally. A number of studies (Kalas & Finlay, 2009; Shafiq, Ahsan, AdnanNadeem, Shaikh, & Siddiq, 2014) have identified some ICT facilities generally used for climate related issues, such as: geographical information system (GIS); wireless sensor networks (WSN); mobile technology (MT); web based applications; satellite technology and remote sensing (RS). Similarly, these applications have been found useful in many other areas of life. For instance: ICT smart grids is an application used in power generation and consumption, to control the transmission and distribution of energy (Niyibizi & Komakech, 2013); wireless sensor network application is used in environmental monitoring, military field and robotics (Arampatzis, Lygeros, & Manesis, 2005) as well as for digital video to monitor wetland ecosystems (Shafiq et al., 2014). Further, in a study conducted by the International Telecommunication Union, (ITU, 2008) to understand the effects of ICTs on climate change, the report found that ICTs contribute about 2.5 per cent to greenhouse gas GHG emission, but have the capability of providing solutions to reduce 97.5% of GHG emissions generated by other factors (ITU, 2008). This means that the advantage of using ICT tools supersedes the negative impact on the environment. It also implies that ICT installations are advantageous to climate change adaptation. In similar studies (ITU, 2008, p. 2; Ospina & Heeks, 2010, p. 4), ICT has been useful for four key areas, namely: “mitigation, monitoring, adaptation and strategy”. Out of these areas, this study focuses on the use of ICT for climate change adaptation.

According to Shafiq et al. (2014), the integration of ICT into climate change for monitoring, mitigation and adaptation has played a significant roles to save vulnerable environments from destruction and degradation. Similarly, Shabajee et al. (2014) argued that ICT has the potential to help in climate change adaptation. It is therefore evident in these studies (ITU, 2008; Ospina & Heeks, 2010; Shabajee et al., 2014; Shafiq et al., 2014) that ICT plays significant roles in the dissemination of agro-climatic information to farmers, adaptation, mitigation, monitoring and strategy. However, a number of recent studies (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36) have shown that ICT alone is unlikely to solve the problems of SHFs.

In conclusion, studies (Misaki et al., 2016, p. 12; Sullivan et al., 2012; Yohannis et al., 2019, p. 36) reviewed in this study have shown that CSA and ICT, adopted separately, have inadequately helped SHFs combat the climate change threat. This is a gap that this study aimed to fill by proposing the intersection between ICT and CSA. However, the factor of ICT literacy of the SHFs in interfacing ICT and CSA appeared to be important.

2.5.2. ICT literacy and acquisition

ICT literacy was defined by the International ICT Literacy Panel report (ICT Literacy Panel, 2002), as the use of "digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society" (p.2). in a similar study, Lowe and MacAuley (2000) define ICT literacy as "the skills and abilities that will enable the use of computers and related information technologies to meet personal, educational and labour market goals" (p. 6). In this research, the ability to use ICT devices to perform a task is regarded as ICT literacy. This ability to use ICT appeared to be a required condition for SHFs to adopt ICT. However, previous studies revealed that most farmers are characterised by "lack of ICT skills" (Nzonzo & Mogambi, 2016, p. 310) and "lack of technical knowledge" (Asif et al., 2017, p. 41).

In Botswana, for example, Lekopanye and Sundaram (2017) study found that livestock farmers lack ICT literacy to use ICT tools. Similarly, Chikaire et al. (2017) findings show that lack of ICT skills is one of the topmost challenges limiting Nigerian farmers' use of ICT devices. Furthermore, Angello (2015) concludes that the inability of Tanzania farmers to use ICT for effective agricultural activities largely depends on their lack of ICT literacy. On the basis of the findings from the literature (Angello, 2015; Chikaire et al., 2017; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016), it can be inferred that most rural farmers in developing countries in Africa lack the ICT literacy to adopt ICT into farming practices. However, the studies were unable to provide evidence on the level of ICT literacy the farmers had.

In the Republic of South Africa (RSA) context, Chisango and Lesame (2014) have found that the lack of ICT literacy has hindered rural dwellers of Eastern Cape from using ICT. This has invariably resulted into a digital divide and poverty among the rural community members (ibid). Similarly, the result from Hlatshwayo (2017b) shows that rural community members in Mafikeng lack the ICT literacy needed to adopt ICT in their daily activities. In summary, these findings reveal that ICT literacy is a problem confronting the use of ICT among subsistence farmers in RSA. It is therefore necessary to understand how the farmers have been acquiring ICT literacy in rural areas, as suggested in Xaba and Urban (2016).

ICT training is regarded as one major form of acquiring ICT literacy. The study of Atasoy (2012) identified two prominent ways to attain ICT literacy among organisation workers, namely: "on-the-job learning for ICT skills, and off-the-job ICT skill acquisition" (p. iii). The author claims that on-the-job ICT skill acquisition is to enable learner learns how to use ICT as he or she carries out a given assignment in the workplace (Atasoy, 2012). According to the general educators report (Hague & Logan, 2009), on-the-job learning is an informal training (Sieben, De Grip, Longen, & Sørensen, 2009) conducted in the workplace. This can be achieved by interacting with colleagues who might have ICT skills, to teach a beginner as he or she performs his or her daily routine job. When this happens on a regular basis, such informal training might enable the novice to acquire some measure of ICT skills on-the-job (Sumra & Katabaro, 2017).

Off-the-job ICT skills on the other hand refers to formal training received in the workplace for the work employed to do (Felstead & Unwin, 2017). This type of ICT skill training is gained through in-house training of ICT skills (Atasoy, 2012) or a sponsored training in a training centre (Choi & Jacobs, 2011). To acquire ICT skills in this case, the service of a trainer will be employed. Some of the ICT skills that users can gain are listed in Atasoy (2012)'s study. However, in this research, off-the-job training was adopted since the SHFs were drawn from different parts of uMsinga community and out of their farming activities to acquire the ICT literacy (Choi & Jacobs, 2011). In addition, the uMsinga SHFs' learning must be studied to understand how the SHFs could be influenced to learn interfacing between ICT tools with their adopted CSA practices. Likewise, fast learners among the SHFs could facilitate others to acquire the skills at group work level during the learning processes.

In addition, Atasoy (2012) also explained how ICT skills could tested to ensure acquisition. The author classified ICT skill acquisition into three categories, namely: "basic ICT skills, medium-level ICT skills, and advanced ICT skills" (p. 66). These classes were used to test the level of ICT literacy proficiency among the company employees. In this study, these categories will be adopted to test the level of ICT literacy of the uMsinga SHFs.

Other studies (Chikaire et al., 2017; Nzonzo & Mogambi, 2016; Olaniyi et al., 2013) reviewed in this study suggest ICT training for farmers in order to develop their ICT literacy. For example, Chikaire et al. (2017) suggest that Nigerian farmers should be "exposed to practical computer training for the enhancement of ICT use" (p. 104). In Kenya, a similar study that was conducted by Nzonzo and Mogambi (2016), suggested that "adequate workshops, training and awareness should be given to the farmers" (p. 295). According to Wawire et al. (2017), ICT skill plays a major impact in technology adoption because the use of ICT devices will require practical knowledge. It is apparent from the studies of Chikaire et al. (2017), Nzonzo and Mogambi (2016) and Wawire et al. (2017), that farmers' ICT literacy should be developed, but how the literacy will be developed is scarcely discussed in literature (Chikaire et al., 2017, p. 14; Nzonzo & Mogambi, 2016, p. 295). In the South African context, similar results were found in Xaba and Urban (2016) claim that farmers' ICT literacy development is lagging behind in RSA. The study by Xaba and Urban (2016) therefore provides basis for this study to develop SHFs' ICT literacy to combine ICT tools and CSA to combat the climate change menace among rural farmers in uMsinga, RSA.

2.5.3. Software design and transfer

Software design and transfer are another category of factors that could inform SHFs' interfacing of ICT with their agricultural practices. Software design is regarded as 'software development' (Buchan, Bano, Zowghi, MacDonell, & Shinde, 2017) or information system development (Lu, Liu, & Shang, 2015), with various elements embedded within it. Information system development is defined by Lu et al. (2015) as the "stage from the user demand analysis to the stage before the system's online implementing" (p. 375). In this study, software design is a process of developing a set of computer algorithms to solve a particular task. In developing a software application, the users' involvement is crucial (Lin & Shao, 2000). This is because it reduces the uncertainty that might arise during software implementation (Begier, 2013) among potential users. The users' involvement should be at all stages of development for "purpose of innovation" (Sada and Wadeisa (2016, p. 1).

A number of studies (Damodaran, 1996; Hope & Amdahl, 2011; Kujala, Kauppinen, Lehtola, & Kojo, 2005) have shown that software developers rarely involve users in their designs. The developer believes in design and transfer to users without their involvement. For example, Damodaran (1996) claims that users are scarcely involved in software design process. He opines that users' interest should determine how software should be developed in order to lead them to acceptance and use of the software. Also, users should be placed centrally in system designs and not have designs imposed on them (ibid). According to Kujala et al. (2005), users are sparingly involved in many designs, which lead to unsuccessful implementation. This was because software developers felt they are expert in design and users are novices that make a meaningless contribution to the software development (Hope & Amdahl, 2011). Thus a number of studies (Churi et al., 2013; Lu & Swatman, 2008; Rugege & Vermeulen, 2017) have shown that farmers are scarcely involved in the design of applications. The software are only transferred to them for implementation (Ismail, 2016; Newman, Lynch, & Plummer, 2000). Thus, users' view on their involvement in software design should be investigated, as suggested in Sada and Wadeisa (2016).

2.5.3.1. Benefits of users' participation in software designs

A good numbers of studies (Bano & Zowghi, 2013a; Buchan et al., 2017) have shown that the active involvement of users in software development yields positive results. For example, Bano and Zowghi (2013a) found that user involvement positively impacts on system success. Likewise, Buchan et al. (2017) study argues that users' involvement promotes successful system design. This means that the users' acceptance and utilisation were influenced by their involvement, in-depth understanding of how the software works and of how it addresses their daily tasks. The participation of users in software brings huge benefits (Bano, 2015; Chammas, Quaresma, & Mont'Alvão, 2015), like: improved quality of system design (Damodaran, 1996; Hunton & Beeler, 1997); avoidance of high cost of system features which are unwanted by user or useless to them (Chammas et al., 2015; Damodaran, 1996); improved levels of user acceptance and satisfaction of the system (Bano, Zowghi, & da Rimini, 2017; Damodaran, 1996; Procaccino & Verner, 2009); greater user understanding of software utilisation (Damodaran, 1996) and improved effective communication among users (Korkala, Pikkarainen, & Conboy, 2009). Knowledge of these benefits informed the collaboration with SHFs in this study, in examining some functionalities needed to be added to the design of the proposed ICT-based agro-weather tool for RSA rural farmers. For example, Anjum (2015) suggested the inclusion of some functionalities like speech technology to disseminate information in the local language and graphic user interface on ICT-based agro-information applications.

In the RSA context, Senyolo et al. (2017) argue that the "failure to involve end-users (farmers) during the developmental stage of design could lead to rejection of a system" like CSA technologies and software (p. 8). The authors hence suggested bottom-up approaches to CSA development in South Africa. The bottom up approach implies that the users form the foundation for system development (ibid). Though Senyolo et al.'s study was not connected directly to issues of software design, but it can be adapted in this study for both users' involvement in design of CSA as well as in developing a web-based weather-related tool for farmers.

2.5.3.2. Factors informing the adoption of designed software

There are factors that appear to inform users' adoption of software. Designed software, like web-based applications, has been deployed and used in areas such as teaching basic programming concepts (Yurcik, Vila, & Brumbaugh, 2000), robotic simulation and agro-weather information dissemination (Churi et al., 2013; Ismail, 2016). For example, in Rwanda, a web-based application was used for agro-climatic information to enable food producers to take decisions on matters relating to climate variability information (Rugege & Vermeulen, 2017). According to Rugege and Vermeulen (2017), the findings reveal that the web-based application was deployed to the farmers, but excluded rural farmers. The reason(s) for excluding the rural farmers is unclear in the study. Similarly, in Kenya, Wawire et al. (2017) study reveals that farmers' access to a market platform called "Kenya Agricultural Commodity Exchange (KACE)" influenced the SHFs to use the ICT facility (p. 128). This application enables the SHFs to sell their farm products. Wawire et al. found that owning ICT devices influence the farmers' adaption of the ICT-based market platform. The study also reveals that farmers belonging to an association group in farming communities acquired knowledge better than others who failed to belong to any society (ibid). This shows how relevant farmers' associations are in influencing use of the system for dissemination of market information in the group. In a similar study, 'Digital Mandi' is used by farmers to access market pricing in India (Saravanan & Bhattacharjee, 2014).

Similarly, Ismail (2016) conducted a study to explore farmers adoption of a mobile-based decision support system (DSS) to access agricultural information in a rural area of Bangladesh. The mobile-based DSS was developed and deployed to perform "Agro Advisory Services, Farm Decision Making application, and E-Administrative application (Field Challenges Reporting)" (p. 25). The author found that factors like individual characteristics, social influence and demographic factors influence the farmers' adoption of ICT (ibid). However, the study is uncertain on actions taken to develop the farmers' ICT skills to use the software as well as the participants' involvement in the design. Also, the study is silent on the ICT literacy with which the farmers engaged the application; whether the farmers possess the required ICT literacy to apply the system is not discussed in the study.

A similar study related to decision support systems (DSS), developed and implemented by Churi et al. (2013) to help SHFs in Tanzania to reduce climate-related risks and increase crop productivity. The web-based application design allows diverse categories of users like

SHFs with low levels of education, who are novices to ICT technologies, and extension officers to use the system. According to the authors, the DSS permits the rural farmers to access the system through mobile phones. This was due to the lack of ICT infrastructure and lack of electricity power, among other reasons, which hindered the use of other ICT devices. The authors involved the farmers at all stage of the design. The study shows that users were able to operate the system by sending text messages that in turn forward their request to a meteorological service agency, to obtain seasonal climatic forecast information (Churi et al., 2013). The study found that use of the web-based application requires adequate knowledge in both agricultural practice and ICT literacy, though, in reality, the farmers were deficient in ICT literacy and as such found the system difficult to use (ibid). It is evident in this study that SHFs' ICT literacy development is required prior to the designing of any web-based application. This is because the knowledge gained during literacy development will aid the SHFs' contribution towards the design. This provided support for the development of ICT literacy for my participants' prior design of the proposed web-based weather tool for uMsinga SHFs.

There are other factors that guarantee successful software development and acceptance for use (Bano & Zowghi, 2013a). User willingness, perceived usefulness, perceived ease of use, social influence (Islam & Grönlund, 2011a; Ismail, 2016; Mahmood, Burn, Gemoets, & Jacquez, 2000), effort expectancy, performance expectancy, facilitating conditions (Venkatesh, Morris, Davis, & Davis, 2003a), hedonic motivation, price values and habit (Venkatesh et al., 2012), among others, were found to be influencing user acceptance and possible involvement in software design. According to Mahmood et al. (2000), perceived usefulness, user experience, organizational support and user attitude toward IS were found to be highly related to user involvement in systems development. In addition, Buchan et al. (2017) claim that factors like developer and users' representative perception, impact the level or degree of users' involvement or participation in the development of system. However, there is little research, in the South Africa context, that examines SHFs using web-based applications to adapt to climate variability. This might be connected to claims by Ziervogel et al. (2014), that "South Africa lacks a robust national system that provides spatially extensive climate data" (p. 612). This study plans to fill this gap by establishing what informs SHFs' use of weather app in South Africa.

2.5.4. ICT infrastructure and awareness

ICT infrastructure is another factor regarded as indispensable to achieving sustainable agricultural productivity among rural smallholder farming communities. A number of studies (Angello, 2015; Freeman & Mubichi, 2017) have shown mobile phone, radio and television as ICT infrastructures readily available for farmers' use today. However, infrastructure like ICT facilities, electricity power and others were found to inhibiting user adoption of ICT in Tanzania (Churi et al., 2013). In addition, Angello (2015) found that the majority of livestock farmers in Tanzania used mobile phones while very few of them use radio and television. The author further reveals that negligible number of the farmers uses the Internet to disseminate agricultural information. Likewise in Thailand, Arunrat et al. (2017) claim that farmers have access to ICT facilities like social media, cell phones, Internet and other technology to enhance agro-climatic information dissemination within their social networks. The authors claim that some of the farmers use "social media to share their experience and pose questions within their group" (p. 12). Ismail (2016) claims that, the availability of mobile phone and the Internet have the propensity to influence Bangladeshi farmers to use web-based agro-climatic application. A similar study by Freeman and Mubichi (2017) found that mobile phones serve as sources for generating agriculture information among Mozambique farmers. However, most of the SHFs used mobile phone for personal communications for phone calls, texts messaging and taking photos.

In South Africa, Tembo (2008) study reveals that farmers use ICT to promote agricultural products. In addition, Tembo (2008) found farmers selling their commodities at the international market by using ICT more than those whose market is locally based. This implies that more commercial farmers in South Africa use ICT than local farmers. Similarly, Ubisi et al. (2017) reveal that few SHFs have access to the Internet (social networks). However, there is limited study in South Africa of SHFs deploying ICT into farming practices to adjust to the effects of climate change in SA. Most research has centred around farmers' use of ICT for social purposes and marketing of farm products (Tembo, 2008; Ubisi et al., 2017). Thus, this research seeks to explore how SHFs use ICT to mitigate climate change.

2.5.5. ICT policy plans for climate change adaptation in rural locations

The formulation and enactment of ICT policy are crucial ingredients for climate change adaptation. When these happen, the policy further strengthen diffusion of ICT (Kifle, Mbarika,

& Tan, 2007) for sustainability and livelihood of most rural dwellers in developing countries where impacts of climate change have been intense and resulted into severe poverty (Ospina & Heeks, 2011). Ospina and Heeks (2011) argue that the formulation of policy could be at national, regional or local level to enhance climate change adaption. On this premise, Wawire et al. (2017) suggest that the Kenyan government should formulate a national policy to guide the conduct of SHFs' ICT development by supporting any ICT projects in the country. This is because a well formulated ICT policy will improve ICT quality, efficiency, security, legality and ethics of a nation (Alinaghian, Rahman, & Ibrahim, 2011). Similarly, the regulatory policies and governance of Tanzania have brought about ICT development in area of mobile telephony (van Gorp & Maitland, 2009) which transform phone utilisation among the populace. Further, in the Bangladesh National ICT Policy 2009, Sarker and Hasan (2011) report that the policy document aims to "enhance the creation and adoption of environment-friendly green technologies, ensure safe disposal of toxic wastes, minimise disaster response times and enable effective climate change management programmes through the use of ICTs" (p. 22). This policy document creates an enabling environment for ICT to thrive in Bangladesh. The document also makes it clear that electronic documents should be used in place of hard copy documents to reduce the impacts of climate change (Sarker & Hasan, 2011). Likewise in Rwanda, the E-soko (a web based platform that permits SMS) initiative, has aided the widespread of ICT use among farming communities (Vrakas, 2012).

In South Africa, ICT policy plan has also been formulated to guide the use of ICT. According to Smith, van der Besselaar, and Avgerou (2008), the majority of ICT policies have addressed challenges like the low level of literacy, lack of ICT awareness and unsuitability of policy initially formulated for rural dwellers, but which is yet unimplemented. Furthermore, a study on interconnection between human development and ICT policy by Brown and Brown (2008) found that South African ICT policy lacks a strong emphasis on human development. This means that the document does not clearly address issue of ICT literacy development which may power challenge. Chisango and Lesame (2014) concur that South African ICT policy makers need to reconstruct current policy documents to accommodate the rural poor.

One of the objectives of the National ICT Policy White Paper (Republic of South Africa, 2016) is that the government of RSA is "committed to the effective allocation, assignment and management of the spectrum resource in order to promote broadband coverage in rural areas and underserviced areas" (p. 82). This objective is to promote wide spread of ICT facilities in the Republic. However, the White Paper clearly states that users' access to ICT infrastructure without the required literacy to use any ICT facilities in the rural communities "will not address the digital divide" that exist between the poor and rich in South Africa (Republic of South Africa, 2016, p. 36). The White Paper further states explicitly that literacy to use ICT is now a major challenge in rural areas of RSA. This, hence, underpins the need for ICT literacy development to be incorporated into any ICT project for the rural dwellers to overcome the inability to use ICT facilities. However, guidelines for the conduct of rural dwellers' ICT literacy development are lacking in this document. In addition, the White Paper revealed that "government will develop a "list" of the basic skills that citizens need to participate in the digital society" (p. 125). Up till now, the list is yet to be developed. This further provides rationale for the conduct of this study. Thus, this research provides guidelines for policy makers to develop policies that should guide the conduct of ICT literacy development among rural dwellers, with particular focus on uMsinga.

2.6. Summary of reviewed studies

The concern of this chapter was to study the existing body of knowledge on adaptation to climate change and to use the understanding to gain insight into what could be done better to mitigate the impacts of climate change. The chapter adopted the literature review model of Creswell (2003, 2008) with six sections.

The review showed that concerted efforts had been made to reduce the impact of climate change among SHFs (Taneja et al., 2014). Climate smart agriculture (CSA) was proven and recommended as a sure way to reduce impacts of climate change studies (FAO, 2010; Sullivan et al., 2012). The review covered 14 countries from Asia, Africa and America that practised CSA. The review identified 35 CSA practices; 18 are practised amongst South African farmers. However, there are few studies conducted to have identified the CSA practices in uMsinga therefore, this study planned to fill this gap. In addition, despite the CSA practices all over the world, the review indicated that CSA alone is inadequate to help SHFs solve the problem of climate change because of the complexity of the environment (Sullivan et al., 2012, p. 1). Therefore, ICT was deployed based on its potential role for "mitigation, monitoring, adaptation and strategy" (ITU, 2008, p. 2; Ospina & Heeks, 2010, p. 4). The review showed that, despite these roles played, the deployment of ICT alone is unlikely to help SHFs mitigate the impacts of climate change for food production (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36).

Based on these findings in the review, this study proposed the intersection between CSA and ICT to understand its possibility for helping SHFs reduce climate change menace.

Nevertheless, it was significant to note in the studies reviewed that the majority of the SHFs in developing countries like Nigeria, Kenya, Tanzania and South Africa, among others lack ICT literacy (Angello, 2015; Chikaire et al., 2017; Chisango & Lesame, 2014; Hlatshwayo, 2017b; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016). On this note, a study suggests ICT literacy training for the SHFs (Xaba & Urban, 2016). However, this review found that there is a paucity of literature on SHFs' ICT literacy training. This study therefore, proposed to fill this gap.

The review found that ICT software has been designed for agricultural purposes, like the Kenya Agricultural Commodity Exchange (KACE) (Wawire et al., 2017), in Rwanda, the E-soko (a web based platform that permit SMS) (Vrakas, 2012) and in India, 'Digital Mandi' (Saravanan & Bhattacharjee, 2014), which influences farmers to access market where they sell their farm produce. In the studies reviewed in this study, a classification of factors influencing the adoption of ICT among users includes seven categories, namely: effort expectancy, performance expectancy, facilitating conditions hedonic motivation, price values and habit (Buchan et al., 2017; Islam & Grönlund, 2011a; Ismail, 2016; Mahmood et al., 2000; Venkatesh, Morris, Davis, & Davis, 2003b; Venkatesh et al., 2012). This study has aimed to identify what factors influence uMsinga SHFs to adopt ICT into their agricultural practices in the face of climate change.

The review found that most software designed was transferred from laboratory to users because the designer felt they are expert but regarded users as novices who could offer a meaningless contribution to software development (Hope & Amdahl, 2011). The review found that policy can strengthen the diffusion of ICT (Kifle et al., 2007). It was found in the reviewed literature that some countries like Rwanda (Vrakas, 2012), Tanzania (van Gorp & Maitland, 2009) and Bangladesh (Sarker & Hasan, 2011) have ICT policy influencing ICT adaption to climate change among the rural dwellers, while other countries in Africa, like Kenya (Wawire et al., 2017) and South Africa (Chisango & Lesame, 2014) are still formulating ICT policy to drive ICT adaptation to mitigate climate change in rural areas. This study promises to provide insight to South Africa policy makers on how to conduct ICT literacy development among rural dwellers.

CHAPTER 3

ANALYTICAL & THEORETICAL FRAMEWORKS

The preceding chapters have provided the background needed to undertake this study. The first chapter presented the contextual background to the problem that this study addresses. The reviewed literature in Chapter 2 also provided the rationale for the empirical study to explore the intersection between information and communication technology (ICT) and climate smart agriculture (CSA) in enhancing uMsinga smallholder farmers' adaptation to the adverse effects of climate change. For new knowledge to be created through this exploration, there is a need for the study to be guided by theoretical frameworks (Osanloo & Grant, 2016). This is because theoretical frameworks provide the needed structure and support for the entire study (Osanloo & Grant, 2016; Tamene, 2016) and make this research credible (Adom et al., 2018). More essentially, the frameworks serve as strong bases for the methods and analysis (Osanloo & Grant, 2016). The concern in this study is to present the evolution of the frameworks used to understand and describe both data and findings of this research. The frameworks used are in threefold, namely:

- Adoption/adaptation strategic tools (AST)
- Community based participatory action research
- Living theory.

To address this concern, this chapter is divided in to four sections, namely:

- Section 3.1 will explain the adoption/adaptation strategic tools (AST)
- Section 3.2 will present community based participatory action research as the data generating framework
- Section 3.3 explains the use of living theory to facilitate CBPAR
- Section 3.4 provides the summary of the frameworks used for this study.

3.1 First adoption/adaptation strategic tools (AST)

The adoption or adaptation strategic tools are regarded as the models used to explain the data generated in this study. In this regard, the section sought to search for theories that explain the complexity behind the SHFs' adaptive behaviour toward the intersecting ICT and CSA practices, in responding to impacts of climate change. There are two perspectives to the AST in this section. The first AST are the theories and models that predict and explain farmers' technology adoption behaviour, and the second AST are the theories that describe the SHFs' adaptive behaviour. The detail of the first AST is discussed below.

3.1.1 The first adaptation strategic tools

This subsection discussed the emergence of the first adaptation strategic tools (AST) used to explain SHFs' acceptance and rejection of ICT devices. This first AST is regarded as information and communication technology adoption related theories. Empirical studies have shown that there are evolving theories that explain users' behaviour to the adoption of technology (Islam & Grönlund, 2011b; Venkatesh et al., 2012). Out of all these models and theories, eight are considered in this study. These theories include: the theory of reasoned action (TRA), theory of planned behaviour (TPB), technology acceptance model (TAM), TAM2, TAM3, rural technology acceptance model (RUTAM), unified theory of acceptance utilisation of technology (UTAUT) and unified theory of acceptance utilisation of technology two (UTAUT2). These theories attempt to predict, explain and categorise various factors influencing users' technology adoption behaviour. The detailed explanation of these eight theories is discussed below to show how the theory adopted in this study evolved.

3.1.1.1 The theory of reasoned action (TRA)

The first to be considered among these theories is the theory of reasoned action (TRA) (Fisbein & Ajzen, 1975). The TRA describes users' behaviour from a social psychology point of view (Venkatesh et al., 2003b). This is shown in Figure 3.1. The theory posits that behavioural intentions are precursors to individual behaviours in using a system (Fishbein & Ajzen, 1975). TRA explains the intention that an individual has to use a technology. The theory has been used extensively in areas like information systems (IS) (Mishra, Akman, & Mishra, 2014) to explain user intentions. However, Ajzen (2002) argued that the TRA is limited by users' complete volitional control. Situating this in this study, it means that the SHFs may be restricted in the choice of utilising ICT devices, as found in the study of Davis, Bagozzi, and Warshaw (1989). It, therefore, appears that reliance on the TRA may limit the free volition of SHFs in this study to make the choices advocated by the participatory worldview (Jones & Garforth, 1997). Therefore, the use of TRA to guide SHFs' ICT utilisation in this study may be unsuccessful or inadequate.

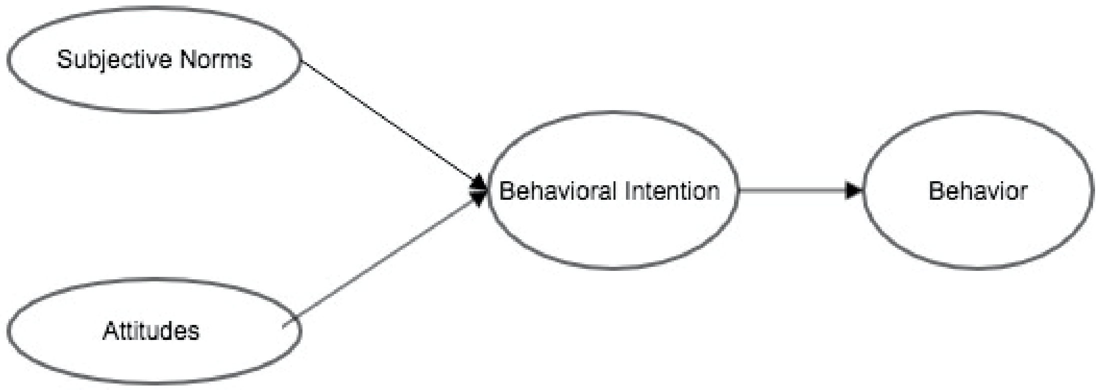


Figure 3. 1: Theory of reasoned action

(Fisbein & Ajzen, 1975)

3.1.1.2 The theory of planned behaviour (TPB)

The theory of planned behaviour (TPB) asserts that attitudes concerning behaviour, subjective norms, and perceived behavioural control collectively inform an individual's behavioural intentions and behaviours (Ajzen, 1991) as shown in Figure 3.2. The TPB extends TRA by adding control beliefs[2] to deal with problem of limited volitional control found to be a challenge in TRA (Ajzen, 2002, p. 665). The control beliefs could be regarded as "perceived behavioural control" (PBC) (ibid). This PBC is the "perceived ease or difficulties of performing the behaviour" (Ajzen, 1991, p. 188). PBC determines how easy or difficult it is to use a system to perform a task. In other words, PBC refers to the degree to which accessible resources, skills, chances and the user's beliefs are perceived as likely to achieve the desired outputs. PBC is therefore used to theorise behavioural intention and actual behaviour toward use of technology (Venkatesh et al., 2003b, p. 429). The addition of PBC to TRA produced TPB. TPB addresses the attitudes, norms and perceived behavioural control that could directly influence individuals' intention to use technology.

Recent studies have shown that the TPB has been used in areas like health (Ifinedo, 2018; Siegel, Dors, Brants, Schuy, & Rau, 2018), information system (IS) (Jaafar, Ramayah, & Teng, 2018), risk management and climate change (Okaka & Odhiambo, 2018) as well as agriculture (Akhtar et al., 2018; Silva, Canavari, & Wander, 2018). However, TPB has been

[2] Control beliefs is defined as an individual's beliefs about the presence of factors that may facilitate or hinder performance of the behaviour (Ajzen, 2015).

criticised on the grounds that intention to use a system is not limited to the three constructs of the theory (Ajzen, 1991). This means that other factors unspecified as constructs of TPB might also influence users' behavioural intentions. This, in turn, predicts the acceptance of ICT tools (Davis, 1989). Similarly, the study of Bernardi, Mynarska, and Cavalli (2010) argues that the constructs in TPB cannot be measured. Likewise, TPB fails to account for other factors such as past experience (Boston University School of Public Health (BUSPH), 2018, August 29), pleasure, ICT literacy, etc., which may possibly inform adoption of technology by users like SHFs. Based on the limitations of TPB, this study found the theory inappropriate to understand the relationship that exists in the intersection between ICT and uMsinga SHFs' CSA practices, because some other factors outside this theory might inform the SHFs' ICT adoption.

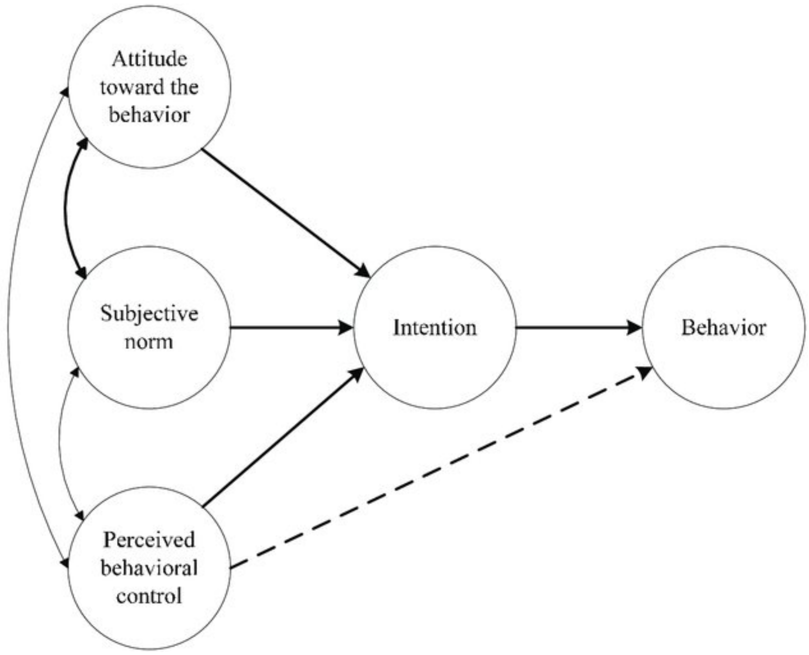


Figure 3. 2: Theory of planned behaviour

Source: (Ajzen, 1991, p. 182)

3.1.1.3 Technology acceptance model (TAM)

Technology acceptance model (TAM) is the first developed theory to specifically predict users' adoption of IS (Davis, 1989; Davis et al., 1989). This theory extends TRA and TPB by adding two other constructs, perceived ease of use (PEOU) and perceived usefulness (PU) (Davis et al., 1989). According to these authors, PEOU is the extent to which a person believes that using a system would be easy while PU is regarded as the degree to which users believe a system will help them to do their job (ibid). Similarly, Amin and Li (2014, p. 125) claim that

TAM is developed to account for the impact of external variables on internal beliefs, attitudes, and intentions. This appears to resolve some of the limitations found in TPB.

TAM has been used by many scholars to predict user behaviour intention and behaviour to adopt IS (Baptista & Oliveira, 2015; Hanafizadeh, Keating, & Khedmatgozar, 2014). A number of studies in Bangladesh, China and India (Amin & Li, 2014; Jain & Dahiya, 2017) employed TAM to know farmers' adoption of technology. Recently, Sikundla, Mushunje, and Akinyemi (2018) used TAM to understand the adoption of mobile phone in marketing farm produce among South African SHFs. Thus, it can be said that TAM is robust and has gained widespread recognition (Shaikh & Karjaluoto, 2015). However, social influence, which also accounts for uptake of technology among users, was found absent in the theory (Venkatesh & Davis, 2000). The degree of social influence may have significant impact on SHFs' adoption of ICT into their practices.

Furthermore, since the application of TAM extends beyond the workplace environment into other range of services such as mobile commerce, therefore, other constructs were added to the theory to form TAM2 (Venkatesh & Davis, 2000). TAM2 was employed in studies undertaken by Wu and Pu (2014) to understand factors informing mobile network users intention to use. However, there was a further need to enhance employees' adoption and utilisation of ICT in TAM2, thereby creating opportunity for the formulation of TAM3 (Venkatesh & Bala, 2008). Similarly, the characteristics of both TAM and TAM2 were combined to form TAM3 as shown in Figure 3.3. The TAM3 was used in Wu, Weng, and Weng (2017) to understand external factors influencing users' attitudes toward use of technology. However, the complexity of the model (TAM3) limited its use (Hassani, Chroqui, Okar, Talea, & Ouiddad, 2017). Despite the number of constructs in TAM3, further relevant variables like past experience, facilitating condition, price value and ICT literacy, among others, were absent in the model. On the basis of these limitations, TAM3 may be unsuitable for this study.

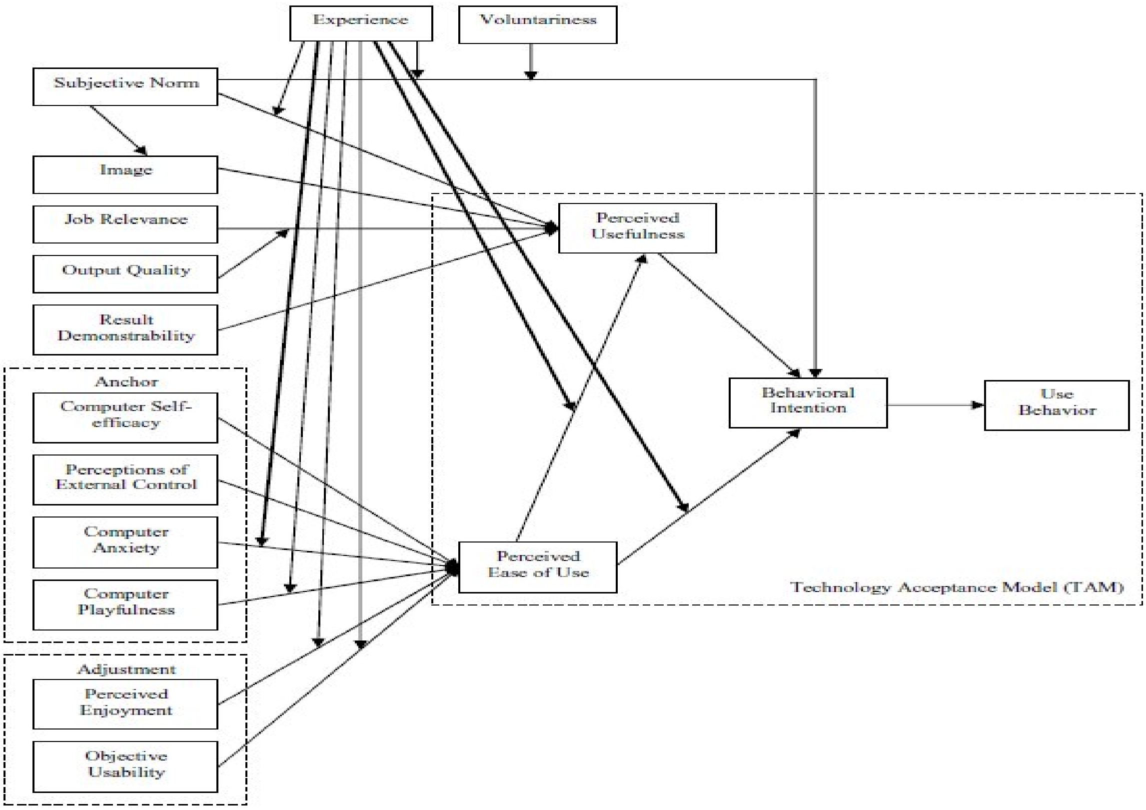


Figure 3. 3: TAM3 containing properties of both TAM and TAM2

Venkatesh and Bala (2008, p. 8)

3.1.1.4 Rural technology acceptance model (RuTAM)

The rural technology acceptance model (RuTAM) extended TAM by including external factors like facilitating condition, tech-service attribute, tech-service promotion, and individual factors (like individual characteristic, demographic, social influence (see Figure 3.4)) (Islam & Grönlund, 2011b). According to Islam (2011, p. 6), there is a limited "model that explicitly explains the technology acceptance factors" in relation to farmers in poor regions of developing countries. This means that, there is a lack of a model that directly predicts and explains farmers' acceptance and use of new technology. As such, RuTAM was developed to predict factors informing farmers' technology acceptance, such as factors influencing rural farmers' acceptance or rejection of ICT tools (ibid). However, RuTAM has only been used within the region of its origin. This means that the model is yet to be widely tested, unlike the unified theory of acceptance and use of technology (UTAUT; see below). Furthermore, relevant constructs that are likely to influence SHFs' utilisation of technology, like past experiences, perceived pleasure and ICT literacy, are absent in RuTAM. Based on these limitations, RuTAM may be unsuitable for use in this study.

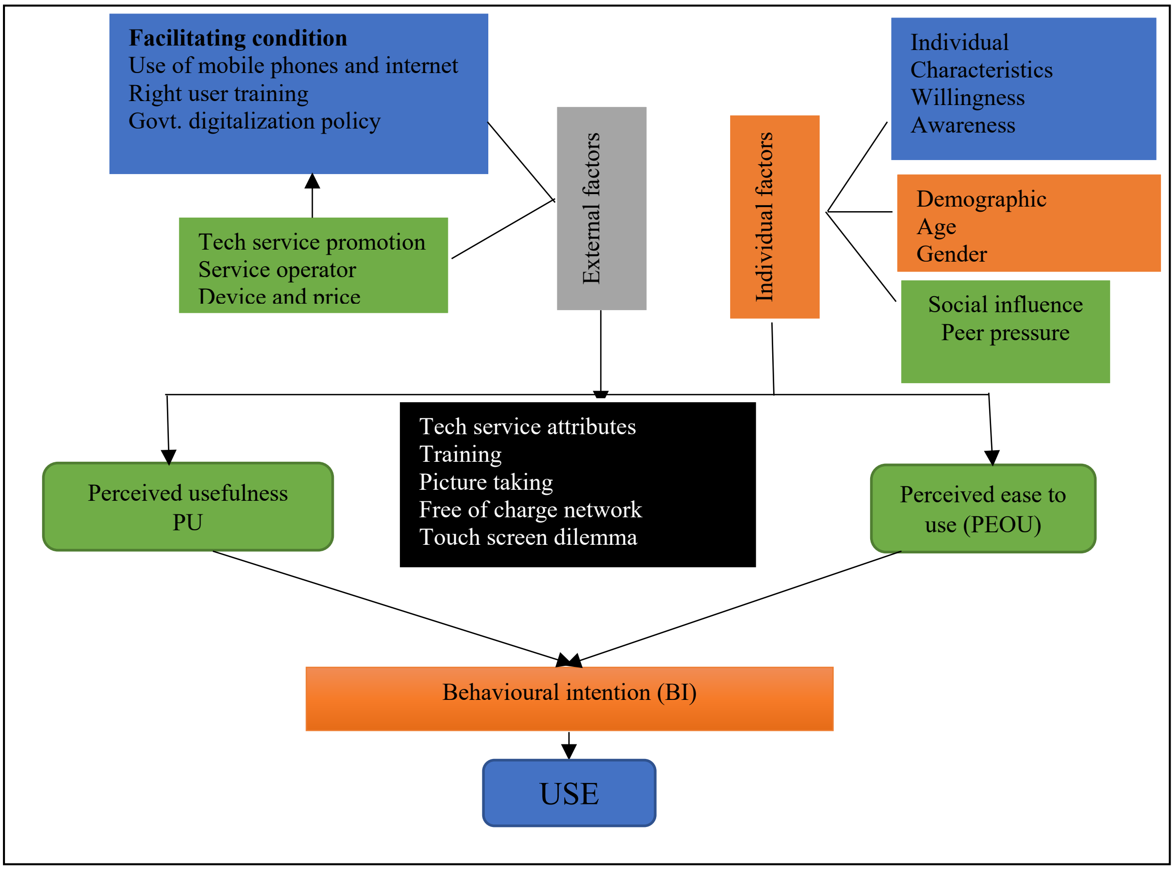


Figure 3. 4: Rural technology acceptance model RuTAM

Adapted from Islam (2011)

3.1.1.5 Unified theory of acceptance and use of technology (UTAUT)

The unified theory of acceptance and use of technology (UTAUT) is a model developed by Venkatesh et al. (2003b) to explore the intentions and behaviour regarding technology use. UTAUT draws on eight different theories and models, like the theory of reasoned action (TRA), the motivational model (MM), technology acceptance model (TAM), theory of planned behaviour (TPB), model of PC utilisation (MPCU) (Thompson, Higgins, & Howell, 1991), innovation diffusion theory (IDT) (Moore & Benbasat, 1991), and social cognitive theory (SCT) (Bandura, 1989). Having these eight different theories, which have similar and varying characteristics, combined together into a model, has given UTAUT a better chance of achieving a technology acceptance model to explain users' behavioural intentions. According to Venkatesh et al. (2003b), UTAUT has four major constructs: performance expectancy, effort expectancy, facilitating conditions and social influence as shown in Figure 3.5. These components predict and explain users' behavioural intentions and the actual behaviour of users regarding technology adoption.

UTAUT has been broadly used since its formulation in various fields like IS, health, and agriculture to explain farmers' mobile-learning in Uganda (Nampijja & Birevu, 2016). Likewise, it was used to understand the behavioural intention and actual use of technology among Ethiopia SHFs (Alemu & Negash, 2015). However, other constructs that may possibly aid behavioural intention and use behaviour were found to be absent in UTAUT (Venkatesh et al., 2012). As such, UTAUT2 extended UTAUT primarily to understand people's behavioural intentions and use behaviour in the context of technology consumption (Venkatesh et al., 2012, p. 158). UTAUT2 added three constructs to UTAUT namely: hedonic motivation, price value, and habit as shown in Figure 3.6 (Venkatesh et al., 2012). Thus, UTAUT2 consists of seven constructs, which are performance expectancy, effort expectancy, facilitating conditions, social influence, hedonic motivation, price value, and habit. The detail is discussed below.

The first construct, hedonic motivation (HM), is defined as the fun or pleasure derived from using a technology device (Venkatesh et al., 2012, p. 161). This explains the enjoyment that users derive from the use of the ICT tool. Thus, in this study, HM is regarded as the perceived enjoyment uMsinga SHFs derived from use of ICT tools like a mobile phone. Previous studies have shown that HM plays an important role in determining technology acceptance and use (Beatty, Magnusson, Fortney, Sayre, & Whooley, 2018). The authors found that HM influences the habitual use of ICT. Similarly, in a Pakistani study (Rahi, Ghani, & Ngah, 2018), it was revealed that HM had a strong positive influence on users' intention to adopt Internet banking. However, a study in Ethiopia (Beza et al., 2018) has shown that farmers were insignificantly influenced by HM to adopt mobile SMS. The authors further explained that this low relevance of HM has implications for the use of SMS amongst the farmers.

Habit, on the other hands, is defined as the extent to which people tend to perform behaviours automatically because of learning (Limayem et al., 2007). According to Venkatesh et al. (2012, p. 161), habit is a perceptual construct that reflects the results of prior experiences. In this study, habit is considered to be born out of SHFs' reflections on several outcomes of past experiences to inform their future actions on the use of ICT device. In a study conducted by Venkatesh et al. (2012), habit is found to be a significant influencing factor on users' behaviour. However, Beza et al. (2018) found that habit insignificantly informed Ethiopian SHFs' behavioural intention to adopt mobile SMS in their study. The authors further claimed that the failure of the farmers to inculcate the habit of using mobile SMS was due to their lack of previous experiences.

Price value is defined as consumers'/farmers' cognitive trade-off between the perceived benefits of the applications and the monetary costs of using the ICT facilities (Venkatesh et al., 2012, p. 161). It is to be noted that the monetary value of a product or service needs to be combined with the quality inherent in it, in order for us to know the perceived value of such service or product (Beza et al., 2018; Rahi et al., 2018; Venkatesh et al., 2012). In this study, price value (PV) means the SHFs make a cognitive trade-off between the perceived advantages of adopting mobile devices and the monetary cost of using the ICT tool. The PV variables include network serve charges, data service carrier costs, cost of device and service (Beza et al., 2018). A recent study (Rahi et al., 2018) has revealed that PV negatively informed the intention of users to adopt Internet banking in Pakistan. This finding is consistent with Oliveira, Thomas, Baptista, and Campos (2016) in Portugal. In contrast, Venkatesh et al. (2012) found PV as a predictor of behavioural intention to utilise technology. Similarly, Beza et al. (2018) found that price value positively and significantly related to the SHFs' intention to use ICT tools.

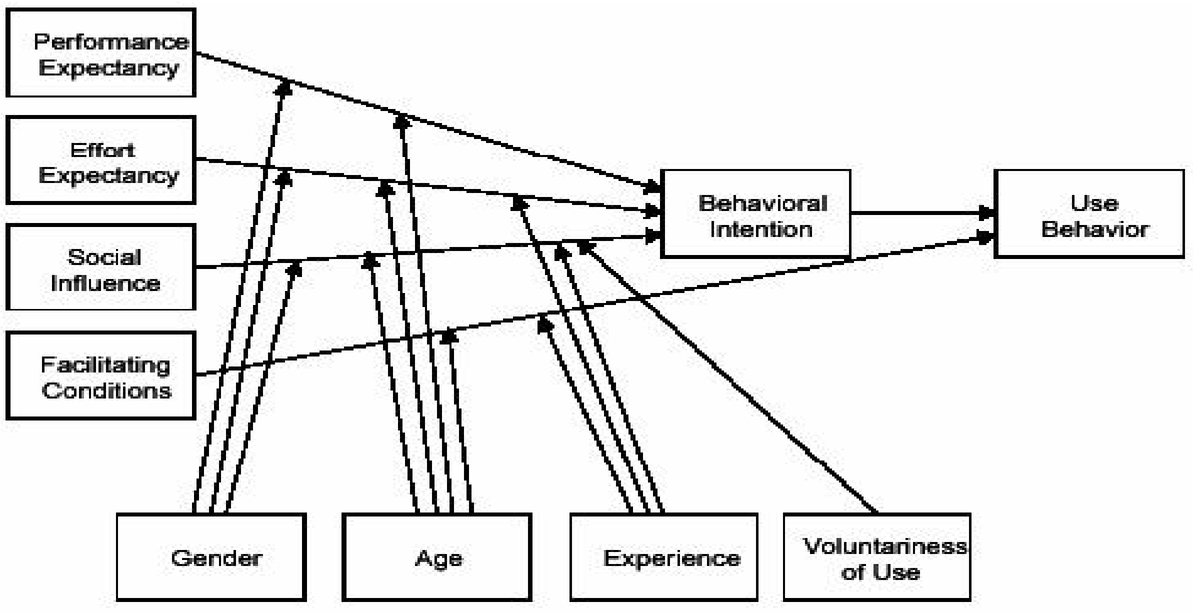
Performance expectancy (PE) is defined as the degree to which an individual believes that using an ICT device will yield benefit to activities being performed (Venkatesh et al., 2003b, p. 447). Similarly, in this study, PE is referred to as the degree to which SHF believes that accessing agricultural information using mobile devices will benefit them. It is believed that PE remains a key driving factor behind users' intention and behaviour to adopt ICT devices (Venkatesh et al., 2012). A number of studies in Pakistan, Honduras, Ethiopia and India (Beza et al., 2018; Rahi et al., 2018) have shown that PE positively and significantly informs users' intention to use ICT devices. Similarly, in Uganda, Moya and Engotoit (2018) found that PE was positively related to behavioural intentions and ICT adoption. This finding is consistent with the study of Mugerwa, Moya, and Kituyi (2018) in Uganda. Similarly, Hobololo and Mawela (2017) found that PE positively influences participants from Buffalo City Municipality in South African to adopt mobile devices.

Effort expectancy (EE) is regarded as the degree of ease associated with the use of a technology (Venkatesh et al., 2012). In previous models like TAM/TAM2, the concept of EE was referred to as perceived ease of use (Venkatesh & Bala, 2008), complexity in MPCU (Thompson et al., 1991), and ease of use in IDT (Moore & Benbasat, 1991). In this study, EE is defined as the degree with which SHFs found mobile phones easy to use. The construct, EE, has been found to positively influence behavioural intention and use of users (Venkatesh et al., 2012). More importantly, in recent research, Beza et al. (2018) finding revealed that EE positively related to the behavioural intention of SHFs. The authors claim that EE enhanced the Ethiopian SHFs' adoption of SMS into their practices (ibid). Similarly, Oliveira et al. (2016) finding showed that EE is a direct predictor of behavioural intention to accept a new technology in Portugal.

In the context of technology use, social influence (SI) is defined as the degree to which an individual perceives that important others believe he or she now should use a new system (Venkatesh et al., 2012). This construct is regarded as a direct determinant of behavioural intention in other models, like TRA and TAM2 (Venkatesh et al., 2003b, p. 451). The concept of SI is known as subjective norm in TRA, TAM2, TPB/DTPB and C-TAM-TPB (ibid). Similarly, SI is called social factors in MPCU while in IDT, it is image. In this study, SI is regarded as the degree to which SHFs perceive that associating with other important others aid their adoption of ICT tools into their CSA practices. In recent studies conducted, SI was found positively related to users' intention (Oliveira et al., 2016; Rahi et al., 2018; Venkatesh et al., 2012). In contrast, Beza et al. (2018) showed that SI is a weak predictor of SHFs' behavioural intention to accept and use SMS. This means that farmers are unlikely to use ICT simply because family members or friends used it to perform an activity (ibid).

Facilitating conditions (FCD) are defined as the degree to which an individual believes that an organisational and technical infrastructure exist to support the use of the system (Venkatesh et al., 2003b). In other words, FCD refers to individuals' perceptions of the resources and support that are available to perform a behaviour (Venkatesh et al., 2012, p. 159). FCD could be regarded as referring to the degree to which SHFs are perceived to have the knowledge to use mobile phones (Venkatesh et al., 2003b). Other models like TPB/DTPB, and C-TAM-TPB regard FCD as "perceived behavioural control" (Venkatesh et al., 2003b, p. 453). Likewise, the MPCU model maintains the name while, in the IDT model, FCD is called compatibility (ibid). In this study, FCD is regarded as degree to which SHFs perceive that ICT facilities are available to support the adoption of mobile phone in order to improve CSA practices. Previous research (Venkatesh et al., 2012) indicates that FCD was found as a predictor of users' behavioural intention and ICT adoption. Furthermore, the authors claim that FCD directly influences user behaviour, as shown in Figure 3.6 (ibid). In contrast to the study of Venkatesh et al. (2012), the findings of Beza et al. (2018) are that FCD is unlikely to inform SHFs' intention to accept mobile devices. This was because importance was not given to FCD.

Figure 3. 5: Unified theory of acceptance and use of technology (UTAUT)



Venkatesh et al. (2003b, p. 447)

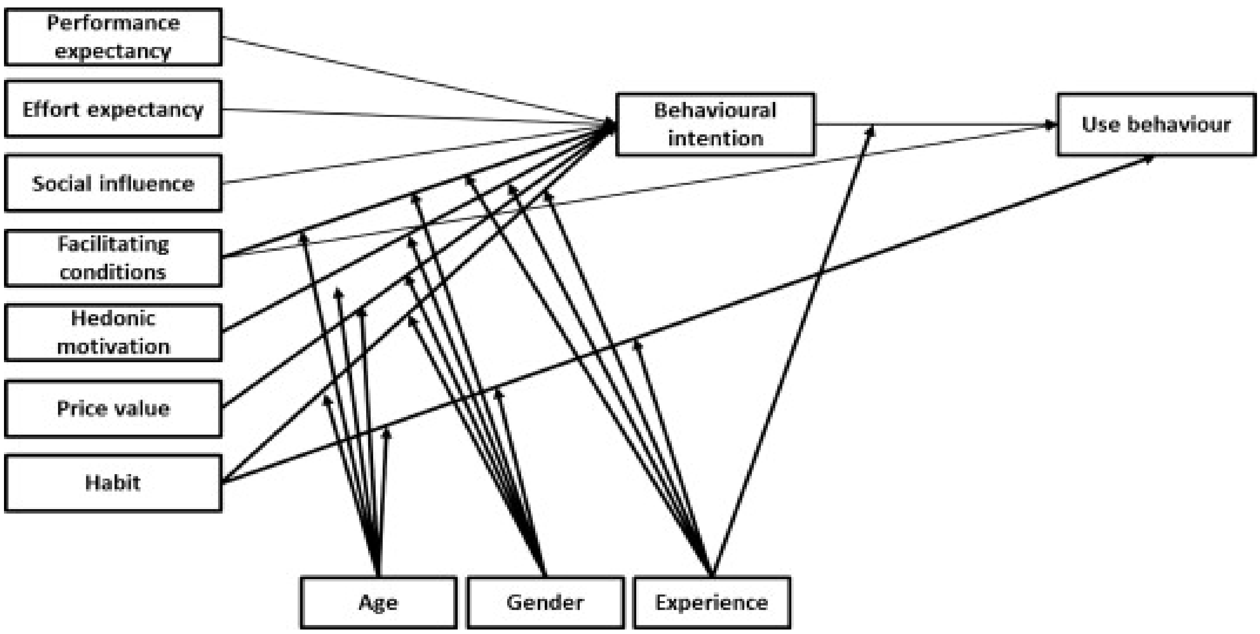


Figure 3.6: UTAUT2

Venkatesh et al. (2012, p. 160)

In this study, the constructs discussed in UTAUT2 above appeared to be appropriate to explain factors influencing uMsinga SHFs' intention to interface between ICT and their CSA practices. This is because the theory is made up of nine models and theories, namely: (TRA), the motivational model (MM), technology acceptance model (TAM), theory of planned behaviour (TPB), model of PC utilisation (MPCU) (Thompson et al., 1991), innovation diffusion theory (IDT) (Moore & Benbasat, 1991), and social cognitive theory (SCT) (Bandura, 1989) and UTAU (Venkatesh et al., 2003b). Based on this, UTAUT2 is considered suitable and robust for this study. However, this study plans to extend UTAUT2 by adding other variables in order to describe and explain the relationship in the interface between ICT and CSA. In other words, it was observed that the use of UTAUT2 constructs alone may insufficiently handle the relationship that exists between ICT and CSA. It is therefore necessary to examine other frameworks that could combine with UTAUT2 for the intersection. As such, the next subsection discusses models that describe irrigators' behavioural intention to adopt CSA.

3.1.2 The second adaptation strategic tools

This section explains the evolution of SHFs' adaptive behaviour theory used in this study. The evolution of the theory is necessary because the impact of climate change on uMsinga SHFs is huge. The theory should be able to explain categories of CSA practised by the SHFs, challenges involved and informing factors. In addition, the theory should consider some peculiarities of the participants and data to be collected in this study. For example, a previous study (Sinyolo et al., 2014) has shown that majority of the SHFs practise irrigation farming to sustain their livelihoods in the face of climate change. Likewise, Schreiner, Tapela, and van Koppen (2010) reported that South Africa is the "30th driest country in the world in terms of available water per capita" (p. 1). Furthermore, the Midlands of KwaZulu-Natal where uMsinga is situated has been declared a hot spot for climate change (Hitayezu, Zegeye, & Ortmann, 2014). Thus, the uMsinga community is faced with poverty arising from protracted periods of drought (Sinyolo et al., 2014). It is therefore necessary to explore frameworks that could explain SHFs' adaptation to climate change through CSA practice.

Three theories are considered in the evolution of this second AST in this study, namely: protection motivation theory (PMT), theory of planned behaviour (TPB) (Ajzen, 1991) and theory of irrigators' planned behaviour (TIPB) (Wheeler et al., 2013). The detail is discussed below.

3.1.2.1 Protection motivation theory (PMT)

The protection motivation theory was propounded by Rogers (1975, 1983). This theory explains factors that determine risk adaptive behaviour needed for effective risk protection communication. The theory also focuses on changes in the attitudes and behaviours of individuals (Bockarjova & Steg, 2014, p. 278). PMT extends the study of "fear appeals" (Rogers, 1975), with the intention of changing attitudes and later change behaviour. The fear appeal is an informative communication regarding threat to an individual's welfare (Milne, Sheeran, & Orbell, 2000). Thus, PMT proposed threat appraisal and coping appraisal as two approaches to determine an individual's response to adaptive behaviour (Rogers, 1975, 1983). The theory assumed that the fear stimulus has an influence on attitudes and behaviour (Milne et al., 2000). Furthermore, PMT explains factors influencing risk adaptive behaviour through constructs like: perceived severity, perceived vulnerability, perceived self-efficacy, and perceived response efficacy (Bockarjova & Steg, 2014, p. 277). The theory was originally proposed in the context of health threats and used successfully. More so, PMT was used in natural hazard contexts like flooding (Grothmann & Reusswig, 2006), and drought (Wuepper, Zilberman, & Sauer, 2016). The findings of these authors are that both perceived self-efficacy and farming skills improve the adaptive capacity of farmers (ibid). However, there is limited research on the use of PMT to predict the behaviour of irrigators to climate change adaptation. In addition, constructs like human capital, which could determine the response of SHFs to threats from climate change, is absent in PMT, as illustrated in Figure 3.7.

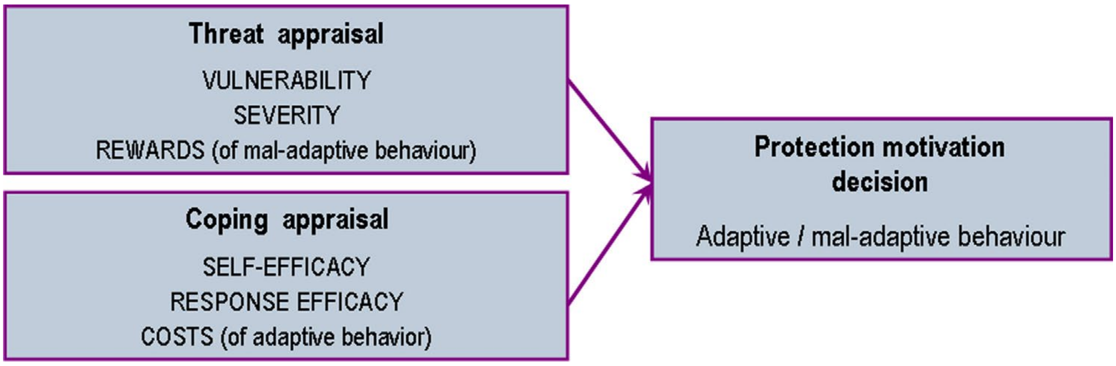


Figure 3. 6: Protection motivation theory

(Bockarjova & Steg, 2014, p. 277)

3.1.2.2 Theory of planned behaviour (TPB) in adaptation

The theory of planned behaviour (TPB) was propounded by Ajzen (1991) and used to explain individual's behaviour on environmental issues (Bockarjova & Steg, 2014). TPB was directed to focus on cost and benefits of adaptive behaviour (Bockarjova & Steg, 2014, p. 285). A number of studies have revealed that TPB has gained wider recognitions in fields like health (Ifinedo, 2018; Siegel et al., 2018), IS (Jaafar et al., 2018), climate change (Okaka & Odhiambo, 2018), and agriculture (Akhtar et al., 2018; Silva et al., 2018) among others.

A study (Arunrat et al., 2017) in Thailand has incorporated TPB into their study to assess farmers' intention to adjust to impacts of climate change. The study found that the farmers' intention to adapt was sparingly influenced by perceived behavioural control factors, attitude and subjective norms (ibid). Similarly, in Brazil, a study (Silva et al., 2018) shows that TPB was used to explain the behavioural intention to purchase farm produce. Furthermore, TPB has been combined with other models to explain the response of individuals to climate change threats. For example, Akhtar et al. (2018) combined the health belief model (HBM) and TPB to explain the adaptive response of rice farmers in Malaysia to climate change. Similarly, Fielding, Terry, Masser, and Hogg (2008) interfaced social identity theory (SIT) and TPB to understand factors influencing sustainable agricultural practices in Australia. However, TPB is limited by external factors that could influence SHFs to adapt to climate change. As such, a study by Wheeler et al. (2013) extended TPB to formulate a theory of irrigators' planned behaviour (TIPB) which explained Australian irrigation farmers' response to climate variability issues.

3.1.2.3 Theory of irrigators' planned behaviour (TIPB)

The theory of irrigators' planned behaviour (TIPB) extended TPB to account for constructs like human, farm, social, financial and physical capital (Wheeler et al., 2013). TIPB focuses on irrigators' adaptation to climate change. Likewise, the theory assumes that farmers' beliefs about climate change informed their adaptation strategies (Bockarjova & Steg, 2014; Wheeler et al., 2013). As mentioned in Chapter Two, these adaption strategies include agricultural practices like irrigation, multiple crops planting and others that SHFs could engage in to reduce the climate change threat. The theory therefore posited that the capacity for irrigators to cope with, and adapt to, climate change was informed by various variables in the model (Wheeler et al., 2013, p. 546). Thus, TIPB consists of constructs like physical capital, financial capital, regional capital, natural capital, human capital and social capital. According to Barrera-Mosquera, De los Rios-Carmenado, Cruz-Collaguazo, and Coronel-Becerra (2010), these five constructs determine the foundation of sustainably livelihood among rural inhabitants. More so, the variables depend on each other to function (ibid). The details of these constructs are discussed below.

Physical capital is regarded as a variable that includes the size and type of farm, land composition, the technology used, and the size of water entitlement and usage (Wheeler et al., 2013, p. 542). This definition is similar to other scholars who referred to physical capital as "the basic infrastructure (transport, shelter, water, energy, communications) and the production equipment which people need to pursue their livelihoods" (Rakodi, 2014, p. 11). Likewise, Vasco, Bilsborrow, Torres, and Griess (2018) regard PC to be irrigation canals, agricultural machinery and implements, as well as roads. Similarly, Donkor, Onakuse, Bogue, and De los Rios-Carmenado (2018) claim that owing facilities like a mobile phone, a radio set, a television (TV) set, a vehicle, a motorbike and access to electricity are regarded as physical capital (p. 4). Based on these definitions, this study regarded physical capital as including components like irrigation materials and ICT devices (such as TV, radio, mobile phone). These components were used in studies by Donkor et al. (2018) and Vasco et al. (2018) as forms of physical capital. Studies show that farmers expect that climate change may possibly alter their plans to change from existing agricultural strategies to adopt more efficient ones like irrigation infrastructure (Wheeler et al., 2013), and ICT devices (Donkor et al., 2018). Likewise, Wheeler et al. (2013) found that factors of physical capital significantly informed farmers' adjustment to climate change. Similarly, Dassanayake, Mohapatra, Luckert, and Adamowicz (2018) found significant impact of physical capital on the adoption of livestock in South Africa.

Financial capital (FC) is regarded as variables that included productivity change, net farm operating surplus, farm debt and equity as well as off-farm work (Wheeler et al., 2013, p. 542). The financial resources available to people include savings, credit, remittances and pension, which provide various means of livelihoods for the participants (Rakodi, 2014, p. 11). According to Donkor et al. (2018), financial capital is referred to as the state to which a farmer has access to credit as well off-farm activities. Thus, in this study, FC variables are regarded as marketing opportunities, donations of farm inputs, and access to credits.

A number of studies in Australia and Zimbabwe (Mutumhe, 2016; Wheeler et al., 2013) have shown that FC informs farmers' adaptation. For example, the study by Mutumhe (2016) shows that variables of FC like "credit access, household financial savings and income levels" significantly informed SHFs' adaptive strategies. Likewise, findings by Chukwuemeka, Kingsley, and Ume (2018) are that Nigerian farmers are constrained by limited access to loan and farm credit and, as a result, their adaptive capacity is reduced. Additionally, in Ghana, Sumani (2018) found that "lack of agro-inputs, loan inaccessibility, weed infestation, crop pests and diseases, and poverty or lack of capital to buy chemical fertilizers, pesticides, weedicides, and other agro-inputs" limited the SHFs' adaptive capacity (p. 195). Likewise, in Mozambique, Tanzania and Zimbabwe, a study by van Rooyen, Ramshaw, Moyo, Stirzaker, and Bjornlund

(2017) suggests that financial institutions should grant farmers access to credit to purchase farm inputs.

In the South African context, Luvhengo and Lekunze (2017) findings showed that SHFs in Taung municipality, North West Province who had access to credit are those that had either primary (20%) or higher (80%) education background, whilst the majority, who are uneducated, lack access to formal credit. This indicated the relevance of financial capital as a construct to be considered in this study.

Natural capital (NC) variables include rainfall and evaporation, regional location, and the closing water seasonal allocation (Wheeler et al., 2013, p. 542). NC is regarded as natural resource stocks from which livelihoods are derived, like land, water and other environmental resources (Monwar et al., 2018; Rakodi, 2014; Vasco et al., 2018). In addition, Chen, Gao, Swisher, House, and Zhao (2018) claimed that NC variables included "soil fertility, oxygen, rainfall/groundwater, and pollination" (p. 201). Based on these definitions, this study regards NC as variables that include rainfall, water availability and other environmental factors like temperature, soil pests and diseases, among others. A previous study in Australia (Wheeler et al., 2013) shows that farmers need more water for future farming activities to reduce the impact of climate threat.

Human capital (HC) is regarded as factors such as farmers' characteristics, like age, gender, education and the length of time spent in farming activities (Donkor et al., 2018; Wheeler et al., 2013, p. 542). Similar scholars consider human capital as the level of education and skills as well as health status of household members (Rakodi, 2014, p. 11). In this study, human capital refers to as age, gender, education, year of farming experience and SHFs' ICT literacy level. A study by Wheeler et al. (2013) reveals that human capital significantly informs Australian farmers' adaptation to climate change. The authors' findings show that younger farmers have a tendency to change their climate change agricultural strategies in order to adopt more efficient infrastructure based on their human capital. Similarly, a study in Taung Municipality, South Africa (Luvhengo & Lekunze, 2017) have shown that 41.81% of the SHFs lack formal education, 33.63% have primary education while 24.54% have higher education. Likewise, Ubisi et al. (2017) showed that the adaptive capacity of Limpopo SHFs was hindered by their low level of education. In this case, the majority (54.7%) of the SHFs lacked formal education.

The social capital (SC) variables are regarded as the irrigator's making of decisions regarding membership of different groups (Wheeler et al., 2013, p. 542). Similarly, SC is defined as the social resources (networks of membership of groups, relationships of trust and reciprocity, access to wider institutions of society) on which people draw in pursuit of their livelihoods (Rakodi, 2014, p. 11). Likewise, Donkor et al. (2018) refer to SC as a farmer being a member of a cooperative, access of a farmer to extension officers and location variables. Drawing from these definitions, this study thus defined SC as SHFs' membership of cooperative, access to extension officers, and links to local social networks with other farmers, within and outside groups. A previous study shows that SC is important to Australian farmers' sustainability (Wheeler et al., 2013), but the authors' findings are that SC insignificantly informed farmers' adaptation to climate threat (ibid). However, a study conducted in South Africa, (Nthabeleng, 2017) showed that SC informed farmers' adopted agricultural strategies to mitigate the impact of climate change. In contrast, Ubisi et al. (2017) findings show that only 30% of the SHFs had access to social groups.

In conclusion, all the constructs discussed above are illustrated in Figure 3.8. The constructs appeared to be relevant in understanding SHFs' adoption of CSA as climate change adaptation strategies that reduce the impacts of climate change among rural farmers. Similarly, the figure reveals that TPIB extended TPB (Ajzen, 1991). Thus, TPIB is adapted and combined with UTAUT in this study to explain factors informing SHFs' uptake of CSA and ICT and the unintended challenges that might result from the adoptions.

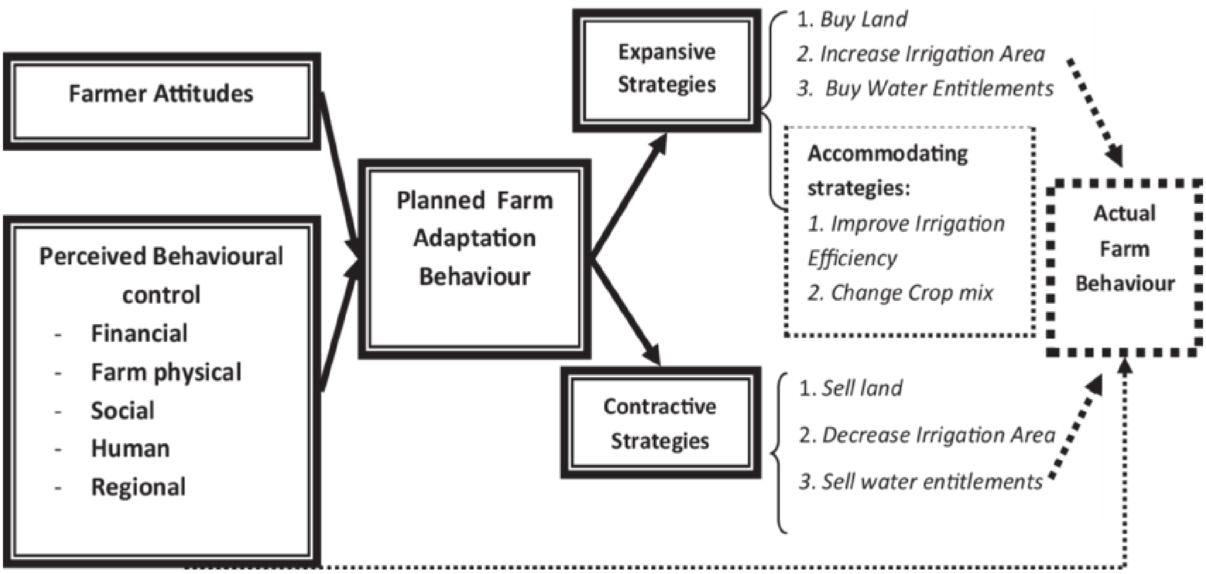


Figure 3. 7: Showing theory of planned irrigators' behaviour

(Wheeler et al., 2013, p. 540)

Though TPIB is yet to be applied beyond its original context, but based on the theory assumptions and constructs, TPIB is combined with UTAUT2 to explain uMsinga SHFs' response to the intersection between ICT and CSA. This relationship is used in building the SHFs' adaptive capacity amongst uMsinga farming community (Eakin & Lemos, 2006).

3.1.3 Intersection between UTAUT2 and TIPB

The combination of the two theories, UTAUT2 and TIPB, in this study, is to explain the nature of the relationship in the intersection between ICT and uMsinga SHFs' CSA practices. This is symbolically represented as ICTnCSA. The intention of this AST is to build the missing link of farmers' adaptive capacity (McKeown & Hopkins, 2010) in order to combat threats posed by climate change amongst the SHFs. In an attempt to search for AST for this research, UTAUT2 and TIPB were considered suitable to predict and explain factors informing the SHFs' adoption/adaptation or maladaptation to climate change. The combination of the two theories is illustrated in Figure 3.9.

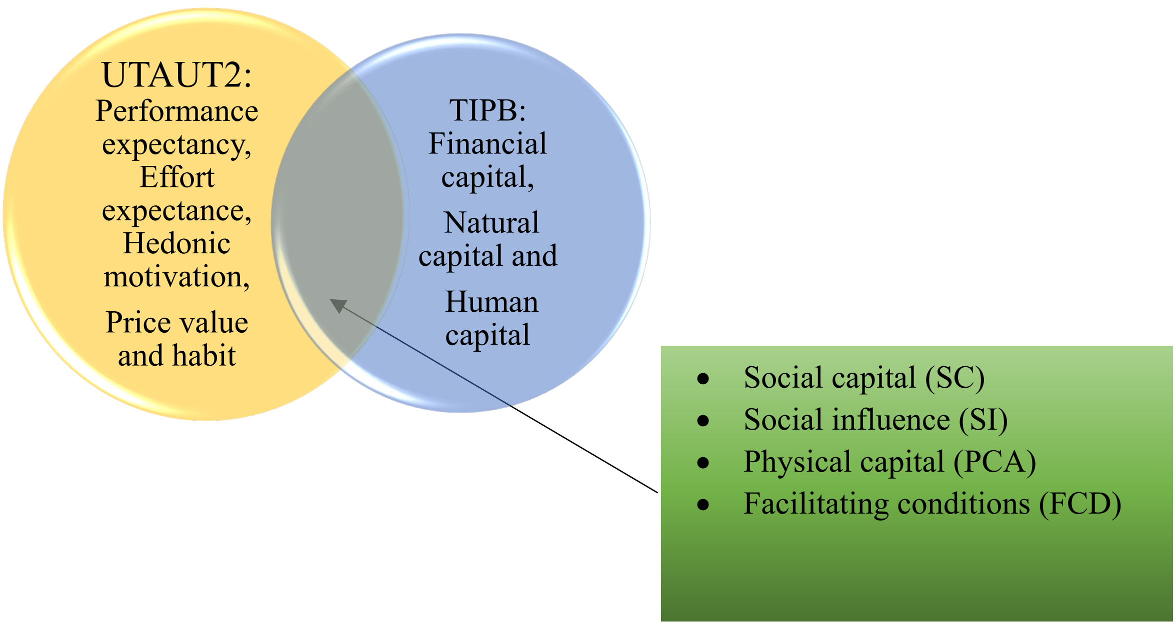


Figure 3. 8: Conceptual framework of UTAUT2 and TPIB

As shown in Figure 3.9, there are two key aspects to the relationship between UTAUT2 and TIPB constructs. These two parts consisted of convergent and divergent regions. The convergent region occurred at the point where there is intersection between UTAUT2 and TIPB with social capital in TIPB (Wheeler et al., 2013), relating to social influence in UTAUT2 (Venkatesh et al., 2012). Likewise, physical capital (PCA) in TIPB (Wheeler et al., 2013) relating to facilitating conditions in UTAUT2 (Venkatesh et al., 2012). The divergent constructs[3] include performance expectancy, effort expectance, hedonic motivation, price value and habit in UTAUT2 as well as natural, financial and human capital in TIPB. These components therefore form the main conceptual framework for this study.

3.2 Community based participatory action research (CBPAR) as framework

A theoretical framework is the foundation upon which all knowledge is built for a research study (Osanloo & Grant, 2016). It provides the anchor for the literature review, methods of data collection as well as data analysis (ibid). Community based participatory action research (CBPAR) is used as the framework guiding data gathering in this study. CBPAR is defined as a research approach that provides opportunities to democratise the creation of new knowledge, from research questions to data analysis (Burke, 2012). Similarly, Hills, Mullett, and Carroll (2007) define CBPAR as "a collaboration among community groups/practitioners, policymakers/ decision makers, and researchers to create new knowledge or understanding about a practical issue in order to bring about change" (p. 127). Based on these definitions, CBPAR was adopted as a research approach that allowed for fully collaboration with uMsinga SHFs in order to understand the nature of their practices, challenges and adaptions to climate change and to co-generate new knowledge to bring about improvement in their practices (Burns, Cooke, & Schweidler, 2011). The concept of collaboration with the SHFs emphasised the importance of working with the community members, irrespective of their educational background, as part of the research team (Burns et al., 2011).

Furthermore, CBPAR is not a research method but an approach to research (Horowitz, Robinson, & Seifer, 2009; Pain, Whitman, Milledge, & Trust, 2011). Contextually, the term research approach means a predetermined procedure or process to conduct a research. For example, Tyan (2010), in her research, refers to CBPAR as a methodological study approach. She uses the concept CBPAR to guide the methods of data collection (Tyan, 2010). CBPAR consists of five stages, namely:

[3] The divergent constructs are regarded as the factors that differ from each other in the combination between UTAUT2 and TIPB.

(i) design and implementation of intervention programme with SHFs (1st stage);
(ii) SHFs' engagement (2nd stage);
(iii) data collection (3rd stage);
(iv) data analysis (4th stage); and
(v) reporting the findings (5th stage) (Burns et al., 2011, p. 11).

In this study, SHFs' engagement is considered as the 1st stage. This entails identifying the participants of study and inviting them for collaboration with academic researcher(s) for new knowledge creation (Burns et al., 2011). As such, I located an intermediary who connected and introduced me to a group of uMsinga SHFs for this project as discussed in Chapter 4. Likewise, the design and implementation of intervention programme with SHFs are considered the 2nd stage in this study. It is regarded as the stage of planning and execution of intervention for the project. Shortly after our introduction to the community members, the purposes of the project were made known to the uMsinga SHFs. The SHFs as well as their assigned extension officer were interested in collaborating with us for the project. Thus, the entire stakeholder collectively agreed on how the intervention was done. In addition, the 3rd stage comprises of data collection. In this study, the uMsinga SHFs and other stakeholders were involved in data gathering. Data analysis, the 4th stage, entailed deliberation with the SHFs and other stakeholders on how the collected data would be analysed to generate findings. Reporting the findings (5th stage) involved the discussion of study findings with the SHFs during the community meetings at every stage. These five stages of CBPAR were used in conjunction with living theory to guide data gathering.

3.3 Living theory (LT)

Living theory (LT) is an explanation produced by an individual for their educational influence in their own learning, in the learning of others and in the learning of the social formation in which they live and work (Whitehead, 2008, p. 104; 2014, p. 3). In other words, LT is a process of producing and sharing explanations of educational influences in learning (Whitehead, 2010, p. 3). The idea of LT emerged from the question by Ilyenkov (1977) which states that, '*If an object exists as a living contradiction what must the thought (statement about the object) be that expresses it?'* (p. 205). This was explained by Whitehead that the expression of "how do I improve what I am doing? In which 'I' exists as a living contradiction"(Whitehead, 2018). This reveals the concern that this study has towards improving uMsinga SHFs' practices.

In this study, our passion is drawn towards improving uMsinga SHFs' farming practices in the face of climate change.

Living theory is used in this study to facilitate the five stages of CBPAR in this study. The theory consists of 10 action reflection cycle questions. The detail of these 10 questions is discussed in section 4.4.2.3 of Chapter 4. However, this concept of LT evolves from an action research approach that enquires how to improve what I am doing (Whitehead, 2014, p. 4). This, is thus expressed as 'How do I develop the SHFs' ICT literacy in order to improve their practice?' This question implies, 'How do I learn how to assist the SHFs to learn the use of ICT?' (McNiff & Whitehead, 2006, p. 132). To do this, I have to show how I gathered data to support the account of my new learning and the learning of the SHFs (McNiff & Whitehead, 2006, p. 137). According to McNiff and Whitehead, two dimensions are involved to gather such data, namely: first**,** I had to record the events when I did not know so well how to develop the SHFs' ICT literacy and when I began to assist them to learn the use of ICT for food production (McNiff & Whitehead, 2006, p. 167)**.** Secondly, I had to record the events when the SHFs did not know ICT literacy sufficiently well to use ICT tools and when they began to learn how to use ICT for food production (McNiff & Whitehead, 2006, p. 149).

The two dimensions mentioned above were employed in the production of evidence on the factors that enabled learning of ICT to improve CSA practice of the SHFs, and thus the creation of new knowledge. This study generated evidence in the form of 'What did I want the SHFs to do? 'How did I do it and how they did it?' 'Why did I do it in that way as well as how did they do it?' The evidence regarding these actions was generated as claims in this study. The claims were presented to critical friends for critiquing. This implies that the claims were subjected to critical judgement of others (like my supervisor) to be authenticated before they could be claimed as new knowledge or theory (McNiff & Whitehead, 2006, p. 169). Additionally, my experience with the critical judgment of others were noted to reflect what I gained out of their discussion, how I knew what I had learnt and reasons for arriving at such learning (McNiff & Whitehead, 2006, pp. 167, 169). Finally, the authenticated claims were used to produce the new knowledge about the relationship that existed in the intersection between ICT and uMsinga SHFs' CSA (ibid, pp. 149, 169). The LT action reflection cycle was used to facilitate the five stages of CBPAR, as discussed in Chapter 4.

3.4 Summary of frameworks used in this study

The aim of this chapter was to present the evolution of the frameworks used to understand and describe both data and findings of this research. The frameworks used are in threefold, namely:

- Adoption/adaptation strategic tools (AST)
- Community based participatory action research
- Living theory.

This chapter was divided into four sections, namely:

- Section 3.1 dealt with the adoption/adaptation strategic tools (AST)
- Section 3.2 presented community based participatory action research as the data generating frame
- Section 3.3 explained living theory as facilitator of CBPAR
- Section 3.4 summarised the frameworks used for this study.

The study considered eight theories identified as the most suitable to explain factors influencing SHFs' adoption of ICT into CSA, namely: the theory of reasoned action (TRA), theory of planned behaviour (TPB), technology acceptance model (TAM), TAM2, TAM3, rural technology acceptance model (RUTAM), unified theory of acceptance utilisation of technology (UTAUT) and UTAUT2. This study adopted UTAUT2 and the theory explains and describes uMsinga SHFs' intentions to interface ICT into their CSA practices. UTAUT2 was preferred, based on its robustness and wide range of use of the theory. In that the model consist of nine other models put together. However, it was significant to note that UTAUT2 alone might be inadequate to explain how uMsinga SHFs would handle the intersection between ICT and CSA. The study planned to extend the theory by fusing it with another theory because of the particular circumstances of the participants and the nature of the data collected (Creswell, 2008, p. 6). Similarly, the study revealed the evolution of TIPB out of the two other theories that might be likely to explain the response of uMsinga SHFs to climate change threats, namely: PMT and TPB. TIPB was adopted to explain the factors possibly influencing the SHFs' choice of agricultural practices and the unintented challenges resulting from these practices. In addition, the chapter showed the expected combination of UTAUT2 and TIPB in this study.

Furthermore, the study explained the purpose of CBPAR and living theory as frameworks adopted to engage the community of SHFs. These frameworks were preferred above others because they were developed for community development and brought to the fore the voices of the community members in the study. It was significant to note that the participation of uMsinga SHFs in this study was required in order to get rich data that explained the SHFs' behavioural intentions to interface between ICT and CSA. CBPAR contained five stages and each stage was to be facilitated by corresponding questions in the action reflection cycles of living theory. Hence, the entire chapter is summarized using the diagram in Figure 3.10.

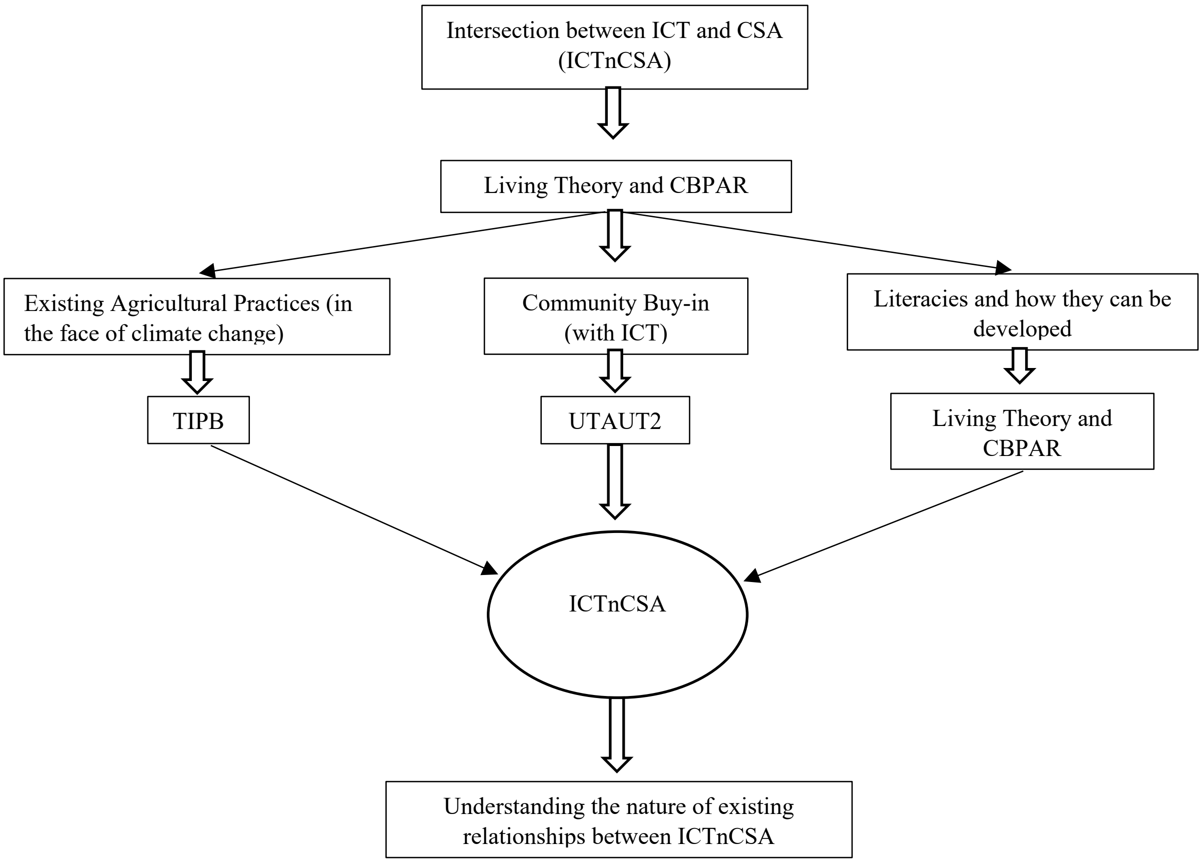


Figure 3. 9: The intersection between ICT and CSA (ICTnCSA)

CHAPTER 4

RESEARCH METHODOLOGY

The previous chapter, Chapter 3, presented the evolution of the frameworks used to understand and describe the data and findings of this research. The frameworks used were threefold, namely:

- Adoption/adaptation strategic tools (AST);
- Community based participatory action research; and
- Living theory.

The chapter shows evolution of four frameworks, namely: unified theory of acceptance and use of technology (UTAUT), theory of irrigators' planned behaviour (TIPB), community based participatory action research (CBPAR) and living theory (LT). The UTAUT and TIPB were adopted to explain factors informing uMsinga SHFs' intersection between ICT and CSA, whilst CBPAR and LT were to guide participation of the SHFs in the study. The concern of this chapter is to present the research methodology for this study. In this regard, the chapter is divided into eight sections, namely:

- Section 4.1 will discuss the research paradigm;
- Section 4.2 will explain the research approach;
- Section 4.3 will briefly discus frameworks guiding the research methodology;
- Section 4.4 will present the study methods of data collection;
- Section 4.5 will explain the research instruments used;
- Section 4.6 will discuss the study data gathering procedure;
- Section 4.7 presents the methodological challenges involved in the process of data collection and analysis; and
- Section 4.8 will summarize the methodological chapter.

The detail of the sections is discussed below.

4.1. Research paradigm

The term paradigm has been defined as "a basic set of beliefs that guides action" (Denzin & Lincoln, 2011, p. 91; Guba, 1990, p. 17). This might mean a set of principles that governs the inquiry that an individual undertakes in a research. Likewise, Guba and Lincoln (1994) view the concept of paradigm as a world view. This study employs the participatory paradigm.

The participatory paradigm is about understanding that everyone in the context of a project should be involved in knowledge creation with the researcher, to make a collective effort in the study (Brydon-Miller et al., 2011). This implies that the researcher's personal experiences, the nature of the uMsinga SHFs, as well as data to be collected, all informed the choice of participatory paradigm from amongst other world views like positivism, social construction, and pragmatism (Creswell, 2008, p. 6). This is because collaboration with the SHFs is required to get deeper insight to how they engage ICT in their agricultural practices. This paradigm supports indigenous people's inquiry (Wilson, 2008). As such, the participatory paradigm was considered as the most appropriate worldview that would align with the research approach for this study.

4.2. Research approach

The terms research approach and research design have been used interchangeably in literature (Ullah & Ameen, 2018, p. 54) to mean the procedures of inquiry in which participants are engaged participants (Creswell, 2008; 2013, p. 19). According to Creswell, research approaches "are plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation" (p. 3). Research design, on the other hand, "serves as the architectural blueprint of a research project, linking data collection and analysis activities to the research questions and ensuring that the complete research agenda will be addressed" (Bickman & Rog, 2008, p. 11). For this study, a sequential transformative strategy[4] mixed methods is employed because of the nature of the data to be collected. Both numerical and textual data will be collected in sequence and will be guided by frameworks (Creswell, 2008; 2013, p. 19). Community based participatory action research (CBPAR) and living theory were used to guide this study.

4.3. Brief discussion on frameworks guiding the research methodology

First, CBPAR is defined as a research approach that provides opportunities to democratise new knowledge creation from research questions to data analysis (Burke, 2012; Burns et al., 2011). CBPAR is regarded as "a collaboration among community groups/practitioners, policymakers/ decision makers, and researchers to create new knowledge or understanding about a practical issue in order to bring about change" (p. 127) (Hills et al., 2007, p. 127). The

[4] Sequential transformative strategy is a mixed method of data collection which is guided by theoretical framework (Creswell, 2008).

concept of collaboration emphasises the relevance of CBPAR in this study. This is because CBPAR created the opportunity to work with an indigenous community like the SHFs in uMsinga, enabling them to share their minds regarding the concern of this study. In addition, the approach afforded the opportunity to undertake critical dialogue with the SHFs to gain insights into the link between ICT and CSA, as we reflected on it in a forum meeting (Hills et al., 2007).

In this study, CBPAR provided opportunities for the SHFs to express their concerns regarding the devastating impacts of climate change on crops (Hills et al., 2007). Likewise, CBPAR facilitates data collection as the SHFs got involved in the research as key active stakeholders (Drolet & Sampson, 2014), as they championed and suggested interventions that would improve their skills and practice (Singleton, Rola-Rubzen, Muir, Muir, & McGregor, 2009). The SHFs were involved at all stages of the research from the formulation of research questions formulation to data analysis (Burke, 2012; Smith, Bratini, Chambers, Jensen, & Romero, 2010). CBPAR is in contrast to the traditional research approach, where the researcher takes the lead as participants, or community members act passively in the study (Smith et al., 2010). In this study, CBPAR is used to guide methods of data collection (Tyan, 2010). CBPAR consists of five stages, namely:

(i) Design and implementation of the intervention programme with SHFs (1st stage);
(ii) SHFs' engagement (2nd stage);
(iii) Data collection (3rd stage);
(iv) Data analysis (4th stage); and
(v) Reporting the findings (5th stage) (Burns et al., 2011, p. 11).

In this study, each of these stages guided this study with the use of living theory.

Second, Living Theory (LT), on the other hand, is "an explanation produced by an individual for their educational influence in their own learning, in the learning of others and in the learning of the social formation in which they live and work" (Whitehead, 2008, p. 104; 2014, p. 3). As mentioned in Chapter 3, section 3.3, LT is a process of producing and sharing explanations of influences on learning (Whitehead, 2010, p. 3). In this study, LT is to facilitate each stage of the five CBPAR discussed above. LT consists of 10 action reflection cycle questions to facilitate the stages, namely:

(i) What was my concern?
(ii) Why was I concerned?
(iii) What experiences can I describe to show why I was concerned?
(iv) What did I do about my concern?
(v) What I did about it?
(vi) What kind of data did I gathered to show the situation as it unfolded?
(vii) How did I explain my educational influences in learning?
(viii) How did I show that any conclusions I came to were reasonably fair and accurate?
(ix) How did I evaluate the evidence-based account of my learning?
(x) How did I modify my concerns, ideas and practices in the light of my evaluations? (McNiff & Whitehead, 2006, p. 3; Whitehead & McNiff, 2006, p. 89).

The above 10 action reflection cycle question and the five stages of CBPAR guided this chapter.

The use of CBPAR and living theory in this study provide insight into the concerns of indigenous community by employing indigenous methods (like storytelling in conversation, community forum) (Deacon-Crouch, 2016; Wilson, 2001, 2008) rather than the use of conventional methods (like interview, questionnaire) (Creswell, 2003; Creswell & Clark, 2007; Creswell & Creswell, 2017). This is because a number of studies (Beaulieu-Banks, Sundeen, & Christopherson, 2018; Drawson, Toombs, & Mushquash, 2017; Villaluz, 2017; Wilson, 2008) have shown that conventional methods are inadequate to conduct research involving indigenous community members. These methods thus required direct application of indigenous knowledge, indigenous worldviews, nature, collaboration, and reflexivity among others (Drawson et al., 2017; Kovach, 2010). Since this study adopted the participatory paradigm to collaborate with the indigenous people of uMsinga in order to understand the impacts of climate change on their livelihood, conventional methods are inappropriate. For example, conventional approaches appear suitable to access students and teachers who are readily available in the schools, but inappropriate to engage the uMsinga SHFs. The most suitable method requires that one may have to contact them through a leader who has to meet them one-on-one for a scheduled meeting. Unlike learners and teachers in schools, it may require an interpreter to discuss with the SHFs, this is because they have the right to express themselves in IsiZulu (indigenous language). However, the CBPAR and living theory approaches adopted in this study provide opportunity to engage with these SHFs (Beaulieu-Banks et al., 2018; Drawson et al., 2017;

Villaluz, 2017) using indigenous research methods like the community forum method (Gonzalez-Guarda, Diaz, & Cummings, 2012) to gather data despite communication challenges.

4.4. Methods of data collection

A community forum is regarded as an organised platform which permits participation of interested parties in addressing a concern (Duenpen, Onwan, & Phoewhawm, 2016). According to Blyden (1995), community forum is as an approach to data collection which provides the opportunity to capture the general ideas of a community within a short period by providing space for their voice to be heard. In this study, community forum is defined as a research method of data gathering which permits participation between indigenous people and academic researcher in a meeting to investigate the concerns relating, in this case, to development of the uMsinga community. Community forum meeting is one of the methods of data collection among indigenous people (Wilson, 2008).

An indigenous research method is the process of obtaining and analysing data that is harmonious to the indigenous paradigm[5] (Beaulieu-Banks et al., 2018; Wilson, 2008). The methods must be in congruence with the indigenous worldview by using storytelling and, community forum meetings for people to share stories and ideas, among others (Deacon-Crouch, 2016; Wilson, 2001, 2008). In this study, community forum was used as a platform for us to discuss issues relating to the impacts of climate change on uMsinga SHFs' agricultural practices. A number of studies (Blyden, 1995, p. 43; Duenpen et al., 2016; Ernst et al., 2016; Gonzalez-Guarda et al., 2012; Mullens et al., 2018) in Thailand, U.S, Florida, Australia, and Kenya have used community forum as a method of data collection to permit participants to express their views, ease of organizing, and identified available resources in a given community. For example, Duenpen et al. (2016) used the community forum for participants to brainstorm on local tourism business. Similarly, Ernst et al. (2016) used community forum to collect information among villagers in Kenya on factors related to use of bed nets and ownership. The discussions took place during meetings and were audio recorded (ibid). According to Blyden (1995), a community forum meeting enables community members to

[5] The indigenous paradigm is regarded as a worldview and description used to generate ontology, epistemology, axiology and methodology in indigenous contexts (Beaulieu-Banks et al., 2018; Wilson, 2008). In other words, indigenous paradigm is a set of ideas suitable for indigenous contexts (Whitehead & McNiff, 2006).

express their opinions on issues that they have concern for, the planning process is easy, it is relatively cheap and used to identify indigenous people's resources. On the basis of these arguments for the use of a community forum, this study adopted community forum meetings as a viable method of data collection. However, the researcher facilitated the community forum meetings using four instruments described below.

4.5. Research instruments

Research instrument is defined as a tool that is used to facilitate data gathering (Mumenya & Wagoki, 2018). According to Grove, Burns, and Gray (2012), a research instrument is a tool to collect data on a particular subject. The design of data collection tools generally follows both quantitative and qualitative patterns. In quantitative research, for example, it is required that the researcher constructs an instrument to measure the research questions in a standard and predetermined way (Golafshani, 2003) while, in qualitative research, the researcher is regarded as the instrument (Pezalla, Pettigrew, & Miller-Day, 2012). This means the researcher may not require designed instruments as in quantitative research, yet data will be gathered. In this study, four instruments were used, namely: preliminary study forum meeting protocol (PSFMP) (see Appendix C), ICT literacy assessment tool (ILAT) (see Appendix F), SHFs' ICT literacy development protocol (SHFIDP) (see Appendix D), and SHFs' functionalities inclusion discussion protocol (SHFFIDP) (see Appendix E). PSFMP was used to generate data for the preliminary research questions while ILAT was employed to produce quantitative data for the main study, research question one (1). Furthermore, SHFIDP and SHFFIDP were used to generate data to answer the second main research questions. SHFIDP was used to facilitate our planning for the SHFs' ICT literacy development programme and SHFFIDP was used to facilitate the data generation regarding the functionalities SHFs wished to add to the existing web based agro-weather application (like the demo app). These instruments were used in the data gathering in this study.

4.6. Data gathering procedure

The data gathering was divided into three major sections, namely:

- Pre-intervention;
- During intervention; and
- Post-intervention.

The details of data collection in this study are discussed below.

4.6.1. Pre-intervention stage

This section presents six stages of the pre-intervention, namely: identification of research participants, invitation and meeting with identified participants, our collective concern during engagement with the SHFs, addressing the preliminary research questions, responding to main research question one and planning for the intervention training programme. The detail is discussed below.

Pre-Intervention Challenges

Ethical Clearance application

Identification of Research Participants

Community Based approaches

This study adopted community based participatory action research and living theory approaches for data collection. This was because of context and nature of the participants of the study. Prior to application of the frameworks in this study, ethical clearance had to be sought for approval by the university research and ethical committee. This process took eight months before we could get down to data collection. As part of the ethical clearance requirements, the participants' signatures had to be appended on informed consent forms and attached to the ethical clearance application in order for it to be approved.

Getting started with the research

Looking for intermediary 1

I had to seek for a person to introduce me to the uMsinga SHF community. A researcher from UKZN who had been working in the area for a year introduced me to the community extension officer as a colleague who is doing similar research and keen to conduct research in the community. He gave me the phone number of the extension officer.

Navigating access into the community by looking for intermediary 2

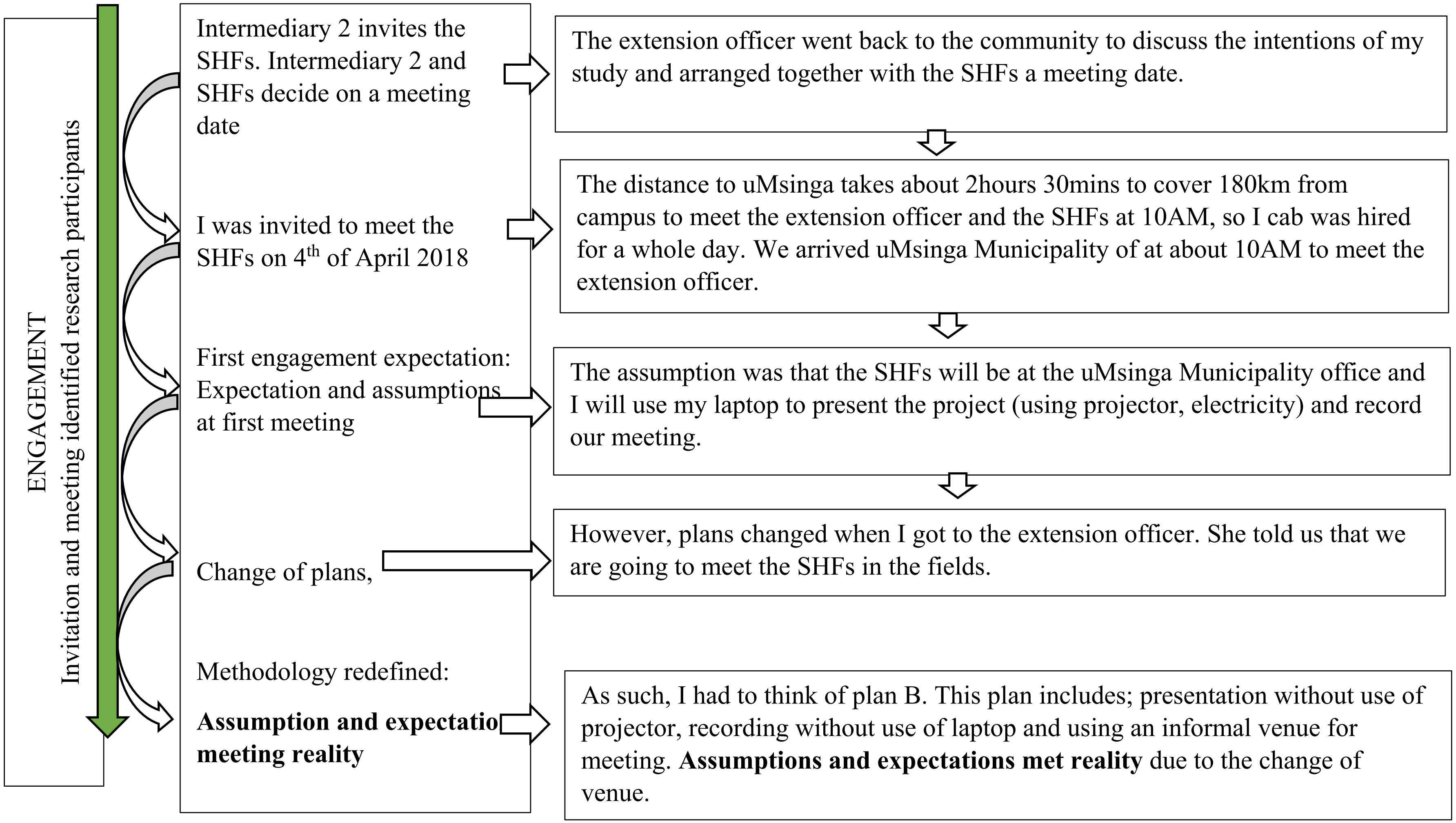
I called the extension officer to introduce myself to her as well. She gave me her email address. I emailed the extension officer to introduce myself as well as the study. In the email I requested her to link me up with the SHFs to secure their consent and collaboration in my study. I attached a copy of the participants Informed Consent Form to the email.

Seeking community buy-in and signing of informed consent form

She responded to my request by getting the SHFs informed about my study and asked for their collaboration with me. This the SHFs did by asking their chairman to append his signature on behalf of the SHFs. The extension officer whatsapped back the consent letters with the SHFs signature agreeing to audio recording, video-recording and photographs of the sessions.

Ethical clearance requirement conflicting with approach

The signed informed consent and ethical application were sent to the University's Research Ethical Committee for approval before the commencement of data collection. However, the committee advised that the video-recoding and photography in the inform consent form be removed before the approval could be granted. That I did, in order to secure approval before data collection activities.


ENGAGEMENT
Invitation and meeting identified research participants
Intermediary 2 invites the SHFs. Intermediary 2 and SHFs decide on a meeting date
The extension officer went back to the community to discuss the intentions of my study and arranged together with the SHFs a meeting date.
I was invited to meet the SHFs on 4th of April 2018
The distance to uMsinga takes about 2hours 30mins to cover 180km from campus to meet the extension officer and the SHFs at 10AM, so I cab was hired for a whole day. We arrived uMsinga Municipality of at about 10AM to meet the extension officer.
First engagement expectation: Expectation and assumptions at first meeting
The assumption was that the SHFs will be at the uMsinga Municipality office and I will use my laptop to present the project (using projector, electricity) and record our meeting.
Change of plans,
However, plans changed when I got to the extension officer. She told us that we are going to meet the SHFs in the fields.
Methodology redefined:
Assumption and expectatio meeting reality
As such, I had to think of plan B. This plan includes; presentation without use of projector, recording without use of laptop and using an informal venue for meeting. **Assumptions and expectations met reality** due to the change of venue.

What is our concern?

Living theory action reflection cycle question.

Introduction of research team and project

On our arrival at the farm site, the extension officer invited all the SHFs to tell them we had arrived. The SHFs came out of their plots of farm to welcome us. We stood by the side of a road that is often used to move farm produce out of the farm. The SHFs, who were about 35 in number, sat on the floor of the farm in a semi-circle form to listen to the speech of the extension officer as she introduced our research team to them.

Establishing the need for the project. Is my concern their concern? To establish mutual concern

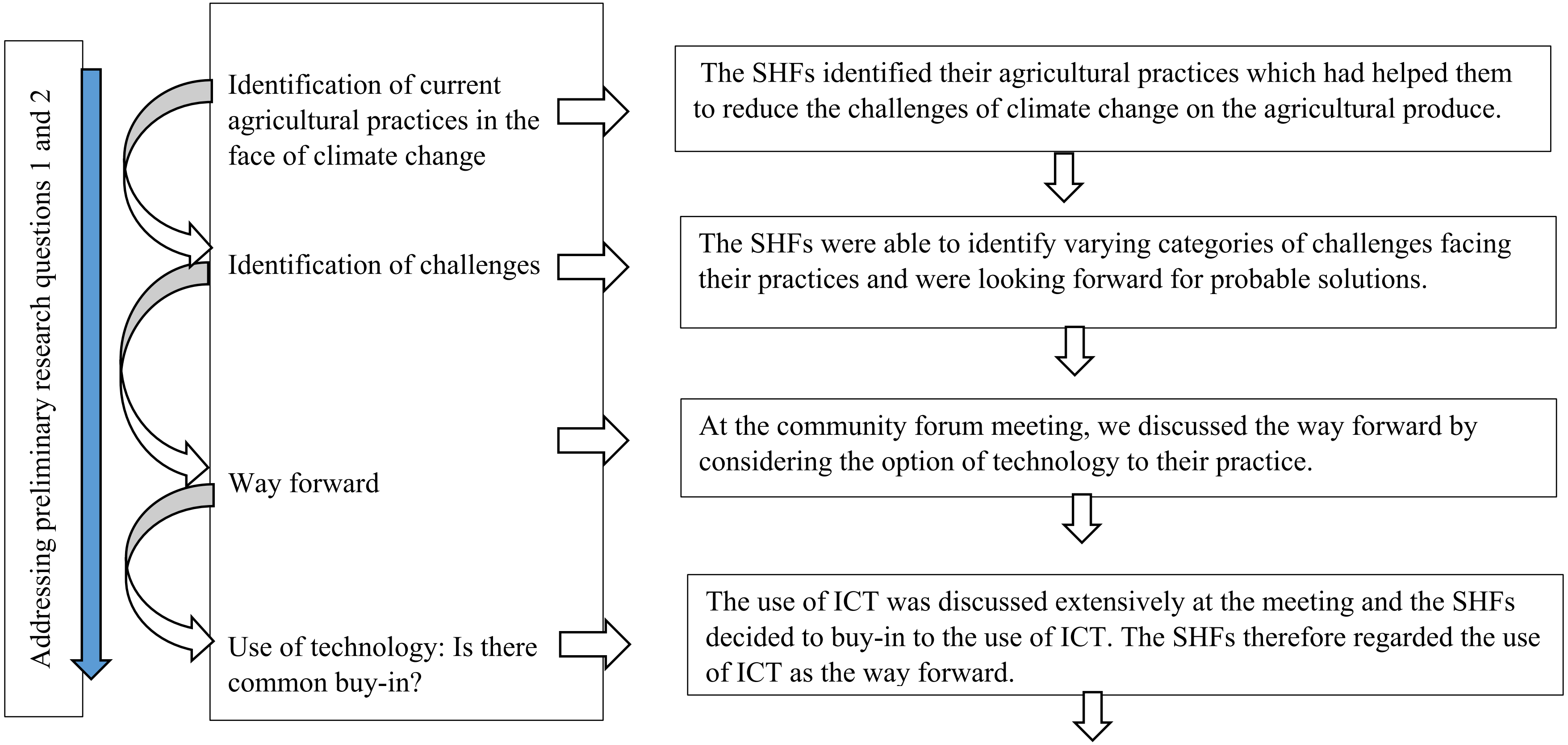
The extension officer told the SHFs the reasons for our visit again using the local language. As the extension officer spoke in IsiZulu, the research assistant (RA) translated everything into English for me to understand. After a brief introduction, I explained in detail the purpose of our meeting with the SHFs.

Misrepresentation of concern due to misinterpretation, language barrier

However, the aim of the project was misrepresented by the research assistant while I was explaining.

Re-established the mutual concern

The extension officer had to come in and intervene and explain that our team was not in uMsinga to solve their problem but we came for research. I further elucidated that we came to them so that we can all brainstorm together as a research project in order to provide a probable way to address their agricultural challenges. As such, our mutual concern was re-established, the SHFs began to explain what they do on the farms.


Addressing preliminary research questions 1 and 2
Identification of current agricultural practices in the face of climate change
Identification of challenges
Way forward
Use of technology: Is there common buy-in?
The SHFs identified their agricultural practices which had helped them to reduce the challenges of climate change on the agricultural produce.
The SHFs were able to identify varying categories of challenges facing their practices and were looking forward for probable solutions.
At the community forum meeting, we discussed the way forward by considering the option of technology to their practice.
The use of ICT was discussed extensively at the meeting and the SHFs decided to buy-in to the use of ICT. The SHFs therefore regarded the use of ICT as the way forward.

Addressing main research question 1

Do SHFs understand the use of ICT?

I therefore asked the SHFs if they can use ICT? They all chorused *'yebo'* meaning yes, and laughed. I then wanted to understand the extent of their knowledge on use of mobile phones.

Through probing, the SHFs learnt that they needed more knowledge in the use of ICT in their farming

A questionnaire titled ICT literacy assessment tool (ILAT) was used to facilitate the probing. ILAT was divided into six sections, namely: demographic information; mobile phone symbol identification literacy (first level); basic ICT literacy (second level); semi-medium-level ICT literacy (third level); medium-level ICT literacy (fourth level); and advanced ICT literacy (fifth level). This categorization was drawn from the ideas of Atasoy (2012, p. 67), who categorised ICT literacy into "basic ICT skill, medium ICT skill, and advanced ICT skill". These five levels were premised on nature of the participants and context in which this study was situated. The SHFs responded to the first level of ICT literacy by identifying symbols on mobile phone. We proceeded to second level, the SHFs could use their mobile phone to perform basic skills. However, as we moved to the third level, only two of the SHFs responded to items. Similarly, at level four and five, they barely attempted any item. The SHFs were amazed to see their performance at the end of the exercise.

Analysis of finding

All the SHFs thus acknowledged that they only knew few use of ICT and agreed that training was needed. As such, we needed to plan for the training.

Planning for ICT literacy training

Agreement reached by common members

At the community forum meeting, we discussed the major benefits of the ICT training, when and where would the SHFs want the ICT literacy development to take place.

What?

The major points for their decision to understand better ways of using ICT were discussed at the meeting as well as the time for the training.

When?

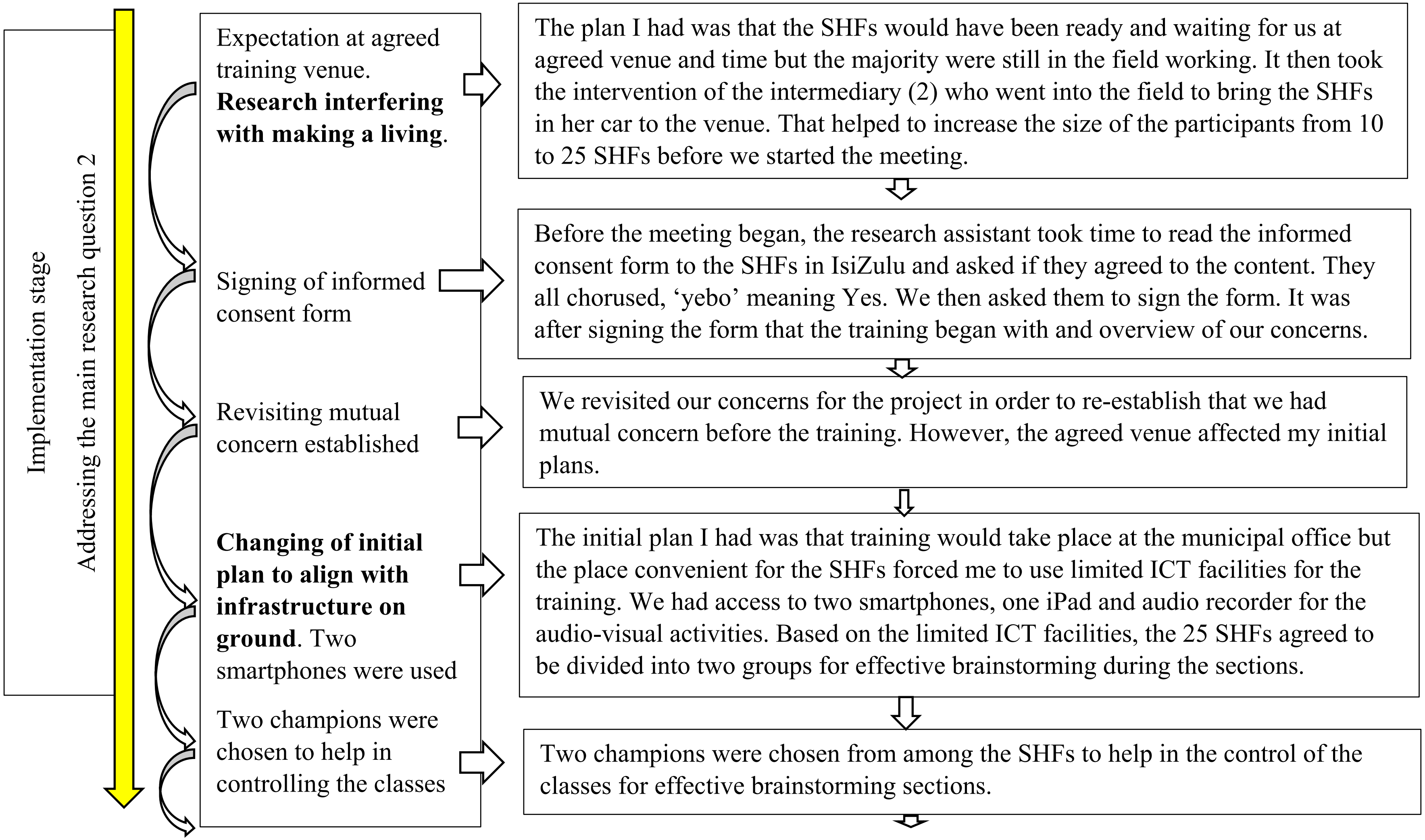
The extension officer led the discussion of time of the ICT literacy training. Based on their busy schedule at the moment, they wanted the training as quick as possible. The SHFs considered their farm time table and requested that if our team could come back, the subsequent week would be suitable for them, otherwise it will be after the season, which was two to three months into the future. As such, we all agreed to have the training the next week and a day and time were decided by the SHFs.

Where?

Similarly, the SHFs decided where could be more convenient for them to have the training. One of them directed our attention to upper side of the farmland and said “in the hall over there”. I was excited to here that a hall would be available for our use, not knowing that it was a shipping container. We all agreed to use the venue for the training.

4.6.2. During intervention implementation

This section presents implementation of the intervention programme by addressing the main research question two. The detail is discussed below.



How did I explain my educational influences in learning?

List of activities taking

There were nine activities we undertook during the training, namely: identifying the SHFs with smartphones (SPs). Only two had SPs; we grouped the SHFs into two groups of 13 based on the available SPs; Assigning SHFs with SPs as group leaders; using iPad as hotspot for the smartphones to access the Internet; accessing demo weather app (www.weather.com) by connecting SPs via the hotspot to the Internet (with the support of research assistants); identifying weather icons and symbols on the app in order to interpret the information (graphic) e.g. partly cloudy, cloudy, showers and sunny among others; locating their locale in order to access the weather forecast specific to their area and homework task – application of what was learnt during the workshop in daily life in their respective groups. The actions during the activities were audio recorded.

No visual representation, no visual recording, limited the records to be used as evidence.

Audio recording was used to provide evidence of how uMsinga SHFs participated in the intervention programme. The SHFs were practically involved in the intervention. However, the evidence of their involvement was not detail enough for analysis using living theory because of the requirements of the Committee to use audio recording only. Audio-visual recorder would have enable me to generate detail evidence of how I influenced the uMsinga SHFs to learn ICT.

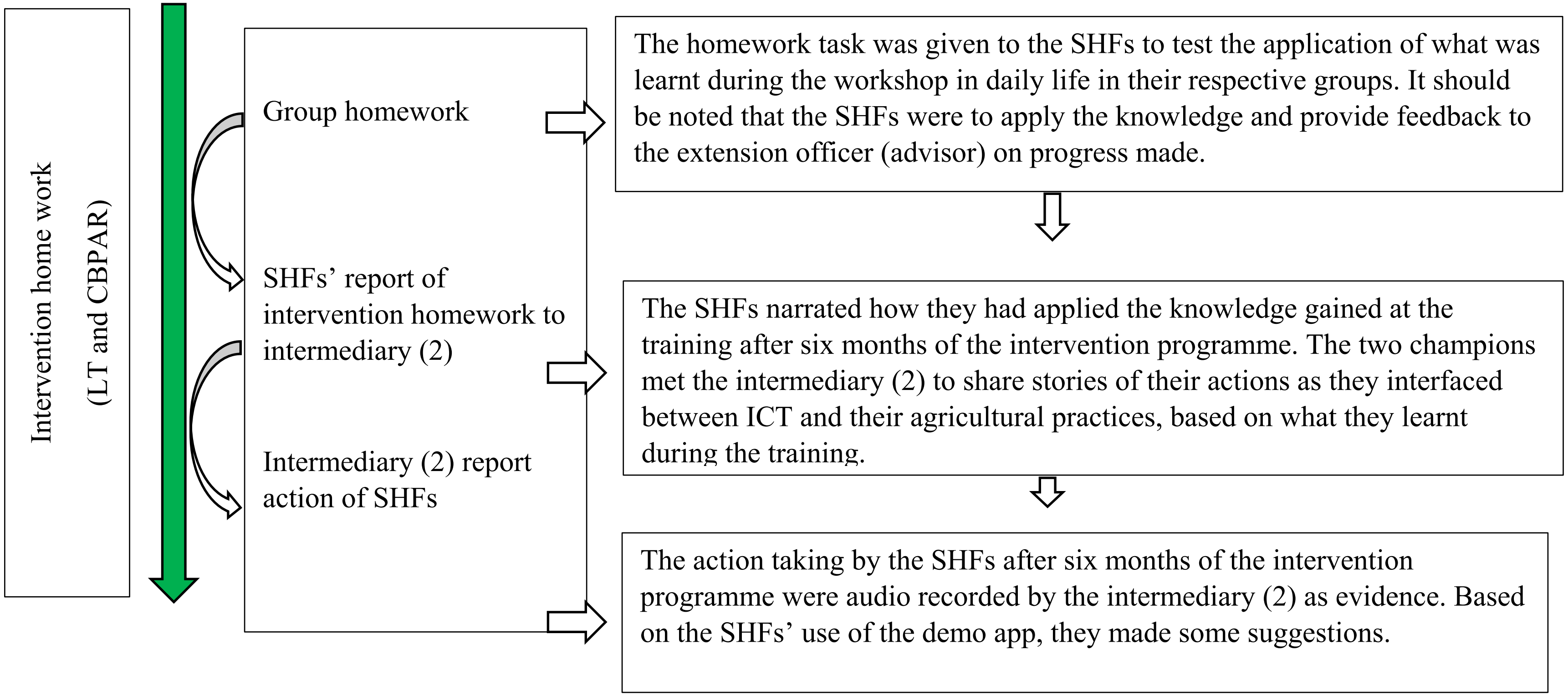
Analysis of implementation

At the end of the training, the uMsinga SHFs stated that they were unaware that their mobile phones could be used to get information that could enable them decide when to fumigate their crops to prevent them from being washed away by rain. Additionally, the SHFs also stated that now, they will be using their mobile phones to access weather information in order to determine when to irrigate their crops to prevent excess water that often spoil crops. At the end of the training, the SHFs were given take home assignments.

4.6.3. Post intervention stage

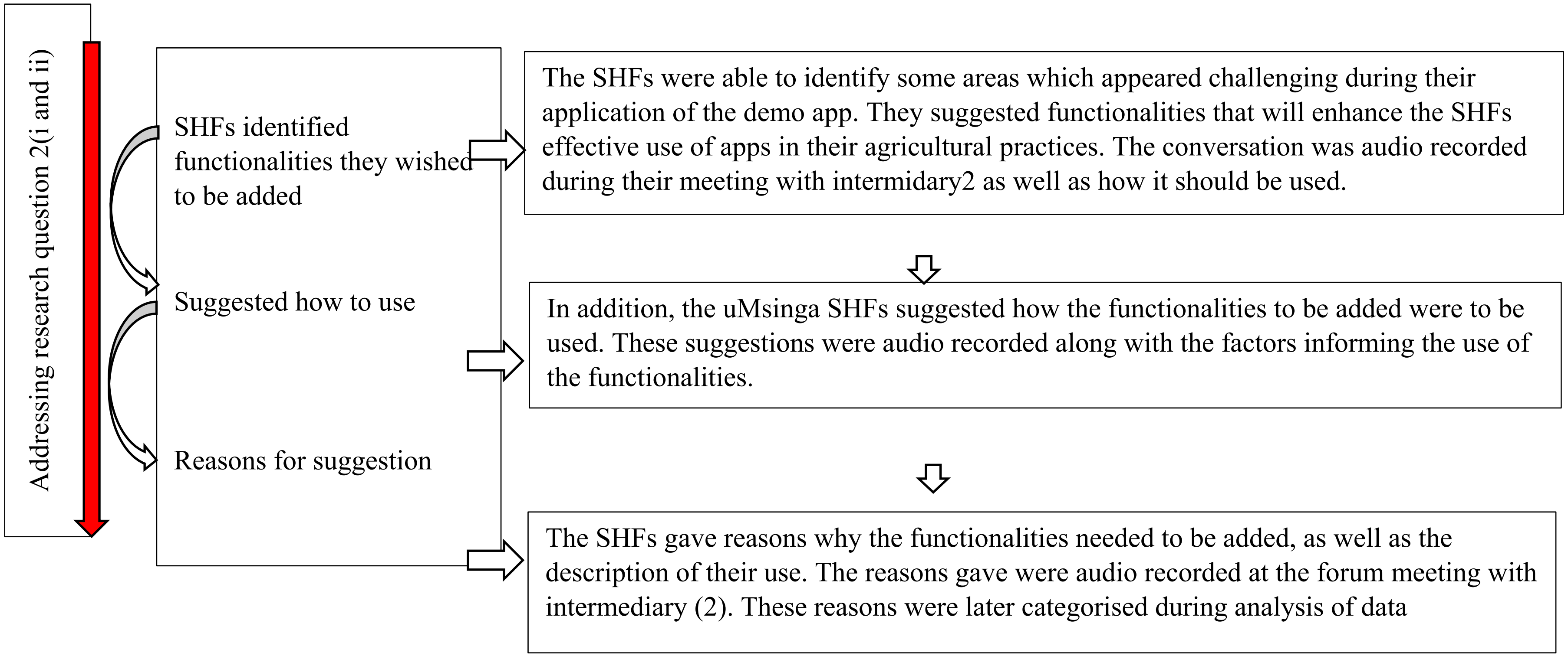
The section presents three actions: intervention homework, addressing main research question 2(i and ii) and data analysis.

4.6.3.1. Intervention homework



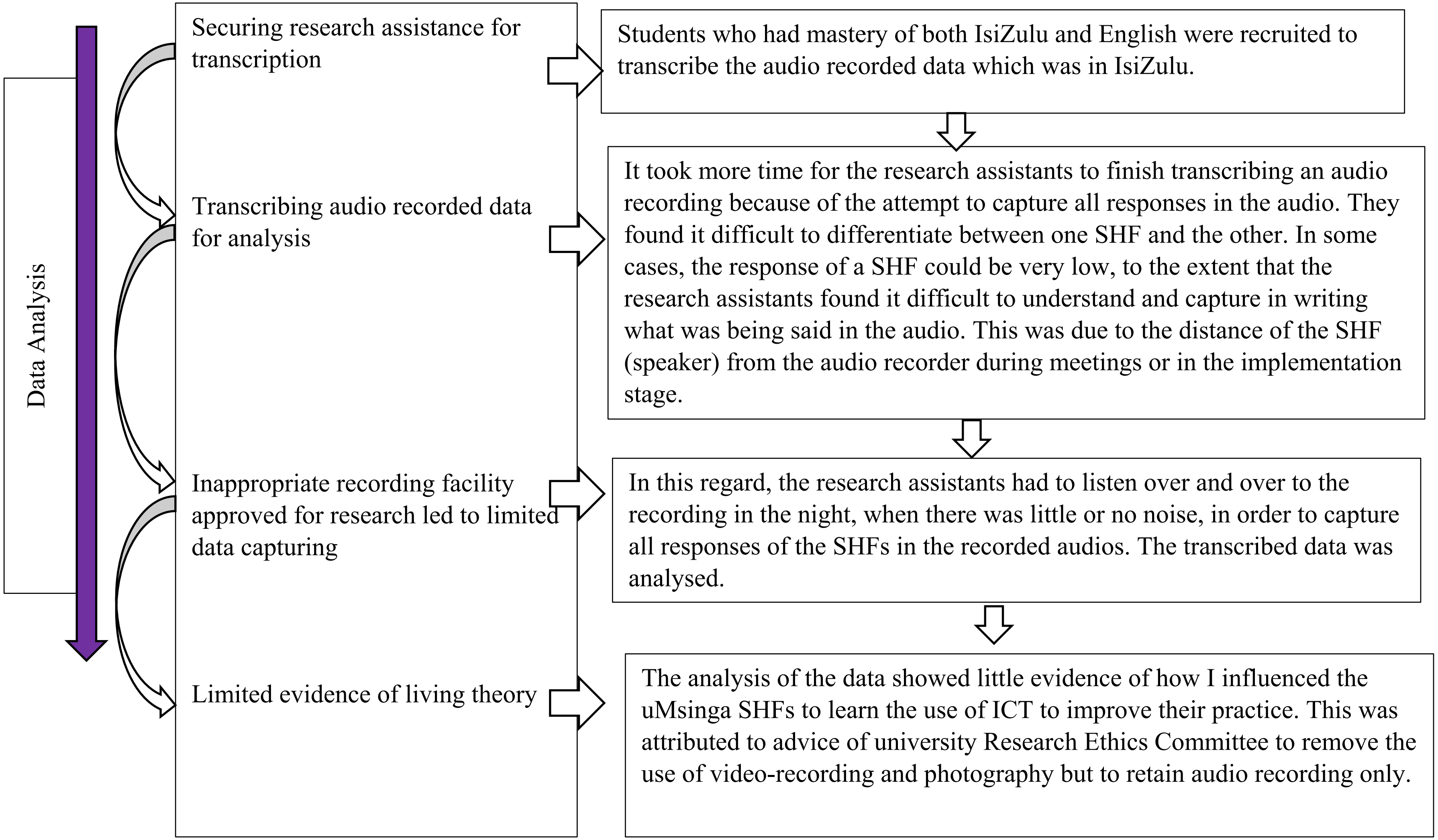
4.6.3.2. Addressing research question (2i and ii).

To address the research question 2(i and ii), the experience of the SHFs during application of the demo app provided clear evidences. The detail is discussed below.



4.6.3.3. Data analysis

This section discussed methods of data analysis in this study. It should be noted that analysis of data in this study was done and concluded with the SHFs during our meetings. This was because of the frameworks used to guide the study (Burns et al., 2011; Whitehead & McNiff, 2006). As such, it was evident at each meeting that the majority of the SHFs agreed with decisions taken at the end of each stage of the study. However, this section elaborates on the analysis for readers to make sense of findings in the study. Therefore, the concern in this section focused on three areas, namely: securing research assistants for transcription, transcribing audio recorded data and providing evidences using the transcripts. The detail is discussed below.


Data Analysis
Securing research assistance for transcription
Students who had mastery of both IsiZulu and English were recruited to transcribe the audio recorded data which was in IsiZulu.
Transcribing audio recorded data for analysis
It took more time for the research assistants to finish transcribing an audio recording because of the attempt to capture all responses in the audio. They found it difficult to differentiate between one SHF and the other. In some cases, the response of a SHF could be very low, to the extent that the research assistants found it difficult to understand and capture in writing what was being said in the audio. This was due to the distance of the SHF (speaker) from the audio recorder during meetings or in the implementation stage.
Inappropriate recording facility approved for research led to limited data capturing
In this regard, the research assistants had to listen over and over to the recording in the night, when there was little or no noise, in order to capture all responses of the SHFs in the recorded audios. The transcribed data was analysed.
Limited evidence of living theory
The analysis of the data showed little evidence of how I influenced the uMsinga SHFs to learn the use of ICT to improve their practice. This was attributed to advice of university Research Ethics Committee to remove the use of video-recording and photography but to retain audio recording only.

4.7. Methodological challenges in the process of data collection and analysis

In this study, methodological challenges are regarded as the setbacks met in the process of research data collection which possibly altered the initial structured research methodology. Eight methodological challenges were identified in this study, namely:

(i) Ethical clearance requirement conflicting with approach;
(ii) Assumption and expectation meeting reality;
(iii) Misrepresentation of concern due to misinterpretation resulting from language barrier;
(iv) Research interfering with making a living;
(v) Changing of initial plan to align with infrastructure on ground;
(vi) No visual representation and visual recording, limited evidences recorded;
(vii) Inappropriate recording facility approved for indigenous research; and
(viii) Inappropriate data recording equipment approved vs study adopted approaches.

The detail of the eight methodological challenges is discussed below.

4.7.1. Ethical clearance requirement conflicting with approach

During the stage of identification of research participants, the ethical clearance requirement conflicted with the research approach adopted for this study. The approach required the use of audio-visual and photography for data capturing, and the participants had consented to this, but the committee advised that audio recording only should be used. The participants had to be re-informed that photography and video-recording would no longer be used in this study.

4.7.2. Assumptions and expectations meeting reality

This challenge came up at the meeting with the identified research participants. The methodological challenges at this stage brought about redefining of initial methodology because assumption and expectation met reality at the field. The reality was categories into three, namely: the SHFs could only be reached in their farm site; there was no electricity to power ICT facilities in the field; the SHFs preferred to use farm land for our discussion rather than meeting in a building equipped with ICT facilities which is outside their field because of farm activities at that period of the year.

4.7.3. Misrepresentation of concern due to misinterpretation resulting from language barrier

At the engagement stage, when the aims of this study were to be communicated to the participants (SHFs), there was misrepresentation of the aims due to misinterpretation resulting from the language barrier. This had implications for the response of the SHFs because they were confused, but intermediary (2), who had a level of understanding in field of agriculture and research, had to intervene by correcting the impression, using IsiZulu and English. As I do not understand IsiZulu, I thought everything was fine until she alerted us, then I reiterated the right statement of aims. Thus the SHFs got the message and we established a mutual understanding regarding the project.

4.7.4. Research interfering with making a living

At the implementation stage in this study, research interferes with making a living of the uMsinga SHFs who decided to participate in the intervention programme. The plan I had was that the SHFs would have been ready and waiting for us at agreed venue and time but the majority were still in the field working. It then took the intervention of the intermediary (2), who went into the field to bring the SHFs in her car to the venue. This intervention enabled a significant increase in the number of the participants, from 10 to 25 SHFs, before we started the meeting.

4.7.5. Changing of initial plan to align with infrastructure on ground

At the implementation stage, the initial plan I had needed to be changed to align with the infrastructure on the ground, due to the change of venue. The initial plan I had was that training would take place at the Municipality office, which would enable the use of ICT equipment, but the place convenient for the SHFs forced me to use the limited ICT facilities for the training. As such, we only had access to two smartphones, one iPad and an audio recorder for the audio-visual activities. In response to this limitation, the 25 SHFs agreed to be divided into two groups for effective brainstorming, with the use of the available ICT facilities during the session.

4.7.6. No visual representation and visual recording limited the evidence recorded

At the implementation stage, the Ethics Committee's requirement that there be no video recording limited the records to be used as evidence based on living theory adopted in this study. One of the action reflection cycle questions of living theory is "How did I explain my educational influences on learning?" (Whitehead & McNiff, 2006, p. 89). To respond to this question became challenging, since only an audio recorder was approved as recording equipment for this study. This limitation has significant implications for the analysis of data using living theory.

4.7.7. Inappropriate recording facility approved for indigenous research

The inappropriate recording facility approved for this research limited data capturing and hindered proper data analysis. This is because it was difficult for the research assistants who were responsible for transcription to recognise each speaker at the community forum, since the data were audio recorded only. In addition, some of the SHFs speaking at a distance from the audio recorder could not capture their speech fully for transcription. These flaws limited the evidence presented to readers of this study.

4.7.8. Data recording equipment inappropriate for theoretical framework

The approved recording equipment for this study became inappropriate because it limited evidence to show that I have influenced the uMsinga SHFs during our intervention programme, a key focus of living theory (McNiff & Whitehead, 2006; Whitehead & McNiff, 2006). This became a limitation because ICT literacy involves actions by the SHFs which the audio recorder poorly recorded. As such, a conflict between the approach adopted and facilities available to this study occurred, limiting the analysis of evidence of my living theory for readers.

4.8. Summary of methodology chapter

This is a transformative sequential strategy mixed methods study. A participatory paradigm was adopted, due to the nature of the study and participants, guided by CBPAR and living theory approaches. In addition, the community forum method was used as a medium of engagement with the uMsinga SHFs. Four instruments were used to facilitate our discussion at the forum meetings, namely: a preliminary study forum meeting protocol (PSFMP), ICT literacy assessment tool (ILAT), SHFs' ICT literacy development protocol (SHFIDP), and SHFs' functionalities inclusion discussion protocol (SHFFIDP). PSFMP was used to generate data for the preliminary research questions while ILAT was employed to produce quantitative data for the main study, research question one (1). Furthermore, SHFIDP and SHFFIDP were used to generate data to answer the second main research question. SHFIDP was used to facilitate our planning for the SHFs' ICT literacy development programme and SHFFIDP was used to facilitate data generation on functionalities. The procedure for data collection was divided into three sections, namely: pre-intervention, during intervention and post-intervention. However, eight methodological challenges were recorded in the process of data collection that had implications for this study, namely:

(i) An ethical clearance requirement conflicting with approach
(ii) Assumption and expectation meeting reality
(iii) Misrepresentation of aims resulting from language barrier
(iv) Research interfering with making a living
(v) Changing of initial plan to align with infrastructure on ground
(vi) No visual representation and visual recording limited evidence recorded
(vii) Inappropriate recording facility approved for indigenous research
(viii) Data recording equipment inappropriate for theoretical framework.

CHAPTER 5

PRESENTATION AND ANALYSIS OF RESULTS OF THE FIRST PHASE OF PRELIMINARY STUDY

This chapter presents the analysis of the first research question of the preliminary phase of the study, that is: *What are the uMsinga SHFs' existing agricultural practices in relation to Climate Change Adaptation*? This research question is further broken down into the following three sub-questions:

- What do they do?
- How do they do it?
- What informs what they do?

The aim of this first preliminary research question was twofold:

(i) Firstly, it aimed to determine whether indeed the SHFs use climate smart agricultural practices in relation to Climate Change (CC) adaptation.

(ii) Secondly, it aimed to probe the factors that inform the SHF's current agricultural practices in the face of climate change for food production?

To address the above three questions, the chapter will be divided into four sections, namely: sections 5.1 to 5.3.

- Section 5.1 will seek to identify the SHFs' existing agricultural practices in relation to CC adaptation, foregrounding what they do and how they do it
- Section 5.2 will explore the factors that inform the SHFs' use of particular agricultural practices as well as any unintended consequences
- Section 5.3 will provide a summary of the preliminary phase one findings.

To gather data about the type of agricultural practices SHFs engage in, in relation to climate change adaptation, a community forum meeting was organised during the month of April 2018. A total number of 35 SHFs and a one extension officer attended this forum meeting. A forum meeting interview protocol, the preliminary study forum meeting interview protocol (PSFMIP), explored the questions above (see appendix C). This chapter thus presents the analysis of the findings on the SHFs' existing agricultural practices and what informs their use.

Agricultural practices, in this study, refer to all the activities related to agricultural use, such as crop land, livestock, processing plant, small family farming and so on (Schultz & Jacobs, 2017). In other words, it consists of all the activities the SHFs engage themselves with on the farm for livelihood. As discussed in Chapter 2 (section 2.2.3), the international community is making a concerted effort on reducing the impact of climate change globally on farming communities through the use of climate smart agricultural (CSA) technologies and approaches (Taneja et al., 2014). CSA is thus regarded as an "approach for transforming and re-orienting agricultural systems to support food security under the new realities of climate change" (Lipper et al., 2014, p. 1068). It is perceived as a mechanism for "strengthening farmers' resilience to climate change, while at the same time reducing agriculture's climate imprint through curbing greenhouse gas (GHG) emissions by limiting deforestation and increasing carbon storage, included in the soil" (Saghir, 2014, p. 66).

It is significant to note that our document analysis (see appendix G) of the global CSA practices shows that, only 17 CSA practices[6] (Nethavhani, 2013; Senyolo et al., 2017; Sinyolo et al., 2014; Ubisi et al., 2017) have been identified in South Africa out of a total of 35 globally identified CSA practices (see appendix G on global CSA practices). It is in this regard that this study sought to explore the type of CSA practices adopted by the SHFs in uMsinga; the reasons for their adoption and the resultant consequence thereof.

5.1 The uMsinga SHFs' existing agricultural practices

The results of this study indicate, as illustrated in Figure 5.1, that the agricultural practices that SHFs have been engaging in fall into the following seven categories, namely:

[6] According to Makeleni et al. (2018); Nethavhani (2013); Senyolo et al. (2017, 2018); Sinyolo et al. (2014); Ubisi et al. (2017), the 17 practices are: agro-ecology, agroforestry, bio-char, changing planting dates, conservation agriculture, crop diversification, crop rotation, drought early warning detection, early maturing, farming near rivers, irrigation farming, mixed cropping, rainwater harvesting, seed varieties, site-specific nutrient management, and strip intercropping (see appendix G).

(i) multiple cropping;
(ii) crop rotation;
(iii) irrigation farming;
(iv) farming near rivers;
(v) using chemicals/manure to fertilize soil for maximum yield;
(vi) planting of improved varieties; and
(vii) planting of improved local varieties.

It is significant to note that all the seven categories identified in this study fall within the 17 CSA practices prevalent in South Africa. In the following section, each of the seven categories of practice is discussed in detail.

5.1.1 Using multiple cropping

Multiple cropping is regarded as the planting of more than one crop in a piece of land in a year (Roy, 2009; Yin & Xiang, 2010). The use of multiple cropping, as found in this study, is consistent with the findings in previous studies in South Africa (Senyolo et al., 2018; Sinyolo et al., 2014). The studies reveal that the farmers practise multiple cropping in South Africa for three reasons: (i) high crop production, (ii) income generation and (iii) adaptation (Senyolo et al., 2018; Sinyolo et al., 2014). However, the authors used mixed cropping, instead of multiple cropping, as used in this study.

Mixed cropping is a system of farming where two or more crops are grown concurrently in the same piece of land (Metwally, Safina, & Noaman, 2015), whilst multiple cropping refers to growing two or more crops on a field concurrently or after one other within the same year (Degla, Adekambi, & Adanhoussode, 2016; Paudel, 2016).

The result in this study shows that mainly six different types of crops are grown in uMsinga. These include: (i) sweet potatoes (*Ipomoea batatas*), (ii) maize (*Zea mays*), (iii) potatoes (*Solanum tuberosum*), (iv) cabbage (*Brassica oleracea*), (v) butternuts (*Cucurbita moschata*) and (vi) tomatoes (*Solanum lycopersicum*) as pointed out in the excerpt below.

Ziyisithupha (six) zitshalo. Ubhatata, ummbila, amazambane, amaklabishi, amabhathanathi, otamatisi. ...
There are six crops that we grow: sweet potatoes, maize, potatoes, cabbage, butternuts, tomatoes. ....

5.1.2 Using crop rotation

Crop rotation is the practice of planting different crops species in sequence on a piece of land for many seasons (Altieri & Nicholls, 2019). The use of crop rotation as found in this study is consistent with findings in Malaysia (Masud et al., 2017), Bangladesh (Eyasmin, Ghosh, & Hossain, 2017), Nigeria (Wahab & Popoola, 2018), Chinyanja Triangle like Zambia, Malawi and Mozambique (Makate et al., 2017) as well as South Africa (Makeleni et al., 2018). The studies indicated that SHFs practise crop rotation for adaption purpose in South Africa (Makeleni et al., 2018) and in Malaysia (Masud et al., 2017). Similarly, crop rotation was practised in Nigeria to reduce adverse effects of climate variability on crops (Wahab & Popoola, 2018). However, in Bangladesh (Eyasmin et al., 2017) it was used for high crop production.

The analysis shows that uMsinga SHFs do indeed, plant different species of crops within a planting season (summer and winter). The SHFs practise crop rotation as CSA to reduce impacts of climate change (like drought and flooding) on their crops. The SHFs plant crops like tomatoes (*Solanum lycopersicum*) and cabbage (*Brassica oleracea*) when there is no much rainfall but maize (*Zea mays*) as described in the excerpts below.

Yebo, ukuguquguquka kwesimo sezulu kuyazinika inking izitshalo zethu. Impela, njengeklabishi ngoJanuary amanzi ayengenel e okubangele ukuthi life. Yebo ukuguquka kwesimo sezulu kuyinkinga enkulu. Yebo uma kunguJanuawari no julayi uma sitshala umbila amanzi asuke enegekho. Ayaye abuye ngo Agasti.
……. water was not enough so cabbages died, climate change is really a problem. Yes, when it January and July when we plant maize, we don’t have water. In August it will be back.

.... Yilokhu esikutshalayo. Isikhathi esiningi uma kungutamatisi, ezinye izitshalo ezinjengekabishi zenza kancono nawo ngapahandle kwesikhathi sezimvula ezinkulu lapho zingamoshakala. Kodwa ebusika, zenza kancono ngoba kusuke kunenzimvula ezincane.
... We plant but most of the time it tomatoes. Tomatoes and other plants do well when planted. But heavy rain does not work with tomatoes and cabbage because they get ruined, when it rains heavily, the crops die. In winter it doesn't rain much so the cabbage is few.

5.1.3 Using irrigation farming

This category refers to as the artificial application of water to land for the purposes of planting crops (Jibrin, 2019; Kingwell-Banham, 2019; Suman, Kumar, Sarkar, & Ghosh, 2017). According to Dube (2013), irrigation farming is a way of agriculture that utilises several water sources for food production. The practice of irrigation farming, as found in this study, is consistent with the findings in previous studies in Western Turkey (Erbaş, 2009), Limpopo, Western Cape (Williams, Malherbe, Weepener, Majiwa, & Swanepoel, 2016) and KwaZulu-Natal (Belete, Setumo, Laurie, & Senyolo, 2016; Sinyolo et al., 2014). These studies reveal that the farmers practise irrigation farming in South Africa for crop production, income generation, adaptation to impacts of drought, mitigation of greenhouse gas (GHGs) emissions, and poverty reduction (Belete et al., 2016; Senyolo et al., 2018; Sinyolo et al., 2014).

In Malaysia (Masud et al., 2017) and in Cameroon (Bella, Nchanji, Ndifon, Nfor, & Bernard, 2018) irrigation farming was used to reduce the impact of climate change. In Bangladesh, it was practised for the purpose of high crop production (Eyasmin et al., 2017) and in Ghana for crop production, youth empowerment and to reduce youth urban migration, as well as poverty reduction (Dinye & Ayitio, 2013).

The results in this study show that the uMsinga SHFs use a diesel and petrol pumping machine to irrigate their crops. As illustrated in the excerpt below, the water is drawn from River UThukela into their field. The river is very close to the farm land, about 100 metres away.

…amanzi siwadonsa ezansi oThukeleni ngenjini, kufanele ihambe lenjini iyowahlanzela noma iyowakhiphela ngenhla,
…we get water downwards using the engine from uThukela and it spreads the water upwards.

5.1.4 Farming near rivers

This category means the act of growing crops around river side or plains for water (Gyampoh, Amisah, Idinoba, & Nkem, 2009). The practice of farming near a river (the uThukela river), as found in this study, is consistent with the findings in previous studies in Bangladesh, Malaysia (Eyasmin et al., 2017; Masud et al., 2017) and Limpopo Province of South Africa (Nethavhani, 2013). These studies regarded this category as farming near any water sources, not necessarily rivers. The studies reveal that the farmers practise farming near water bodies for the purpose of adapting to impacts of climate change in South Africa (Nethavhani, 2013) and in Malaysia (Masud et al., 2017). In Bangladesh (Eyasmin et al., 2017) this practice was used mainly to achieve high crop production.

The results in this study show that uMsinga SHFs farm near the UThukela River so they could have access to sufficient water and create canal to irrigate their crops. Furthermore, the SHFs farm near the UThukela in order to mitigate impacts of climate change like drought as illustrated in the excerpts below:

Emfuleni uThukela. Sisungule umthobo wamanzi ukuze sikwazi ukuba namanzi, kodwa uma kunesomiso kuyenzeka ukuthi anagafinyeleli kithina.
At uThukela. They created a source of water there so that we can all be able to have water, but when there is drought it happens that it will not reach us.

5.1.5 Using chemical/manure to fertilize soil for maximum yield

This category refers to the use of chemicals and fertilizer to improve soil fertility for maximum yield of the crops using either organic or inorganic fertilizer. The SHFs' use of chemicals and manure in this study, is in line with the findings in a number of studies, such as in Ghana (Dinye & Ayitio, 2013), Cameroon (Bella et al., 2018), Uganda (Nalubwama, Kabi, Vaarst, Kiggundu, & Smolders, 2018), Zambia, Malawi, and Mozambique (Makate et al., 2017), Malaysia

(Masud et al., 2017) and South Africa (Nyiraruhimbi, 2013). These studies reveal that the farmers practise the use of chemicals/manure for crop production in South Africa (Belete et al., 2016) and Bangladesh (Eyasmin et al., 2017). In both Malaysia (Masud et al., 2017) and Cameroon (Bella et al., 2018) the practice is used to reduce the impacts of climate change. Furthermore, in Ghana it is used to improve the quality of crop production as well as respond to impact of climate change (Denkyirah et al., 2017; Dinye & Ayitio, 2013).

The result in this study shows activities of uMsinga SHFs that could be linked to CSA practices. The excerpt shows that government supplies manure to the SHFs. The SHFs use the manure to improve quality of soil nutrient and chemicals to get rid of the pests that plague on tomatoes (*Solanum lycopersicum*) as well as other crops for food production. The importance of this practice therefore requires that the accessible farm inputs should be shared among the SHFs, as illustrated in the excerpts below:

5.1.6 Planting improved varieties (seedlings or crops)

kodwa uhulumeni uqalileke ukusinika ngoba mhla elethe utamatisi lo afika nawo, esinika wona, wasinika imithi, namanje njengoba kade sinikwa nje umanyolo. ......
.... but the government has started giving us because when he gave us tomatoes, he gave us chemicals too. Even now we have been given manure to share……
Inhiangano esiyingenelile i-coop iyona esisizayo iphinde isinike umguba ovela kuHulumeni iphinde isilethele amkhemikhali. Kuyimanje sizogala ukubona ukuthi kwenzekani
The association that we have joined is CO-OP it is the one that helps us and gives us manure from government and gives us chemicals. As from now on, we will see what else they give us.

This category refers to the set of people that use the new types of crops to replace the old variety of crops for maximum yields. The planting of improved varieties of crops, as found in this study, is consistent with the findings in previous studies in countries such as Ghana (Denkyirah et al., 2017), Nigeria (Lawan, 2013), Uganda and Tanzania (Kinuthia & Mabaya, 2017). In South Africa the farmers' practice of planting improved seedlings is mainly used for crop production, income generation and adaption to drought (Belete et al., 2016; Senyolo et al., 2018; Ubisi et al., 2017). Similarly, in Ghana (Denkyirah et al., 2017; Dinye & Ayitio, 2013), Bangladesh (Eyasmin et al., 2017) and Nigeria (Lawan, 2013), it is used for the purpose of high crop production. In Malaysia it is used as a strategy of adaption to the impacts of climate change (Masud et al., 2017).

The finding in this study shows that uMsinga SHFs plant improved varieties of seedling for high yield crop production. The SHFs plant the improved seedlings to minimize impacts of climate change like drought, plant pest and diseases on their crops. It should be noted that the drought, plant pest, and diseases exist before now but they increase rapidly in recent time beyond the SHFs use of conventional method to predict occurrence. This often prompts the SHFs' struggle to get the improved seedlings from government approved locations in places like Pietermaritzburg through extension officers attached to oversee their work. This is because the SHFs have limited access to the improved seedlings. In addition, the extension officer who was part of our community forum meeting as earlier mentioned, confirmed that the SHFs make efforts to buy the improved seedlings from a distant place for planting as illustrated in the excerpts below:

... Asiwatholi amadonashini nakumasipala imbala. Kodwa uHulumeni usinika otamatisa nezitsha lo kanye namakhemikhali, bese siyahluka niselana phakathi kwethu. ......
...We don't get donation from any person even from the municipality. But the government provide tomato seedlings and chemicals which we share among ourselves. ……
Bathenga izimbewu nomanyolo ngo R2500 endaweni yase Pietermaritzburg. Ngakho thina (extension officers) siyabasiza ngemoto yokuthi bakwazi ukulanda umanyolo kanye nembewu
They buy the seedlings and fertilizer R2500 from Pietermaritzburg so we (extension officers) help them with transport to collect the fertilizer and seedlings.
...Izito esizidingayo izinto ezizosisa imbewu ....
...what we need are the crops (improved seedlings)................

5.1.7 Planting locally improved seedlings

This category refers to the set of local crops that are bred to minimize the negative impact of nature on the old seedlings, in order to produce high yields (Abadassi, 2013). The planting of local improved seedlings as found in this study, is consistent with the findings of studies done in Nigeria (Oseni, 2010) and Republic of Benin (Abadassi, 2013). In Benin the farmers practise the planting of locally improved seedlings for the purpose of yielding high crop production in unfavourable conditions (Abadassi, 2013). Similarly, in Nigeria, it was to improve income generation and crop production (Oseni, 2010).

The data shows that in uMsinga in 2018, the planting of the local improved seedlings was going to begin in December 2018. It is a new practice that the community together with the extension workers were going to embark upon in December 2018. The purpose of planting the new local improved seedlings is to have crops that are highly resistant to peculiar local climate change threats and increase crop production. The planting will follow a given procedure to afford both the SHFs as well as extension officer a chance to discover and learn new things, which may be challenging, as illustrated in the excerpt below:

Bathenga izimbewu …… ....
They buy the seedlings and fertilizer R2500 from Pietermaritzburg …… .... We do have the new local improved seedlings now which follow the procedures for producing seedlings.

In summary, this section identified seven categories of CSA practice that uMsinga SHFs practise, namely: multiple cropping, crop rotation, irrigation farming, farming near rivers, using chemicals/manure to fertilize soil for maximum yield, planting of improved varieties, and planting of improved local varieties. It was significant to understand that all the seven categories identified fell within the 17 identified CSA practices prevalent in South Africa. It is therefore necessary to understand what informs these categories of CSA practice amongst uMsinga SHFs. This is discussed in the subsequent section.

5.2 Factors informing the SHFs' use of a particular CSA practice and their resultant consequences

The concern in this section is to explore the factors that informed the uMsinga SHFs' adoption of the above-mentioned CSA practices as well as their resultant consequences. In this regard, the theory of irrigators' planned behaviour (TIPB) (Wheeler et al., 2013) was employed to understand and explain the challenges that inform the SHFs' agricultural practices in the face of climate change for food production. The five constructs: physical; financial, natural, human and social capitals, offered by TIPB, were found to be relevant in not only understanding the SHFs' adoption of CSA to reduce the impacts of climate change, but also bring to the fore the unintended consequences brought about by the chosen practices. As previously discussed in section 3.1.2.3 of Chapter 3 in this study, physical capital is regarded as a construct that addresses factors that include the size and type of farm, land composition, the technology used, the size of water entitlement and usage, basic farm infrastructure, irrigation canal, televisions, vehicles, mobile phones etc (Donkor et al., 2018; Rakodi, 2014; Vasco et al., 2018; Wheeler et al., 2013). Similarly, financial capital (FC) is regarded as the variables that include productivity change, net farm operating surplus, farm debt and equity, off farm work, access to credit, marketing opportunities, access to farm inputs and so on (Donkor et al., 2018; Rakodi, 2014; Wheeler et al., 2013). Likewise, natural capital (NC) is referred to as the variables that include rainfall, water availability and other environmental factors like temperature, soil fertility, pollination, oxygen and climatic factors (Chen et al., 2018; Wheeler et al., 2013). In addition, human capital (HC) has factors that include farmers' characteristics like age, gender, education and the length of time spent in farming activities (Luvhengo & Lekunze, 2017; Rakodi, 2014; Wheeler et al., 2013). Also, social capital (SC) variables are regarded as the SHFs' membership of different groups and networks used as sources of their information (Donkor et al., 2018; Rakodi, 2014; Wheeler et al., 2013).

The results of this study show that seven factors seem to inform the SHFs' CSA practices, namely:

(i) Flooding;
(ii) Unpredictable weather conditions;
(iii) Drought;
(iv) Lack of infrastructure (pump, pipes, etc.);
(v) Lack of funds to maintain irrigation farming infrastructure;
(vi) Problem of pests and diseases; and
(vii) Low crop yields.

Furthermore, the analysis shows that in exploring these factors, other unintended consequences come to the fore as a result of a particular CSA practice. This relation amongst the uMsinga SHFs' CSA practice, the factors that inform the practice as well as the unintended consequences as a result of the practice, are captured in Table 5.2 below. TIPB is used to make sense of both the factors influencing the uMsinga SHFs' practices as well as the resultant consequences. The factors informing the SHFs' choice of CSA and their corresponding classifications using TIPB is presented in Table 5.1.

Table 5. 1: Factors Informing uMsinga Choice of CSA Practice and their Classification

Factors informing the practice	Analysis/Classification of challenge faced, using TIPB
Flooding	Natural capital
Unpredictable weather conditions	Natural capital
Drought	Natural capital
Lack of irrigation infrastructure	Physical capital
Lack of fund to maintain irrigation infrastructure	Financial capital
Problem of pests and diseases	Natural capital
Low crop yield	Natural capital

The findings in this study show that three out of the five TIPB capitals are prevalent, namely: natural, physical and financial capital. These three capitals are the major climate change challenges facing uMsinga SHFs. Despite their attempts to mitigate these challenges with the chosen CSA practice, the SHFs experience unintended problem from the practices. The unintended challenges and classifications using TIPB are presented in Table 5.2.

Table 5. 2: Factors informing the SHFs' use of a particular CSA practice and their resultant consequences

CSA Practice	**Factors informing the practice**	**Analysis/classification of challenge faced using TIPB**	**Unintended challenge[a] as a result of the practice**	**Analysis/classification of challenge faced using TIPB**
Using multiple cropping	Flooding	Natural capital	Lack of know how in dealing with flooding	Human capital
Using crop rotation	Unpredictable weather conditions	Natural capital	Lack of know how to forecast weather condition of the environment	Human capital
Using irrigation farming (local canals)	Drought	Natural capital	Lack of resources to maintain the irrigation system and	Physical capital
	Lack of irrigation infrastructure	Physical capital	Lack of funds to maintain irrigation infrastructure	Financial capital
Farming near rivers	Drought Lack of funds to maintain irrigation infrastructure	Natural capital Financial capital	Lack of know how to forecast weather condition of the environment	Human capital
Using chemicals/manure for maximum yield	Problem of plant pests and diseases	Natural capital	Lack of financial resources to purchase the seedlings, and	Financial capital
	Low crop yields	Natural capital	Dependence on the government/extension workers to supply.	Social capital
Planting improved varieties (seedlings/crops)	Low crop yields	Natural capital	Lack of financial resources to purchase the seedlings and	Financial capital
	Drought	Natural capital	Dependence on the government/extension workers to supply	Social capital
	Problem of plant pest and diseases	Natural capital		
Planting local improved seedlings	Low crop yield Drought Problem of plant pest and diseases	Natural capital Natural capital Natural capital	Lack of scientific know how	Human capital

Note. [a]The unintended challenge used here means the challenge that the SHFs do not envisaged or planned for in their agricultural practices.

The resultant consequences of the SHFs' CSA practices and the sense drawn, using TIPB, are discussed below.

5.2.1 Use of multiple cropping to mitigate flooding and its consequence

Flooding is defined as any occurrence of water submerging an area that is normally dry (Adame & Miller, 2016). In the context of this study, the covering of crops, normally planted on dry land, with water over a period of time could be regarded as flooding or water logging (FAO, 2016). The results of this study indicate that flooding inform the practice of multiple cropping practised by uMsinga SHFs. A number of studies (Mubaya, Njuki, Liwenga, Mutsvangwa, & Mugabe, 2010; Smith, Simelton, Duong, Le, & Coulier, 2017; Williams et al., 2016) in Vietnam, Lao PDR, Cambodia, Zambia, Zimbabwe, and South Africa show that SHFs face the challenge of flooding. An experimental study conducted by Iijima et al. (2016) reveals that farm flooding could be mitigated with multiple cropping.

To adapt to flooding, the uMsinga SHFs plant multiple species of crops. This practice is to deal with flooding by planting crops that could produce high yield under the negative condition of excess water, as illustrated in the excerpt below. This practice helps the SHFs adjust quickly to impacts of climate change for food production. However, the unintended challenge of practising multiple cropping is lack of "know-how" to deal with flooding amongst the SHFs. This is because SHFs need to know the crops to be planted in an area prone to waterlogging.

Ziyisithupha (six) zitshalo. Ubhatata, ummbila, amazambane, amaklabishi, amabhathanathi, otamatisi. ... Kuba ngamachibi utamatisi awufuni amanzi amaningi.
There are six crops that we grow: sweet potatoes, maize, potatoes, cabbage, butternuts, tomatoes ...but water become too much to flood the tomato, the tomato does not need much water.
Sihlushwa amanzi, siyawakhiphe emuva kwezinso ku ezintathu ngoba isuk esemaningi. Ezinye izitshalo ziyonakala aziwafuni amanzi amaningi, ezinye siyawasusa amanhla muu azo. Amanzi ayamosha, kuncono uthele aman cane.
On water as well, how to remove water in the fields after three days as it becomes flooded (water logging) is a problem… The plants get spoilt because some of the plants don't want water, some will have their leaves peeled off. Water destroys, it is better if you don't pour a lot.
.... Ipulazi iba yizikhukhula phansi kanti utamatisi awuthandi imvula enkulu...

…The farm becomes flooded on the ground and tomato doesn't like too much rain…
….. Njengebhontshisi, ayifuni amanzi amaningi, ngoba ngisho neklabishi ayifuni amanzi amaningi kakhulu, ngoba uma ilanga emva kwemvula eyengeziwe, amanzi angaphakathi / phezulu kwesitshalo azophekwa bese uphahla iklabishi yonke. Njengoba ubona, insimu igcwele amakilabhu aphelile....
…. Even beans don't want too much water, also cabbages don't want too much water, because when it is sunny after excess rainfall, the water that is inside/top of the crop will be overheated and spoil the whole cabbage. As you see, the field is full of cabbages that are spoilt….

Using TIPB, lack of "know-how" can be classified as a human capital need facing uMsinga SHFs resulting from the choice of multiple cropping.

5.2.2 Use of crop rotation to mitigate unpredictable weather conditions and its consequence

Unpredicted weather condition describes the inability of individual(s) to determine the weather condition of a given environment (Okem & Bracking, 2019). The results of this study indicate that unpredictable weather conditions inform the practice of crop rotation practised by uMsinga SHFs. A number of studies (Makeleni et al., 2018; Masud et al., 2017; Wahab & Popoola, 2018; Williams et al., 2019), in Nigeria, Malaysia and South Africa have shown that unpredictable weather conditions, like those posed by climate change, is a threat to crops. Crop rotation can be used to mitigate the effects of unpredicted weather condition, such as crop diseases (Rakshit, 2019).

To adapt to unpredictable weather patterns, the SHFs plant varying species of crops in the summer and winter seasons, as illustrated in the excerpt below. As seen in the excerpts, tomatoes (*Solanum lycopersicum*) and cabbage (*Brassica oleracea*) do better in winter and other crops are grown in raining season. The reasons are to improve high crop yields, increase incomes and minimize the poor production of crops. Despite the use of crop rotation, there is lack of know how to predict the weather condition of uMsinga amongst the SHFs. This is because rain falls after the SHFs irrigate, as illustrated in the excerpt below. However, the limiting factor as a result of uMsinga SHFs' use of crop rotation is their lack of know how to forecast the weather conditions of the environment.

....Yilokhu esikutshalayo. Isikhathi esiningi uma kungutamatisi, ezinye izitshalo ezinjengekabishi zenza kancono nawo ngapahandle kwesikhathi sezimvula ezinkulu lapho zingamoshakala. Kodwa ebusika, zenza kancono ngoba kusuke kunenzimvula ezincane.
. .... This is what we plant. Most of the time, if we plant tomatoes and other plants like cabbage, they do better except during the period of heavy rain when it comes to ruin crops. But in winter, it does better when there is scanty rain.
Mina ngokwami ngibhekene nale nkinga yokubikezela sezulu ngempela, ngoba nginisela futhi emva kwesikhathi imvula izamatamatisi zami zithatha futhi zife, zifa ngoba angazi ukuthi izokuvula noma cha.
I personally face that problem of weather prediction indeed, because if I irrigate and it later rains, then my tomatoes get spoilt and die, they die because I don't know if it will rain or not.

Using TIPB, lack of "know-how" can be classified as a human capital need facing uMsinga SHFs resulting from the choice of crop rotation.

5.2.3 Use of irrigation farming (local canals) to mitigate drought and lack of infrastructure as well as its consequence

This category addresses using irrigation farming to mitigate impact of drought and lack of irrigation infrastructure. Drought is referred to as shortage of rainfall over a period of time, causing water scarcity (Solh & van Ginkel, 2014). Similarly, the report of Intergovernmental Panel on Climate Change (IPCC) defines drought as "a period of abnormally dry weather long enough to cause a serious hydrological imbalance" (Field et al., 2012, p. 167). The results of this study indicate that drought and lack of irrigation infrastructure inform the practice of irrigation farming practised by uMsinga SHFs. A number of studies (Chami & Moujabber, 2016; Hassan Gana, Fullen, & Oloke, 2019; Mubaya et al., 2010; Sinyolo et al., 2014; Ubisi et al., 2017; Williams et al., 2016; Zhang & Brown, 2018) show that drought is a threat to SHFs in Zambia, Zimbabwe, Nigeria and South Africa. On the other hand, irrigation facilities like dams, canals, ditches to guide flow of water, electric water pumps and piping are used as infrastructure in irrigation farming (Parry, Rosenzweig, Iglesias, Livermore, & Fischer, 2004; Zhang & Brown, 2018). Irrigation infrastructure is found lacking amongst the SHFs in this study. Previous studies (Abeywardana, Schütt, Wagalawatta, & Bebermeier, 2019; Wang, Huang, Wang, & Findlay, 2018; Williams et al., 2016; Zhang & Brown, 2018) in Sri Lanka, Chain and South Africa show that outdated irrigation facilities are still in use. According to the Food and Agriculture Organization of the United Nations (FAO) report, drip irrigation could be used to mitigate drought (FAO, 2016)

To adapt to drought and challenge of poor irrigation infrastructure, the SHFs practise irrigation farming using local means. The SHFs mitigate drought by using irrigation farming which allows the flow of water through ditches from the UThukela River into the crop fields. This practice mitigates the challenge of drought and lack of irrigation infrastructure facing the SHFs as illustrated in the excerpts below. However, the unintended challenge for uMsinga SHFs as a result of using irrigation farming (local canals) is the lack of resources to maintain the irrigation system and lack of funds to maintain the irrigation infrastructure.

Isizathu salokho senziwa ukuthi amanzi siwadonsa ezansi oThukeleni ngenjini, kufanele ihambe lenjini iyowahlanzela noma iyowakhiphela ngenhla, manje ke thina asinazo lezi lokhu… manjeke sakhanda indlela kanjena ukuthi kufanele iye emasimini, ngobasiwafake lana, sihamba siwafaka ezikhaleni, asinawo amanzi ezinyoni.
The reason for this (inadequate irrigation) is because we get water flowing downhill using the engine from the uThukela and it spreads the water uphill. Now, we don't have these things (materials)… we made a way that goes to the fields, and put it the water in between, we don't have enough for proper pipes to irrigate.
Namazike, sinenkinga yamanzi. Kukhona injini endala eyafa, engasasebenzi.
And water, we have problems with water. The engine we are using is small, there is the old one which is no longer working.
Ukushisa kwelanga nokwenyuka kwamazinga okushisa kuyasiphazamisa kodwa uma kwenzeka siyaye sinisele......
A sunny day (increased temperature) disturbs us but when it does we irrigate......

Using TIPB, lack of resources to maintain the irrigation system can be classified as a physical capital need and lack of funds to maintain the irrigation infrastructure as a financial capital need facing uMsinga SHFs as a result of the choice of irrigation farming.

5.2.4 Farming near rivers to mitigate drought and lack of funds to maintain irrigation infrastructure as well as its consequence

This category refers to the financial incapability of SHFs to maintain irrigation infrastructure. It could be expressed as lack of access to credit from financial institutions (Dube, Dlamini, Farinde, & Tsikati, 2019), lack of access to financial support (Kiarie, 2016; Tshoni, 2015) and inadequate budgeting or lack of budgeting (Kywe & Aye, 2019). The results of this study indicate that lack of funding to maintain irrigation infrastructures inform the practice of farming near the UThukela practised by uMsinga SHFs. A number of studies (Checkol &

Alamirew, 2008; Oates, Mossello, & Jobbins, 2017) (Oates et al., 2017) have shown that the lack of fund affects the maintenance of irrigation infrastructures in Ethiopia and Tanzania. Farmers in Limpopo mitigate drought and overcome the challenge of funds to maintain irrigation infrastructure by clearing canals that carry water from near their river into their farm for irrigation (Nethavhani, 2013).

To adapt to the problem of drought and lack of funds to maintain irrigation infrastructure, the uMsinga SHFs practise farming near River UThukela. The SHFs look to government for financial assistance to fix their faulty pumps and poor piping to convey water from the river into the fields, as illustrated in the excerpts below. The practice of farming near the river mitigates the problem of drought and enables the growing of crops round the year. It also mitigates the problem of the lack of funds to maintain irrigation infrastructure amongst the SHFs in order to improve food production in the face of climate change. However, the unintended challenge as a result of farming near rivers uMsinga SHFs is lack of know how to forecast the weather condition of their area. This is because the SHFs need this knowledge to predict rainfall and plant appropriate crops which required less water supply from near river.

Uma bengasilekelela njengoba sesiyikhiphile safuna umuntu ozoyikhanda, uyadula kakhulu, asinawo amamdla okumkhokhela, uma uhhulumeni engasilekelela, kuthi lezi njinyana usikwekweleza ngazo kanjena bese sezi lekelelwa ile endala, le endala iyawgcwalisa umsele.
If they can help us as we have taken it (the pump) out, when we look for someone to fix it, his price is expensive, and we don't have enough for the person who will fix it for us. If only government can help us with these small engines and the old ones will assist in irrigating.
Uthola ukuthi bayawuvala umthombo beekugcina izitshalo zethu zimoshakala sigcina sinagazi ukuthi ukuthi sonisela kanjani ngoba awasekho amanzi anele. Amanzi aqhamuka kude kunathi kanti yiwo futhi lamanzi asetshenziswa ngumphakathi. Uma sesizama ukuthi sifafaze endaweni yethu uthola ukuthi awasafinyeleli. Kuyenzeka ukuba sibe nesdingo samanzi.
…… And you will find out that even neighbouring farmers closer to the river block water channel to our farm area, then our plant will be spoilt. We end up not knowing how to irrigate, because the water is no longer enough for us here, water comes from far off and they supply to all these people next to us. When it needs to spread to our own side, we will not be able to have it. It happens indeed that we will be in need of water.

Kuyenzeka ukuthi sidinge amanzi kodwa kunezikhathi. .... Syahamba siyowakha kude osukwini bese ebusuku silala lana silinde amanzi. Izitshalo zigcina sezifa ziphele uma sitshalile.
It happens that we need water but there is time (for it)....We go to fetch water far off during the day, then in the night we will sleep here waiting for water to wet our crops so that it will not end up drying and being lost.

Using TIPB, lack of know how to forecast weather condition of the environment can be classified as a human capital need facing uMsinga SHFs, resulting from the choice of farming near the river.

5.2.5 Using chemicals/manure to mitigate low crop yields, the problem of plant pests and diseases as well as the consequence of this practice

This category refers to use of chemicals like fertilizers and pesticides in order to improve crop production (Masud et al., 2017; Nyiraruhimbi, 2013). The term low crop yield refers to a decrease in crop production (Guodaar et al., 2019). The results of this study indicate that low crop yields as well as the problem of pest and diseases inform the uMsinga SHFs' practice of using chemicals or manure for maximum crop production. A number of studies (Guodaar et al., 2019; Mbatha & Masuku, 2018; Shah, Zhou, & Shah, 2019; Tovihoudji, Akponikpè, Agbossou, & Bielders, 2019) in Republic of Benin, Ghana and Pakistan have shown that use of chemicals mitigates low yield in crop production and the challenge of plant pest and diseases.

Thus the SHFs fumigate the tomato (*Solanum lycopersicum*) crop with chemicals to prevent pests and diseases. Other chemicals, like fertilizer, were demanded by the SHFs from government, as illustrated in the excerpts below. These practices were aimed at improving food production and increasing the incomes of the SHFs. However, the unintended challenges as a result of using chemicals/manure by the SHFs are the lack of financial resources to purchase the chemical, and dependence on the government/extension workers to supply.

Izito esizidingayo umanyolo, izitshalo ezizosisa imbewu.
What we need are manure, the fertilizer.
Sinabo abeluleki futhi bayasisiza kodwa abasisizi kangakho njengoba bengenawo amandla okuthi basinike imali yokuthi sithenge imithi asiyidingayo.

We have advisers and they help, but they don't really help much since they don't have the ability to give us money to buy the chemicals that we need.
Utamatisi… angisho nje ukuthi utamatisi unezifo eziningi ezinye zazo asiqondi ukuth yini esingayisebenzisa ukuzivimbela.
Tomatoes… let me just say that tomatoes have lot of diseases and, for some of them, we can't understand what we can use to inject (prevent) it.
Zonke lezi zifo zingena emaqabungeni, njengoba ubona umbila, uba phuzi bese ungasakhiqizi lutho.
All these (disease) get into leaves, like when you see maize meal, it will be yellow and end up producing nothing.
….. Cha, lesi sifo sasingekho ngaphambili. Lesi sifo soma i-peciolo (petiole) bese senza (utamatisi) ukuba sibe nebala khona-ke utamatisi uzoba owomile.
….. No, this disease wasn't existing before. The disease dries up the petiole and makes it (tomato) to have spot, then the tomato will be dry.

Using the frame work of TIPB, lack of financial resources to purchase the seedlings can be classified as a financial capital need and the dependence on the government/extension workers a social capital need facing uMsinga SHFs, resulting from the choice of using chemicals/manure for maximum yield.

5.2.6 Planting improved varieties (seedlings/crops) to mitigate low crop yield, drought, and the problem of plant pest and diseases as well as its consequence

This category refers to use of improved seedlings to overcome challenges of low yield, drought and pest for food production in the face of climate change. A low yield of crop means poor or limited production of crops during harvest. "Plant pest" is defined as an organism or substance that "can directly or indirectly injure or cause disease or damage in or to any plants or parts thereof, or any processed, manufactured, or other products of plants" (US Department of Agriculture, 1987). The results of this study indicate that low crop yields, drought as well as the problem of pest and diseases inform the uMsinga SHFs' practice of planting improved seedling. A number of studies (Didarali & Gambiza, 2019; Guodaar et al., 2019; Mbatha & Masuku, 2018; Shah et al., 2019; Zwane & Nekavhambe, 2019) in Ghana and South Africa show that SHFs face problem of low crop yields, drought and plant pest and diseases. A recent study (Ghanbari & Kordi, 2019) has shown that improved cucumber seedling could mitigate the problem of low crop yields due to chilling stress effect[7]. Similarly, improved seedlings have the propensity to mitigate drought, water logging and the effects of warm/cold weather conditions (FAO, 2016).

To mitigate the problem of low crop yield, drought as well as plant pest and diseases, the uMsinga SHFs practise the use of planting improved seedlings. The purpose of this practice is to increase high yields in crop production as crops resistant to drought, plant pests and disease are planted by the SHFs. The lack of financial resources to purchase the seedlings prompts the SHFs to request a regular supply of the improved crops from government as illustrated in the excerpts below. However, the unintended challenges as a result of planting improved seedlings by the SHFs are lack of financial resources to purchase the seedlings and dependence on the government/extension workers to supply.

…Asiwatholi amadonashini nakumasipala imbala. Kodwa uHulumeni usinika otamatisa nezitsha lo kanye namakhemikhali, bese siyahluka niselana phakathi kwethu.
…We don't get donation from any person even from the municipality. But the government provide tomato seedlings and chemicals that we share among ourselves.

Using TIPB, lack of financial resources to purchase the seedlings can be classified as a financial capital need and dependence on the government/extension workers to supply as a social capital need facing uMsinga SHFs, resulting from the choice of planting improved seedlings.

5.2.7 Planting locally improved seedlings to mitigate low yield, drought, and problem of plant pest as well as its consequence

This category refers planting of locally improved seedlings to mitigate low yields of crops, drought and plant pests. The results of this study indicate that these factors have led to the planting of locally improved seedling practised by uMsinga SHFs. A number of studies (Abadassi, 2013; Oseni, 2010; Ouedraogo et al., 2016; Sastrapradja & Balakhrishna, 2001) in Burkina Faso, Republic of Benin, Sri Lanka and Nigeria show that challenges of low crop yield, drought, as well as plant pest and diseases led to planting of locally improved seedlings.

[7] Chilling stress refers to temperatures between 15° C down to 0° C (Lindstrom & Carter, 1985; Yang, Kong, & Xiang, 2009). This temperature affect growing crops negatively (Yang et al., 2009).

In uMsinga, this practice helps the SHFs as these crops are resistant to the impacts of climate change like drought, outbreak of plant pests and diseases. This purpose has prompted the implementation procedure to start planting of the local improved seedlings in December 2018. The planting procedure might also help mitigate climate change threats in uMsinga, as both the SHFs and extension officers increase their knowledge on adaptation as illustrated in the excerpt below. However, the unintended challenge as a result of planting local improved seedlings by the SHFs is lack of scientific know how.

Bathenga izimbewu nomanyolo ngo R2500 endaweni yase Pietermaritzburg. Ngakho thina (extension officers) siyabasiza ngemoto yokuthi bakwazi ukulanda umanyolo kanye nembewu. Sesinazo izithombo ezintsha zasendaweni ezithuthukisiwe manje sesilandela imigomo yokuzikhiqiza. Ukutshala kuzoqala kusukela ngo December (2018). Thina (extension officers) sisafunda kubo (SHFs) ukwazi uma lembewu entsha izikokwazi yini ukumelana nezifo kanye nezinambuzane okanye ngeke.
They buy the seedlings and fertilizer for R2500 from Pietermaritzburg so, we (extension officers) help them with transport to collect the fertilizer and seedlings....We do have the new local improved seedlings now which follow the procedures for producing seedlings. The planting date will start from December (2018). So we (extension officers) are still learning from them (SHFs) to know if the new local breeds will be resistant to diseases and pests or not.

In terms of TIPB, lack of scientific know-how can be classified as a human capital need facing uMsinga SHFs resulting from the choice of planting local improved seedlings.

5.3 Summary of findings of first phase of preliminary study

This chapter presented the analysis of the first phase of preliminary study. The study revealed that uMsinga SHFs follow seven categories of CSA practice, namely: multiple cropping, crop rotation, irrigation resources, farming near rivers, using manure to fertilize soil for maximum yield, planting of improved varieties, and planting of improved local varieties. The study further identified seven categories of challenge militating against food production in uMsinga. These include: flooding, unpredictable weather conditions, drought, lack of infrastructure (pumps, pipes, etc.), lack of funds to maintain irrigation farming infrastructure, the problem of pests and diseases, and low crop yields. The study further pointed out seven unintended challenges or limitation that result from each of the practices as listed above. These include: lack of know how in dealing with flooding; lack of know how to forecast weather condition of the environment; lack of resources to maintain the irrigation system; lack of funds to maintain irrigation farming infrastructure; lack of financial resources to purchase the seedlings; dependence on the extension workers to supply them; and lack of scientific know how, respectively.

The study therefore posits that, following the TIPB, flooding can be classified as a natural disaster to be mitigated through the use of multiple cropping. Similarly, unpredictable weather conditions can be classified as a natural disaster to be mitigated through the use of crop rotation. Furthermore, drought and poor irrigation facilities can be classified as a natural disaster and lack of physical capital respectively to be mitigated through the use of an irrigation system. Additionally, lack of funds to maintain irrigation infrastructure and drought can be classified as a financial capital need and natural disaster respectively, to be mitigated through the use of farming near river. Likewise, low crop yields as well as plant pests and diseases can be classified as a natural disaster which are to be mitigated through the use of chemicals/manure for maximum yield. More so, low crop yield, drought as well as problem of plant pest and diseases can be classified as a natural disaster to be mitigated through planting improved seedlings, including locally improved seedlings.

CHAPTER 6

PRESENTATION AND ANALYSIS OF RESULTS ON THE PRELIMINARY STUDY – PHASE 2

The previous chapter, Chapter 5, presented the analysis of the first preliminary phase, which was guided by the following question and sub-questions:

What are the uMsinga SHFs' existing agricultural practices in relation to climate change adaptation?

a) What do they do?
b) How do they do it?
c) What informs what they do?

As mentioned in Chapter 5, section 5.1, climate smart agriculture (CSA) is practised by uMsinga SHFs. Despite following these practices, the findings show that uMsinga SHFs face varying degrees of challenges in the areas of financial, natural, human and physical capital. This affirms the claim of Sullivan et al. (2012) that CSA alone is inadequate to solve SHFs' problems in the face of climate change. As such, this chapter seeks to ascertain uMsinga SHFs' attitudes towards the integration of ICT into their existing CSA practices and how this integration will help in alleviating the challenges experienced by the SHFs. The unified theory of use and acceptance of technology (UTAUT2) (Venkatesh et al., 2012) was employed to understand the significance the uMsinga SHFs attach to the use of ICT in their CSA practices. The seven constructs: hedonic motivation, habit, price value, performance expectancy, effort expectancy, facilitating condition, and social influence offered by UTAUT2 were found to be relevant in understanding the SHFs' adoption of ICT as a climate change adaptation strategy to reduce impacts of climate change.

Thus this chapter is guided by the following main question and sub-questions:

Do SHFs in uMsinga regard the integration of ICT and CSA into their existing agricultural practices as crucial for adequate food productivity and livelihood in the face of climate change adaptation?

a) If so, or if not, what informs their perceptions?

b) If not, what informs their perceptions?

To address the above questions, the chapter will be divided into three sections, namely, sections 6.1 to 6.3.

- **Section 6.1** will seek to understand the regard of the SHFs for the intersection between ICT and their CSA practices
- **Section 6.2** will explore the factors that inform the SHFs' decision for the intersection between ICT and their existing CSA practices
- **Section 6.3** will provide a summary of the preliminary phase two findings.

This current section thus presents the analysis of the findings on uMsinga SHFs' attitudes towards the intersection between ICT and their CSA practices.

6.1 Do SHFs in uMsinga regard the integration of ICT and CSA into existing agricultural practices as crucial for adequate food productivity and livelihood in the face of climate change?

In this context, "integration" refers to the combination of ICT and CSA practices. The term "integration" is used as incorporation, interfacing and intersection in this study. Thus, this section presents the statements made by the uMsinga SHFs about the integration of ICT into their agricultural practices. In order to understand the nature of their concerns, the SHFs were engaged at a community forum meeting to discuss this intersection. As mentioned in the introduction of Chapter 5, the preliminary study forum meeting interview protocol (PSFMIP)) (see appendix C) was used to generate data.

From the excerpts below, the uMsinga SHFs positively regarded the integration of ICT into their CSA practices. This concern was raised in our discussion. This result indicates that uMsinga SHFs positively regarded integration of ICT into their CSA practices. This integration is necessary to alleviate the SHFs' unintended challenges resulting from their CSA practices. The SHFs commented that it will be helpful if the integration is implemented, to predict the weather and as well to sell their farm produce to prevent spoilage, as illustrated in the excerpts below. This implies that the SHFs regard the intersection between ICT and CSA as crucial. However, a paucity of study exists on the attitudes of SHFs regarding the integration of ICT into CSA practices.

Despite the positive regard uMsinga SHFs have for the intersection between ICT and their CSA practices, there are two unintended challenges that may crop up. The unintended challenges are the SHFs limited literacy to utilise ICT devices and the lack of indigenous ICT-based agro-weather apps as illustrated in the excerpt below. The SHFs need ICT devices that could predict weather accurately and the knowledge to understand the tool without depending on individuals like extension officers.

Kungaba kuhle impela uma ungasitholela usizo (ngokuhlukanisa ICT kwi CSA. Ngokuthi mase usutshalile kumele kuthengiswe (kudayiswe), kungusizi ngoba akukho muntu owazi onako kuze kubole izitshalo, mekufika imoto izothenga wonke umuntu ufuna ukuyigodla mase izitshalo zethu zivuthwa zize zibole, kulokho okushoyo ngibonga kakhulu. Kunzima kakhulu.
It will be good indeed that you find (us) help (through the intersection of ICT into CSA). That, what you have planted should be bought (sold). It is sad if no one knows what you have until it gets spoilt or rotten, when someone comes with a car to buy, everyone claims him or her and your own get riper until it is rotten. On what you are saying, I thank you. It is very hard.
Kumele siwenze kanjani ukuze sibone isimo sezulu ukuze sizowazi ukuthi kuzonetha khona ngeke sinisele, kuzosisiza kakhulu….; izitshalo ziyabola ngoba ezinye zezitshalo aziwafuni amanzi, ezinye zazo zizoba nokhula elidinga ukususwa. Amanzi acekela phansi, kungcono mawungawafaki amanzi amaningi.
…what we will/must do is to see the weather forecast so that we will know when it will rain so that we will not irrigate, it will help us …The plants get spoilt because some of the plants don't want water, some will have leaves peeling off. Water destroys, it is better if you don't pour a lot.
Yebo sibonile isilekelela, ingakho ke sikudinga ukuthi Sibe nayo, ngoba sesiyakwazi ukubona imvula uma izo Netha noma ingazonetha.
Yes, we have seen that the weather app is helpful, that is why we need to own it, since we now can see if it will rain or not.
Yebo, ukugwema ukuchelela izitshalo ngenkathi imvula ina kunomthelela wezifo ezitshalweni. Siyalusebenzisa ulwazi lwezobuchwepheshe ukubheka ukuthi lizona yini noma cha noma nje singenabo omakhalekhukhwini nomabonakude abasezingeni ukuthola lolo lwazi. Sithembele emahhovisi ukuthi asinikeze ulwazi lwamazinga alindelekile esimo sezulu.
Yes, to prevent irrigating crops while the rain is falling, resulting in favourable conditions for diseases in crops. We use the ICT information to predict whether the rain is coming or not, although we do not have correct devices to source this information. We therefore depend on extension officers to give us weather forecast information.

In terms of UTAUT2, the limitations of literacy to utilise ICT devices can be classified as facilitating conditions and a lack of indigenous ICT-based agro-weather apps as a performance expectance that appears to hamper uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. The regard uMsinga SHFs have for the intersection between ICT and their CSA practices is informed by a variety of factors. These factors are discussed below.

6.2 What informs the SHFs' perception?

The previous section presented the analysis of the attitudes uMsinga SHFs had for the integration of ICT into their agricultural practices. The finding revealed that the SHFs regarded the intersection between ICT and CSA as crucial. Therefore, this section presents the category of factors that might possibly inform the perceptions of the uMsinga SHFs about adopting ICT into their agricultural practices. The data generated were analysed using unified theory of acceptance and the use of technology (UTAUT2) in order to make sense of what informs the decision of uMsinga SHFs (Venkatesh et al., 2012).

UTAUT2 consists of seven categories of constructs which could be used to understand and interpret the SHFs' perception on regard for integration of ICT into CSA practices (Venkatesh et al., 2012). These categories of factors include; hedonic motivation (HM), habit, price value (PV), performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions (FCD) (Venkatesh et al., 2012, p. 158). These constructs were used to analyse what informed the uMsinga SHFs' perception of their regard for ICT adoption into their agricultural practices.

The results of this study show that seven factors seem to inform uMsinga SHFs' regard for the intersection between ICT and CSA practices, namely:

(i) Enjoyment in the use of mobile phones;
(ii) Past experience of using mobile phones;
(iii) Network service charges;
(iv) Perceived usefulness of mobile phones;
(v) Perceived ease of use of mobile phones;
(vi) Perceived association with individuals; and
(vii) Perceived availability of supportive resources.

The seven categories of factors influencing the decision of the uMsinga SHFs' regard for integration of ICT into CSA practices and the sense drawn using UTAUT are discussed below.

6.2.1 Effects of enjoyment in the use of mobile phones on SHFs' ICT adoption

This category in this study is regarded as the pleasure which SHFs derive in the use of mobile phones to perform a particular task relating to farming activities. The category is referred to enjoyable service (Rahi et al., 2018) and hedonic motivation (Venkatesh et al., 2012). In this study, the pleasure in calling and using a mobile phone, was raised twice at the community forum meeting. This could be viewed as perceived enjoyment.

The category of HM refers to the fact that at the forum two SHFs stated that they enjoy calling individuals, advisor and buyers of farm produce on their mobile phone. This attests to experience of other SHFs present at the forum meeting. This category is illustrated in the excerpts below:

Yebo ngajabula kakhulu ukusebenzisa umakhalekhukhwini ngoba ngiyaxhumana nomuntu ohlala kude kunami.
.... Yes, I enjoy (using) it (cell phone) because I can communicate with a person that lives far away.
Yebo ngiyakuthokozela, ngiyakhona ukufona ngifonele Umeluleki, izimakethe kanye nabathengi.
.... Yes, I do enjoy it. I am able to call the advisor, the market and also other buyers.

The finding shows that the uMsinga SHFs enjoy using mobile phone to make calls. The use of mobile phones by the SHFs to call individuals like advisors and traders was to promote their agricultural activities. The SHFs commented that *I do enjoy* the use of mobile phones because I *call the advisor, the market and also other buyers*. This therefore gives the SHFs joy to perform such task. It can thus be said that pleasure derived from the use of mobile phones appears to be informing the SHFs' adoption of ICT into their CSA practices. This study is in line with findings Rahi et al. (2018) in Pakistan who reveal that enjoyment in the use of Internet banking positively informed ICT adoption. Similarly, recent findings (Beza et al., 2018) in Honduras, Ethiopia and India show that pleasure in the use of ICT slightly informs SHFs' adoption of mobile SMS. It can be argued that the finding of the present study might have significant implications for the uMsinga SHFs' adoption of ICT into CSA. Thus, using

UTAUT2, enjoyment in the use of mobile phones can be classified as a hedonic motivation that appears to have informed uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.2.2 Effects of past experience of using mobile phone on SHFs' ICT adoption

This category, in this study is regarded as past encounters that uMsinga SHFs have had with the use of a mobile phone, which may possibly encourage or discourage their use of ICT. It is believed that past experiences of the SHF in the use of mobile phones might form a new habit[8] (Venkatesh et al., 2012). The past experience of SHFs in this study is measured in terms of duration of the use of mobile phones like 'quite a while', 'quite some time' and 'for years'. As shown in the excerpts below, quite a while, quite some time and for years were raised.

The results thus indicate that past experience of uMsinga SHFs appear to be influencing their ICT adoption. The reason for this influence could be subjected to their consistent period of use and experiences that might have form a habit on the SHFs. This is evident in the SHFs comment that *I have been using a cell phone for quite some time now.* Based on the past experience of the SHFs, some have changed their phone from a basic mobile phone (BMP) to smartphone (SP) as illustrated in the excerpts below:

Sekuyisikhashana ngisebenzisa umakhalekhukhwini manje, ngoba ngaqala ngasebenzisa encane kodwa manje sengisebenzisa ethi ukuba nkulu.
I have been using a cell phone for quite some time now, as I started with a small one but now am using a bigger one.
Imnyaka eyisikhombisa ngesebenisa ifoni, umthelela Wakhona ukuthi, ngiyazi nge i-nthanethi, Whatsapp, Facebook, ngikhona ukuxhumana nabantu abaningi Abaseduze nabakude....
..... It has been for seven years now, the effect is that I now know about the Internet, Whatsapp, Facebook and I get to communicate with many people both nearer and afar.
...Sekuyisishathi khona ngisebenzisa umakhalekhukhwini ...
...It has been quite a while (that I have been using a cell phone) ....

The finding in this study shows that past experience of these uMsinga SHFs appears to be influencing the integration of ICT into their CSA practices. This is consonant with the findings in Venkatesh et al. (2012). However, it contrasts with the findings in Beza et al. (2018)

[8] A new habit is said to be formed after consistent repetition of an action over a period of time.

where it was found that past experience of use of ICT insignificantly informed the farmers' adoption of mobile SMS. This implies that past experience in the use of mobile phones grows with time and it could have implication on other factors like owing a smartphone, purchase of data bundles and capacity development of the SHFs. Therefore, using UTAUT2, past experience can be classified as a habit that appears to be informing uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.2.3 The effects of network service charges on SHFs' ICT adoption

This category in the study is regarded as a value that every network service provider attached to credit vouchers for customers like uMsinga SHFs to secure permission to use available services. The charges of the services are measured in monetary terms, known as price value (Venkatesh et al., 2012). In the context of this study, such services are obtained through recharging of airtime and purchase of data bundle. As shown in excerpts below, recharging airtime was raised thrice, while use of data bundle once.

The results thus indicate that network serve charges appear to be influencing uMsinga SHFs' ICT adoption. The purchase of airtime and loading within a particular network permit SHFs to make calls. This is evident in the comments that the SHFs made about buying and loading airtime on their phones to call traders as illustrated in the excerpts below. The SHFs buy airtime to access people like traders living far so as to sell their farm produce.

….umoya wamakhalekhukhwini uma ingane zingekho ngalezokhathi, ngoba angikwazi ukuzifakela yona ......ngibatholela bona(abathengi) ngoba ngiyabafonela.
…. I load airtime when the kids are around at that time, because I do not know how to recharge. ...I get them (customers) because of calling them.
....Yebo Ngiyakwazi ukufaka umoya kumakhalekhukhwini …ngiyayisebenzisa ukufonela abantu.
... Yes, I can recharge airtime .. I use it to call people.
Cha, izingane ezingifakela umoya kumakhalekhukhwini …ngoba ngiyakwazi ukukhuluma nabantu abahlla kude kakhulu.
No, the kids recharge the cell phone for me ...so that I can talk with people living far away.

The finding in this study shows that network service charges appears to be positively influencing uMsinga SHFs for the integration of ICT into their CSA practices. The result of this study is silent on inability of the SHFs to pay for airtime. This might imply that the SHFs could afford to pay for the airtime they use for both farming and other activities. Previous study (Beza et al., 2018; Venkatesh et al., 2012) indicated that service charges positively informed users' use of a technology. However, other findings (Oliveira et al., 2016; Rahi et al., 2018), found that the service charges negatively informed users' adoption of ICT. The authors inferred that service charges may be unnecessary in the context of their study. The result of this study has implications on government policy. The national policy on tariff for rural use in South Africa should be reconsidered in order to encourage the SHFs for successful adoption of ICT into agricultural practices. Therefore, using UTAUT2, network service charges can be classified as a price value that informs uMsinga SHFs' attitudes towards the intersection between ICT and CSA practice.

6.2.4 The effects of perceived usefulness of the ICT tool on SHFs' ICT adoption

This category, perceived usefulness of the ICT tool is regarded as the SHFs' views on the benefits of using ICT (Venkatesh et al., 2012). Three (3) categories of usefulness of ICT tools were raised, namely: calling traders, phoning/calling family, and the TV/radio agro-programme.

The results thus indicate that perceived usefulness of ICT tools appears to be influencing uMsinga SHFs' ICT adoption. The SHFs use mobile phones to call customers to buy their farm produce and to communicate with other farmers and their advisor. Furthermore, the SHFs watch TV and listen to radio for agro-weather information in the local language to know when to irrigate their crops as illustrated in the excerpts below:

Yebo ifoni yiyo esixhumanisa nabathengi, nabanye Abalimi nabeluleki advisor.
Yes, it is through the phone that we communicate with our buyers, other farmers and our advisor.
Kuzo zonke izihlobo zami ukwenza umzekelo nje, uma kukhona oshonole futhi nginomthengi ekumele ngimnake, ngixhumana naye ngomakhalekhukhwini bese ngidayisa izithsalo zami.
.... To call my relatives for example, if someone has passed away and when I have a customer (buyer), I would communicate via the cell phone, and sell my product (harvest).

…Yebo, ukhona umabona kude ekhaya futhi… ilenhlono endala yomagogo…. Kwesinye isikhathi asinaki uma bethula isimo sezulu sosuku olulandelayo… Ngenxa yalokho asibukeli umabonakude ukubona isimo sezulu noma ukuthola ulwazi olungasisiza ukuthi sichelele kanjani… Kuyinkinga impela kodwa siyayibuka sithole olunye ulwazi umabonakude uyasinika isiqiniseko sezinye izinto…
... Yes, there is a television at home and... but it's the old version for grannies ...At times we don't notice when the news announces the weather forecast ...Based on that you are not watching to get information for the next day and you irrigate …it is a problem but when you have watched it to get the information, you can be assured of the truth....
...Yebo (sinabo omakhalekhukhwini, omabonakude Kanye nemisakazo emakhaya),... Siyayilalela I SABC 1 ngesiZulu ukuze sibona isimo sezulu.
.... Yes (we have phone, television and radio at home) …We listen to SABC 1 in isiZulu for the weather programme.
Yini ekumlele siyenze ukuze sikwazi ukubona isimo sezulu ukuze sizokwazi ukuthi kuzonetha nini ukuze singeke sinisele, kuzosisiza kakhulu manje njengoba manje sekukhona omakhalekhukhwini abaseqopheleni eliphezulu.
... what ... we will/must do to see weather forecast so that we will know when it will rain so that we will not irrigate, it will help us; there are now smart phones.
Mina ngokwami ngibhekana nenkinga (yokuqagela isimo sezulu) impela ngoba ngiyanisela mase emva kwesikhathi kuyanetha mase otamatisi bami bayabola bafe, bafe ngoba angazi ukuthi lizonetha yini noma cha.
I personally face that problem (of weather prediction) indeed, because I irrigate and it later rain then my tomatoes get spoilt and die, die because I don't know if it will rain or not.

The result shows that the perceived usefulness of ICT tools appears to be informing the uMsinga SHFs' adoption of ICT into their CSA practice. A number of studies (Beza et al., 2018; Moya & Engotoit, 2018; Mugerwa et al., 2018; Rahi et al., 2018) have shown that perceived usefulness informed users' adoption of technology. This also aligns with a study in Buffalo City Municipality, South African by Hobololo and Mawela (2017), who found that perceived usefulness positively informed users' adoption of mobile devices. This finding has implication for the design of the ICT-based agro-weather app for rural communities in South Africa. This is because the SHFs must understand the usefulness of the app, otherwise, it may be useless after its design (Chammas et al., 2015; Damodaran, 1996). Thus, using UTAUT2, the perceived usefulness of ICT tool can be classified as a performance expectancy that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.2.5 The effects of perceived ease of use of mobile phones on SHFs' ICT adoption

In the context of this study, perceived ease of use is regarded as the SHFs' opinion on how easy it is to use ICT device like mobile phones with little or without assistance (Venkatesh et al., 2012). Two (2) categories of perceived ease of use were raised, perceived ease of use without assistance (WO/A) and perceived ease of use with assistance (W/A) amongst the SHFs at the community forum meeting discussion. The finding shows that the SHFs found the use of mobile phones easy to call farm produce buyers and others, though some of the SHFs have to depend on other important individuals (like children and fellow farmers) for assistance to use a mobile phone for a particular task. The dependence of the SHFs on others may probably be because of limited ICT literacy to use ICT tool as illuminated in the excerpts below:

Yebo (Ngithola kulula ukusebenzisa umakhalekhukhwini) zikhona izingane ezingisizayo.
Yes. (I find using cell phone easy), there are children that help me.
Ngiyakuthol mina kulula ngoba, okuningi sengikufundile. Ifoni ingifundisa izinto eziningi, naseskoleni ngakthola Okuningi ngefoni.
I do find it easy because I have learnt a lot. The phone teaches me a lot of things. I also learnt a lot at school about the cell phone.

Therefore, the study shows that the uMsinga SHFs found it easy to use the mobile phones both with and without assistance. This is partly consistent with the findings of Beza et al. (2018), which reveal that ease of use positively informed farmers' adoption of SMS. Similarly, the findings aligned with previous studies which showed that ease of use positively informed users' adoption of technology (Oliveira et al., 2016; Venkatesh et al., 2012). The implication is that the place of other individuals who matter to the SHFs in the rural area should not be underrated, in the adoption of ICT. Similarly, factors like perceived association with others and ICT literacy might have indirectly inform the SHFs' perceived ease of ICT use. Therefore, using UTAUT2, perceived ease of the use of mobile phones can be classified as an effort expectancy that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.2.6 The effects of perceived association with individuals on SHFs' ICT adoption

In the context of this study, perceived association with individuals refers to relationship with other important people, like family and friends who could motivate uMsinga SHFs to use

ICT (Venkatesh et al., 2012). The excerpt of our forum discussion reveals two categories of perceived association with other people important to the SHFs such as, children/kids and fellow farmers. Children's help was mentioned three times, whilst fellow farmers' help was raised once.

The finding shows that perceived association with individuals that matter appear to be influencing uMsinga SHFs to integrate ICT into their CSA practices. This is evident in comments of the SHFs that *kids recharge the cell phone for me.* It was added that *when I am in the field there are many people there* to help. Some of the factors responsible for the help has to do with visual impairment as illustrated in the excerpts below:

Yebo, ngoba laba abancane bazongisiza kumakhalekhukhwini kanjalo.
Jah, because the little ones will help on the phones as well.
Angazi ngempela (ukuthi ngizolungisa kanjani ubunzima enginabo ngokusebenzisa umakhalekhukhwini) ngane yami. Kwizimo ezinje ngiyazama ukubekezela, kodwa uma ngisensimini baningi abantu abangangisiza.
I really do not know (how to solve some of the hardships encountered when using cell phone) my child. In such cases I also try to cope, but also when I am in the field there are many people there, that could assist.
Izingane zi-ashana umakhalekhukhwini ngoba ezikhathini eziningi kuba nzima ukuba ngibone.
The kids recharge the cell phone for me...because at times I struggle with seeing.

The finding shows that there is strong reliance of uMsinga SHFs on children. This indicates that individuals who matter to the SHFs positively informed the SHFs' ICT adoption. This implies that failure to find assistant would have resulted into inability to use a mobile phone. This is consistent with recent studies that found association with other individuals positively informing users' adoption of technology (Oliveira et al., 2016; Rahi et al., 2018; Venkatesh et al., 2012). However, findings by Beza et al. (2018) show that association with individuals that matter only slightly informs farmer's adoption of mobile SMS. Thus, using UTAUT2, perceived association with other individuals that matter can be classified as a social influence that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.2.7 The effects of perceived availability of supportive resources on SHFs' ICT adoption

This category, perceived availability of supportive resources, is regarded as infrastructure which is accessible for SHFs to use ICT (Venkatesh et al., 2012). This infrastructure includes electricity to charge mobile phones and access to network service providers[9], among others. Two perceived available supportive resources, the issues of electricity and of network signals were each raised twice at our forum meeting.

The finding shows that perceived availability of supportive resources appear to be influencing uMsinga SHFs to integrate ICT into their CSA practices. The supportive resources, such as electricity and network service providers, are available for the SHFs to utilise. Though the SHFs have challenges with connectivity, they are not without access to people in their distant locations, as illustrated in the excerpts below:

Ubunzima kungaba ugesi ngoba iphelelwa ugesi noma Amandla ngezinye izikhathi, kodwa ayijwayele ukwenza njalo.
The challenge would be electricity, as it loses it power at times, but it rarely does so.
Yebo, kodwa ikakhulukazi umoya wokuxhumana.
Yes, but mainly the network.
Umoya wokuxhumana ongihlupha kakhulu mina.
It is the network that troubles me.

Thus, this finding shows the perceived availability of supportive resources inform uMsinga SHFs' positive regard for the integration of ICT into CSA practices. This is consistent with the findings in Beza et al. (2018) which reveal that the perceived availability of supportive resources unlikely informed the farmers adoption of mobile devices. According to the authors, the factor is irrelevant in the context of the study. However, the poor network signal and epileptic electricity supply sometimes experience by uMsinga SHFs might have implication on their adoption of ICT. Thus, using UTAUT2, the perceived availability of supportive resources

[9] The term "network service provider" refers to an organization or business that provides network access to one or more customers (Alcala, Comstedt, & Whitaker, 2015; Lawrence, Gibbings, Comstedt, & El-Aawar, 2016)

can be classified as a facilitating condition that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

6.3 Summary of the preliminary phase two findings

The concern in this chapter was to ascertain the nature of uMsinga SHFs' regard for the integration of ICT into their existing CSA practices and how the integration will help in alleviating the challenges experienced by the SHFs. The finding shows that the SHFs positively regarded the intersection between ICT and CSA practices. However, there are two unintended challenges resulting from the SHFs' approval for the intersection, namely: limited literacy to utilise ICT devices and lack of indigenous ICT-based agro-weather apps. Thus, using UTAUT2, the limited literacy to utilise ICT devices can be classified as a facilitating condition and lack of indigenous ICT-based agro-weather apps as a performance expectance that appears to hamper uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. In addition, the findings show seven factors informing the SHFs' regard for ICT integration into their CSA practices. The factors include: enjoyment in the use of mobile phones; past experience of using mobile phones; network service charges; perceived usefulness of mobile phones; perceived ease of the use of mobile phones; perceived association with individuals; and perceived availability of supportive resources.

The unified theory of acceptance and use of technology (UTAUT2) was found to be relevant in understanding the SHFs' adoption of ICT as climate change adaptation strategies to reduce impacts of climate change. Thus, using UTAUT2, enjoyment in the use of mobile phones can be classified as a hedonic motivation that appears to have inform uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. Furthermore, using UTAUT2, past experience can be classified as a habit that appears to be informing uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. Likewise, using UTAUT2, network service charges can be classified as a price value that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. In addition, using UTAUT2, perceived usefulness of ICT tool can be classified as a performance expectancy that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. Similarly, using UTAUT2, the perceived ease of the use of mobile phones can be classified as an effort expectancy that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. More so, using UTAUT2, perceived association with other individuals that matter can be classified as a social influence that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice. Lastly, using UTAUT2, perceived availability of supportive resources can be classified as a facilitating condition that informs uMsinga SHFs' positive regard for the intersection between ICT and CSA practice.

CHAPTER 7

PRESENTATION AND ANALYSIS OF RESULTS

ON THE MAIN STUDY – PHASE 1

The previous two chapters, Chapters 5 and 6, presented the analyses of the preliminary phase, which were guided by the following two questions and sub-questions:

a) *What are the uMsinga SHFs' existing agricultural practices in relation to CC adaptation?*
b) *Do SHF in uMsinga regard the integration of ICT and CSA into existing agricultural practices as crucial for adequate food productivity and livelihood in the face of climate change?*

(i) If so, what informs their perception?
(ii) If not, what informs their perception?

As mentioned in Chapter 5, seven CSA practices were identified as being practised by uMsinga SHFs. Despite these practices, findings from previous chapter show that uMsinga SHFs face varying degrees of challenges, which affirms the claim of Sullivan et al. (2012) that CSA alone is inadequate to solve SHFs' problems in the face of climate change. As such, Chapter 6, sought to ascertain uMsinga SHFs' regard for the intersection between ICT and the CSA practices and how this integration will help in alleviating the challenges experienced by the SHFs. The finding reveals that an overwhelming majority of the SHFs positively regarded the integration of ICT as being very crucial. The finding further shows seven factors perceived to be informing the SHFs' perceptions of the intersection. The concern in this chapter is guided by the following questions and sub-questions:

(i) What level of ICT literacy do SHF in uMsinga have? And
(ii) What level of ICT literacy do SHF in uMsinga need?

- What is the level of ICT literacy of uMsinga SHFs?
- How adequate is their ICT literacy?
- What informs the level of the ICT literacy?

ICT Literacy Assessment Tool (ILAT) (see appendix F) was used to interrogate the SHFs at our community forum meeting. Likewise, the unified theory of use and acceptance of technology (UTAUT2) (Venkatesh et al., 2012) was employed to understand the level of ICT literacy that uMsinga SHFs have and need to use ICT in their CSA practices. The seven constructs: hedonic motivation, habit, price value, performance expectancy, effort expectancy, facilitating condition, and social influence offered by UTAUT2 were found to be relevant in understanding the SHFs' adoption of ICT as climate change adaptation strategies to reduce impacts of climate change.

To address the above three questions, the following objectives are considered:

- Level of ICT literacy possessed by the SHFs in uMsinga;
- Trends stemming from the analysis of SHFs' ICT literacy level;
- Factors affecting the SHFs' ICT literacy levels;
- The relation between the identified factors and ICT adoption; and
- The type of ICT literacy needed by the uMsinga SHFs to incorporate ICT into their CSA practices in the face of climate change for food production.

Despite the attention given to the roles ICT plays in monitoring the complex nature of our environment, mitigating, adapting and strategies to mitigate climate change (Ospina & Heeks, 2011), studies show that use of ICT alone is inadequate to help SHFs combat the menace of climate change (Misaki et al., 2016; Yohannis et al., 2019). The key point is the interface between ICT and practices. Therefore, the SHFs' level of ICT literacy and the type of ICT literacy needed will allow for the interfacing between ICT and the already identified agricultural practices.

To achieve the above objectives, the chapter is divided into the following sections:

- Section 7.1 contains sub-sections 7.1.1 to 7.1.5 and all five sub-sections will present the results on the level of ICT literacy amongst the uMsinga SHFs.
- Section 7.2 contains sub-sections 7.2.1 and 7.2.2. The sub-section 7.2.1 will present the trends based on the five levels of ICT literacy. The sub-section 7.2.2 will present the analysis of the factors that might be affecting the trend.
- Section 7.3 will explore the factors informing the SHFs' level of ICT needed for the intersection between ICT and CSA practices, and

- Section 7.4 will provide a summary of the main study's phase one findings.

7.1 Research question 1a: What level of ICT literacy do SHFs in uMsinga have?

The dataset for this research question was produced from the semi-structured questionnaires, which sought to ascertain the level of ICT literacy amongst SHFs in uMsinga (see appendix F for ICT literacy assessment tool (ILAT)). The instrument consisted of six sections namely:

- SHFs' demographical data;
- First level of ICT literacy - mobile phone symbol identification literacy;
- Second level of ICT literacy - basic ICT literacy;
- Third level of ICT literacy - semi-medium-level ICT literacy;
- Fourth level of ICT literacy - medium-level ICT literacy; and
- Fifth level of ICT literacy - advanced ICT literacy.

The above literacy levels were previously discussed in Chapter 4. At each level of ICT literacy, the ICT scores of the component questions were generated and summed up for the levels. The total score of each SHF out of the maximum possible score at each level were expressed in percentages. The percentage scores were divided into three tertiles (Ko, Kang, & Lee, 2019) such that scores 33.3% or lower were categorized as "low", scores 33.4 – 66.6% were categorized as "moderate" and scores 66.7% and above were regarded as "high".

7.1.1 SHFs' first level of ICT literacy

This category explores the first level of ICT literacy in which the SHFs were asked to identify seven selected symbols on mobile device (see appendix F on ILAT instrument, level 1 ICT literacy, number 9 to 15). The symbols include: ON button; OFF button; battery fully charged sign; battery discharged sign; battery charging sign; Wi-Fi symbol; and mobile signal sign. The results are presented in Table 7.1 and Figure 7.1.

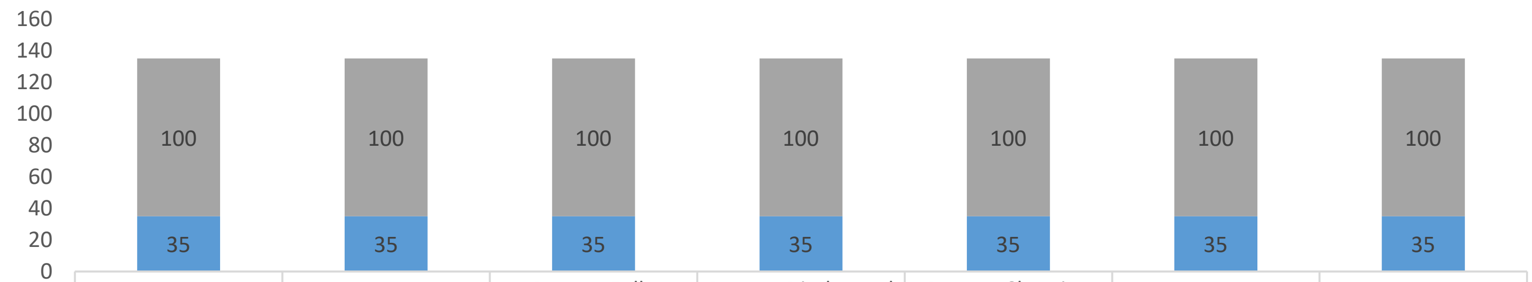
Table 7. 1: First level of ICT literacy: SHFs' mobile device symbol identification[10]

Proficiency	Frequency	Percent	Cumulative Percent
High	35	100.0	100.0

Note. 35 SHFs participated in this study; SHF = smallholder farmers

As shown in Table 7.1, all the SHFs demonstrated an overall high level (100%) of proficiency in recognising key symbols on their basic mobile phone. This implies that the SHFs

[10] N.B there were 35 SHFs that participated in the study



	ON Button	OFF Button	Battery Fully Charged Sign	Battery Discharged Sign	Battery Charging Sign	Wi-Fi Symbol	Mobile Signal Sign
NAR%	0	0	0	0	0	0	0
AR%	100	100	100	100	100	100	100
NAR	0	0	0	0	0	0	0
AR	35	35	35	35	35	35	35

AR NAR AR% NAR%

Figure 7. 1: First level of ICT literacy: SHFs' mobile device symbol identification

Note. AR = able to recognise; NAR = not able to recognise

The analysis of the first level of ICT literacy shows that the SHFs could recognise these seven symbols on mobile phones without assistance. This means that the 100% of the SHFs have sufficiently high proficiency in ICT at the first level of ICT literacy to be able to recognise symbols once they give attention to the signs. This finding is consistent with the study of Robinson-Pant (2016), which shows that "non-literate" Ethiopian farmers identify callers on their mobile phone using symbols like pictures of dogs, butterflies and balls (p. 17). The uMsinga SHFs' ability to identify or recognise the seven symbols has strong implications for their adoption and the design of ICT-based agro-weather app[11] for uMsinga SHF community.

7.1.2 SHFs' second level of ICT literacy

This category explores the second level of uMsinga SHFs' ICT literacy using six basic mobile phone functions (see appendix F on ILAT instrument level 2 ICT literacy number 16 to 21). These operations entail being able to switch a mobile phone ON and OFF, load a mobile phone with airtime without assistance from anyone, use a mobile phone to call someone and terminate the discussion without assistance from anyone, identify callers and check on call logs using a mobile phone. The SHFs were asked if they could perform the six operations using their mobile phones. The analysis of this category is presented in Table 7.2.

Table 7. 2 Second level of ICT Literacy (SHFs' basic level of ICT literacy)

Proficiency	Frequency	Percent	Cumulative Percent
High	35	100.0	100.0

Note. 35 SHFs participated in this study; SHF = smallholder farmers

[11] An app is regarded as any computer software application design to perform a specific task

From Table 7.2, the analysis shows that the uMsinga SHFs have high proficiency in the overall ICT literacy at the second level. This means that their ICT literacy proficiency is 100%. The detail of this category is further explained using the sunburst chart, Figure 7.2.

Figure 7. 3: Second level of ICT literacy (SHFs' basic level of ICT literacy)

Note. SD = satisfactorily demonstrated; PD = partially demonstrated; NAD = not able to demonstrate

As illustrated in Figure 7.2, the SHFs satisfactorily demonstrated (SD) a high level of proficiency in using a basic mobile phone to perform the six ICT operations mentioned above (74% to 100%). However, some SHFs demonstrated a low level of proficiency in two of the six ICT operations identified, namely: identifying callers and missed calls on the call log. With regard to caller identification, the results in Figure 7.2 show that 20% of the SHFs partially demonstrated (PD) sufficient literacy whilst 6% were not able to demonstrate (NAD) such literacy. With regard to the identification of missed calls on call log, the analysis shows that 6% of the SHFs partially demonstrated the necessary literacy whilst 20% of the SHFs were not able to demonstrate full literacy. Conclusively, the percentage of SHFs that successfully demonstrated the six operations at this second level of ICT literacy is higher than that of the others combined. This finding means that the SHFs have adequate capacity to use mobile phones to perform basic operations at the second level.

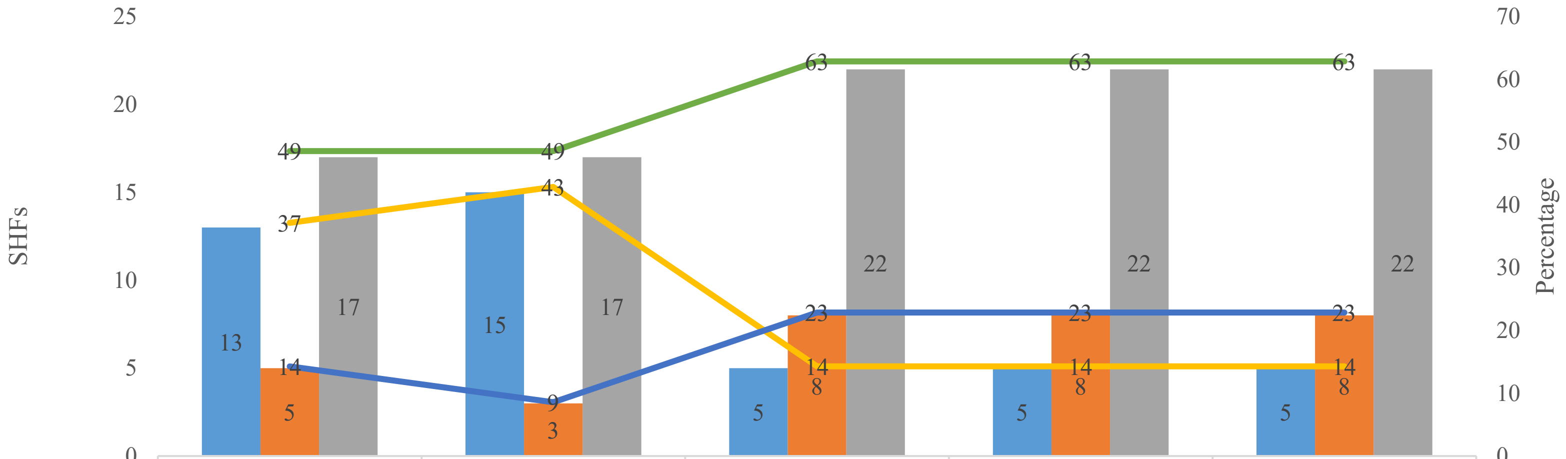
7.1.3 The SHFs' third level of ICT literacy

This category explains the semi-medium level of ICT literacy in this study. This category explores the SHFs' capability to use basic mobile phone for documentation of caller contacts, typing and reading text messages (see appendix F on ILAT instrument level 3 ICT literacy number 22 to 26). The analysis of this category is presented in Table 7.3 and Figure 7.3.

Table 7. 3 Third level of ICT Literacy: SHFs' capacity to use basic mobile phones

Proficiency	Frequency	Percent	Cumulative Percent
Low	17	48.6	48.6
Moderate	6	17.1	65.7
High	12	34.3	100.0
Total	35	100.0	

As shown in Table 7.3, 48.6% of the SHFs possesses low, 17.1% possesses moderate while 34.3% possessed high proficiency at the semi-medium level of ICT literacy. This means that only 34.3% of the SHFs had the proficiency to perform effectively at the semi-medium level of ICT literacy. It was therefore observed that there is a sharp decline in the SHFs' ICT literacy level between the second and the third level. The detail is shown in Figure 7.3.



	Save Contacts of Callers	Retrieve Callers Contacts	Send Text Message	Access and Read Received Text Message	Delete Text Message
SD	13	15	5	5	5
PD	5	3	8	8	8
NAD	17	17	22	22	22
SD%	37	43	14	14	14
PD%	14	9	23	23	23
NAD%	49	49	63	63	63

Figure 7. 4 Third level of ICT literacy: SHFs' capacity to use basic mobile phones

Note. SD = satisfactorily demonstrated; PD = partially demonstrated; NAD = not able to demonstrate

As revealed in Figure 7.3, the uMsinga SHFs demonstrated varying literacy capabilities to use a basic mobile phone for the documentation of caller contacts, typing and reading of text messages. The findings show that 37%, 43% and 14% (for each operation) of the SHFs satisfactorily demonstrated the literacy to save, retrieve caller contacts, send, access and read received text messages, and delete text messages respectively. Likewise, the findings show 49% for the first two operations and 63% (for each of others) of the SHFs were not able to demonstrate the literacy to save, retrieve caller contacts, send, access and read received text messages, and delete text messages respectively. Thus, to compare the percentage of SHFs who satisfactorily demonstrated the operations with those who were not able to demonstrate at this level of ICT literacy, it can be concluded that the greater proportion of SHFs are limited in their ICT literacy proficiency to use basic mobile phones to save, retrieve caller contacts, send, access and read received text messages, and delete text messages.

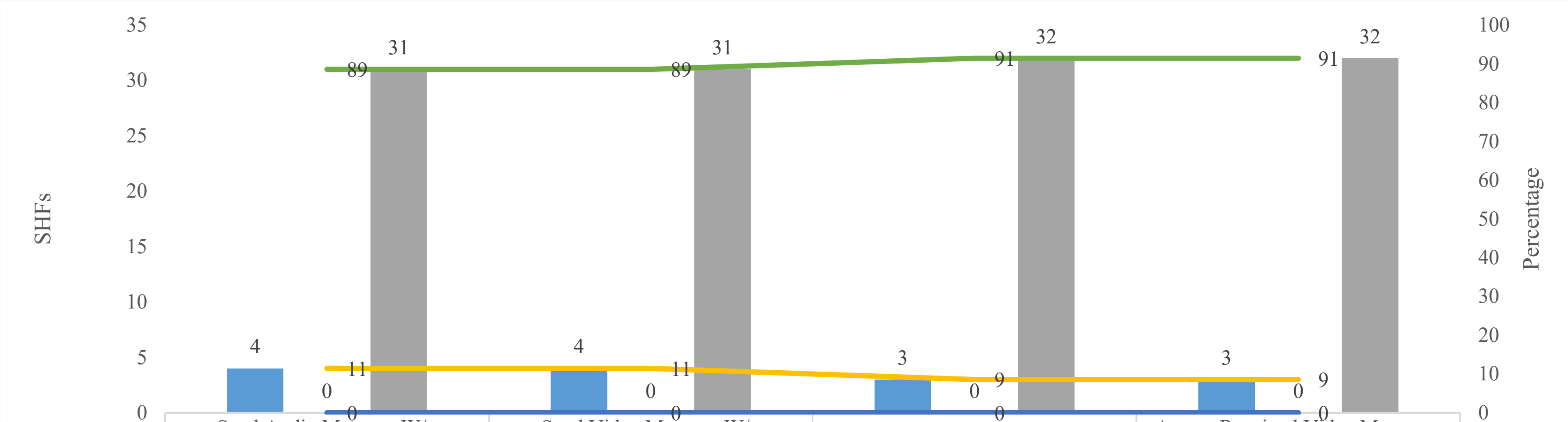
7.1.4 SHFs' fourth level of ICT literacy

This category explores the SHFs' capability to use a smartphone (SP) to perform additional tasks of sending audio and video messages as well as to access received audio and video messages (see appendix F on ILAT instrument level 4 ICT literacy number 27 to 30). The essence of using an SP rather than basic mobile phone (BMP) in this section is based on the fact that BMPs lack the facility to perform operations like receiving and sending video messages. As such, BMPs are limited in their functionalities to perform web-based operations. The analysis of this category is presented in Table 7.4 and Figure 7.4.

Table 7. 4 Fourth level of ICT literacy: SHFs' medium ICT literacy level

Proficiency	Frequency	Percent	Cumulative Percent
Low	31	88.6	88.6
Moderate	1	2.9	91.4
High	3	8.6	100.0
Total	35	100.0	

As revealed in Table 7.4, the SHFs' proficiency show 88.6% low, 2.9% moderate and 8.6% high levels of medium ICT literacy using SPs. The finding indicated that only 8.6% of the SHFs' proficiency is at high level of ICT literacy, which involves using an SP to perform audio-visual operations at the fourth level. This means that the SHFs lacked the ICT literacy to use SPs to send audio and video messages as well as to access received audio and video messages. It is also observed that the SHFs' ICT literacy proficiency declined with a greater percentage at the fourth level than third level. This implies that majority of the SHFs may be unable to make sense of any information sent to them in audio-visual form. The details of the findings at this level are presented in Figure 7.4.



	Send Audio Message W/o Assistance	Send Video Message W/o Assistance	Access Received Audio Messages	Access Received Video Messages on a Mobile Phone?
SD	4	4	3	3
PD	0	0	0	0
NAD	31	31	32	32
SD%	11	11	9	9
PD%	0	0	0	0
NAD%	89	89	91	91

Figure 7. 6 Fourth level of ICT literacy: SHFs' medium ICT literacy level

Note. SD= satisfactorily demonstrated; PD= partially demonstrated; NAD= not able to demonstrate; W/O = without

In Figure 7.4, the results show that 11% of SHFs satisfactorily demonstrated the ability to send both audio and video without (w/o) assistance while 9% satisfactorily demonstrated the ability to access received audio and video messages. On the other hand, the study shows that the majority (89%) of the SHFs are not able to demonstrate literacy to send both audio and video message without assistance. In addition, the majority (91%) of SHFs are not able to demonstrate literacy to access both audio and video messages received. It can be concluded that the majority of the SHFs lack the ICT literacy proficiency to perform medium ICT operations using SPs, specifically lacking the ICT literacy to use SPs to send audio and video messages as well as to access received audio and video messages.

7.1.5 SHFs' fifth level of ICT literacy

This category explores the SHFs' ability to use SPs to access internet facilities (see appendix F on ILAT instrument level 5 ICT literacy number 31 to 38). This advanced ICT literacy level concerns the literacy with which the SHFs surf the Internet to perform operations like:

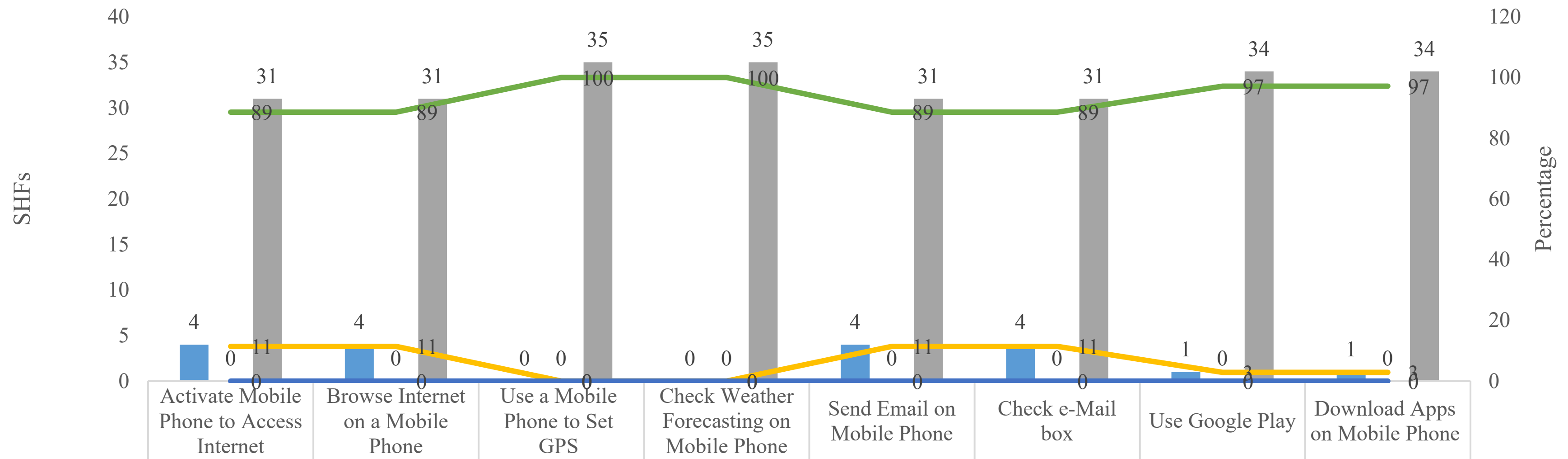
- activate a mobile phone to access the Internet
- browse the Internet with a mobile phone
- use a GPS application to navigate routes
- check weather forecasting information
- send email, check a mail box
- use Google Play, and download apps from Google Store into a mobile phone.

The results are presented in Table 7.5 and Figure 7.5.

Table 7. 5 Fifth level of ICT literacy: SHFs' advanced ICT literacy level

Proficiency	Frequency	Percent	Cumulative Percent
Low	31	88.6	88.6
Moderate	3	8.6	97.1
High	1	2.9	100.0
Total	35	100.0	

As shown in Table 7.5, the finding indicates that SHFs demonstrated 88.6% low, 8.6% moderate and 2.9% high level of proficiency in advanced ICT literacy using SP. Likewise, the results reveal that the SHFs possess 2.9% proficiency at the advanced ICT literacy level, while the majority, 88.6%, have a low ICT literacy. This implies that most of the SHFs lack the ICT literacy to use ICT devices to access Internet, use GPS applications, check weather information, check and send emails, and use Google Play Store to download apps that could enhance the intersection between ICT and CSA. The details of the findings are presented in Figure 7.5.



	Activate Mobile Phone to Access Internet	Browse Internet on a Mobile Phone	Use a Mobile Phone to Set GPS	Check Weather Forecasting on Mobile Phone	Send Email on Mobile Phone	Check e-Mail box	Use Google Play	Download Apps on Mobile Phone
SD	4	4	0	0	4	4	1	1
PD	0	0	0	0	0	0	0	0
NAD	31	31	35	35	31	31	34	34
SD%	11	11	0	0	11	11	3	3
PD%	0	0	0	0	0	0	0	0
NAD%	89	89	100	100	89	89	97	97

SD PD NAD SD% PD% NAD%

Figure 7. 8 Fifth level of ICT literacy: SHFs' advanced ICT literacy level

Note. SD= satisfactorily demonstrated; PD= partially demonstrated; NAD= not able to demonstrate

Furthermore, Figure 7.5 reveals that 11% of the SHFs satisfactorily demonstrated (SD) the literacy to activate their mobile phones to access the Internet, browse the Internet, check and send emails while only 3% could use Google Play Store and download apps. On the other hand, 89% of the SHFs were not able to demonstrate (NAD) the literacy to activate their mobile phones to access the Internet, browse the Internet, check and send emails. Further, 100% of the SHFs are unable to demonstrate the literacy to use smartphones (SPs) for global positioning system (GPS) and weather forecast information. Likewise, 97% of the SHFs are unable to demonstrate literacy to use Google Play Store and download apps on a smartphone. Based on these high level of inability to demonstrate advanced ICT literacy, it can be concluded that uMsinga SHFs lack the ICT literacy to perform the fifth level of ICT literacy. This implies that the inability of the SHFs to carry out the activities at this level may aggravate negative impacts of climate change on crops and possibly limit locating markets to sell their products. The implication of this finding is that the SHFs might be unable to carry out the intersection between ICT and the identified agricultural practices mentioned in previous chapters. The SHFs knowledge about this integration may help them access relevant information to mitigate impacts of climate change. Lack of this skill might limit agricultural production in the face of climate change and increase food insecurity amongst rural dwellers.

Conclusively, since the findings regarding uMsinga SHFs' ICT literacy proficiency in this section reveal that proficiency declines sharply from the third to the fifth level of ICT literacy, the average performance of the SHFs therefore indicates a very low proficiency in the use of ICT. Thus, it is necessary to understand this decline in order to ascertain what factors could be responsible for their low ICT literacy. This will be presented in the next section.

7.2 The trends revealed by the analysis of SHFs' ICT literacy level

The previous section presented the five levels of uMsinga SHFs' ICT literacy and found that the average performance of the SHFs' proficiency in the use of ICT is very low. This section presents the trends and factors affecting the SHFs' ICT literacy. In addition, this section is divided into two subsections. Subsection 7.2.1 presents the trends of findings, based on the five levels of the SHFs' ICT literacy. Subsection 7.2.2 presents three factors that appear to be affecting the SHFs' ICT literacy to possibly adopt ICT in their agricultural practices. The details of these are discussed as follows.

7.2.1 The trends based on the five levels of ICT literacy

This subsection further explores the five levels of ICT literacy of uMsinga SHFs in order to understand the trend of the SHFs' proficiency discussed in the previous section. Furthermore, this is to point out at a glance what ICT literacy levels the SHFs have, in order to determine the ICT literacy, they need to manage the intersection between ICT and their CSA practices. The dataset for this section is, therefore, derived from the analysis of data obtained regarding the first to fifth level of ICT literacy levels to indicate high, moderate and low proficiency of the SHFs, as presented in Table 7.6.

Table 7. 6 The trends based on the five levels of ICT literacy

Levels of ICT Literacy	Low	Moderate	High
First Level	0	0	100
Second Level	4.3	4.3	91.3
Third Level	48.6	17.1	34.3
Fourth Level	88.6	2.9	8.6
Fifth Level	88.6	8.6	2.9

The findings from Table 7.6 show that the SHFs have high proficiency in ICT literacy at the first level. However, as the SHFs progress to the fifth level, their proficiency declines sharply. For better understanding, this trend is presented in Figure 7.6.

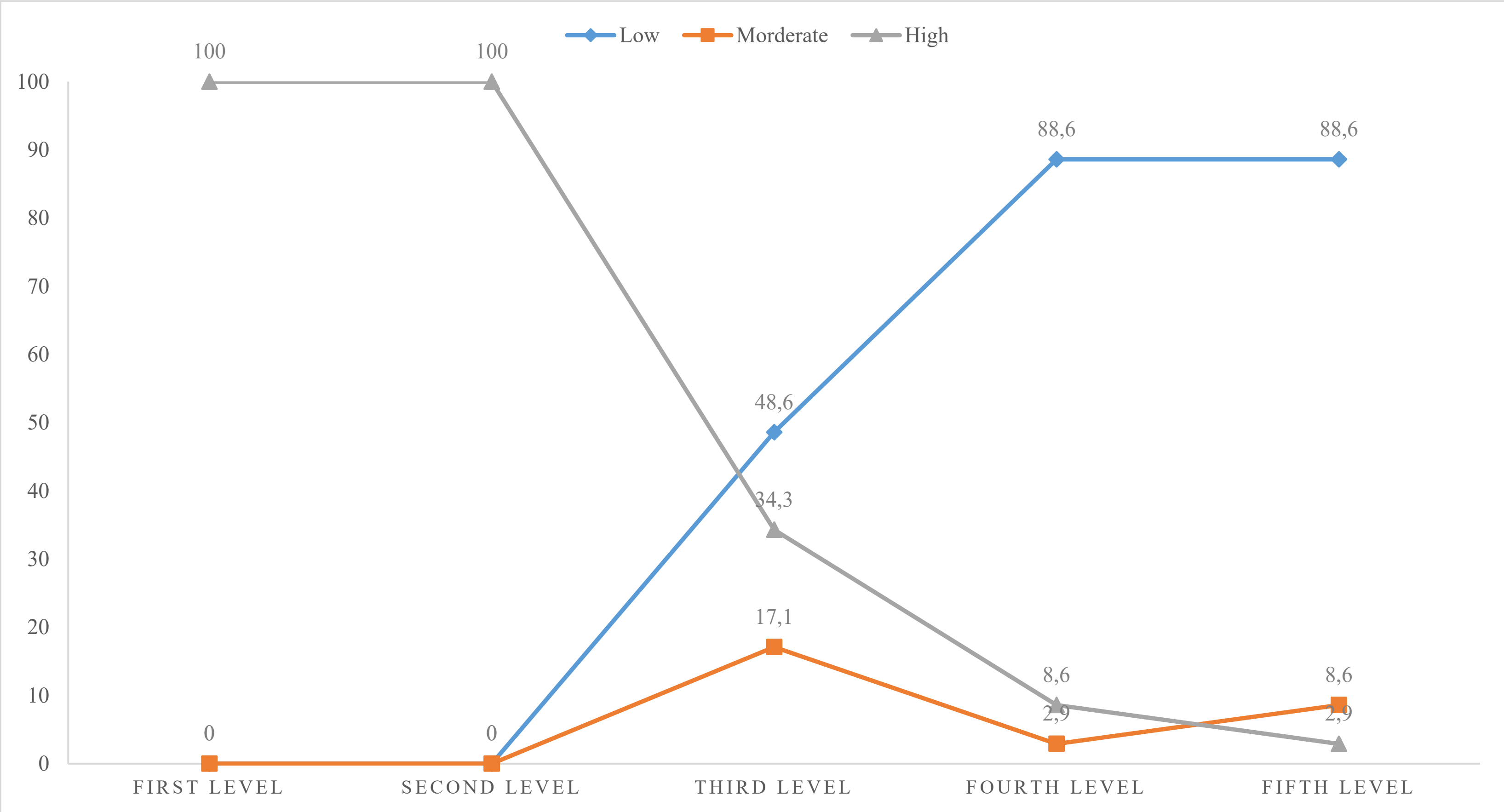


Figure 7. 10 The trends based on the five levels of ICT literacy

As shown in Figure 7.6, the SHFs' high proficiency curve demonstrates a downward decline from the first to the fifth level of the graph. The slope shows a gentle downward decline from the first to the second level but a sharp decline from the second to the fifth level. The moderate proficiency curve on the other hand is undulating, whilst the low proficiency curve ascends upward at a sharp slope from the second to the fifth level. The graph further indicates that as the SHFs progress from first to fifth level, the proportion of low ICT literacy proficiency for that level increased. Thus, the trends clearly show that the uMsinga SHFs have inadequate ICT literacy. This implies that the SHFs might be unable to interface between ICT and their CSA effectively, without being trained.

Based on the low and high ICT literacy proficiency curve, the SHFs might need to be developed so that they rise from the third to fifth level in order to interface between ICT and their CSA practice. However, there is a need to further interrogate the findings to understand the factors responsible for the trends. This will be discussed in the next subsection.

7.2.2 Analysis of the factors affecting the trends

The previous subsection presented the trends based on the five levels of ICT literacy. The findings clearly reveal that uMsinga SHFs have inadequate ICT literacy and need to be developed from the third to the fifth level to enable an effective interface between ICT and their CSA practices. However, this subsection tries to explore whether there is a relationship between the SHFs' ICT proficiency at each level and their demographical data or not. This is to understand what factors may be informing the trends discussed in previous subsection. To achieve this objective, the dataset is obtained from the SHFs using the five demographical data items in ILAT. The items are: age, gender, marital status, education background and years of farming experience. Out of these five items, the analysis shows that only two of the items could be linked to the SHFs' ICT literacy proficiency. These are the SHFs' age and educational level. While there is a paucity of studies on SHFs' ICT literacy, a study conducted by Kabir (2015) shows that farmers' age, level of education, and years of farming experience affect their attitude toward ICT use. In the context of this study, the age of the uMsinga SHFs appears to be in direct proportion to their years of farming experience. For example, if a SHF is old, then the year of farming experience will be longer than that of a younger fellow. In addition, since all participants (SHFs) were female, gender is not relevant as a category that would account for the differences in proficiency.

Furthermore, Spearman rank-order correlation was employed in this study. The Spearman rank-order correlation is a method of calculating an interrelationship between the level of scores on two variables (Hwang, Thomas, Haas, & Caldas, 2009). The Spearman measures monotonic (Lv, Qin, Chen, & Wei, 2018) and nonparametric (Farber, Foreman, Miller, & McGoon, 2011) relationships between two variables. The monotonic relationship refers to a context in which variables appear to change at the same time but not at a constant rate (Ahmed, Hossain, & Khan, 2018), whilst the nonparametric nature of Spearman rank correlation involves disregarding a normal distribution of the data and using the ranks of the test scores to evaluate correlations (Farber et al., 2011). In addition, the Spearman rank-order correlation is represented using *rho* (Henriksen et al., 2018) with its values[12]. I employed Spearman rank-order correlation due to the sample size (35) of the SHFs who voluntarily participated in my study (Kornisch, Robb, & Jones, 2017). Despite the size, parametric test could have been adopted used (Castro-Meneses, Kruger, & Doherty, 2019; Field, 2013; Kamalikhah, Safarian, Rahmati-Najarkolaei, & Yaghoubi, 2019; Mohammad, Malekafzali, & Nehapetian, 1998), but non-parametric test was preferred. This was because of the advantage that non-parametric test prevents making untrue assumption about the study's parameters (Abramo, D'Angelo, & Pugini, 2008; Kundu & Acharyya, 2017). On the other hand, the use of parametric test would require a large sample size for true assumption to hold in this study. Therefore, I adopted Spearman rank correlation using correlation coefficient (r) as well as P-value at both 0.05 and 0.01. The result of the Spearman rank correlation in this study is presented in Table 7.7.

[12] Spearman rank-order correlation values range between ±1, where −1 is a perfect negative correlation, 0 is no correlation, and +1 is a perfect positive correlation (Molofsky et al., 2018, p. 1001)

Table 7. 7 Spearman's correlation coefficient between SHFs' ICT literacy level and demographical data

	r	Level 2	Level 3	Level 4	Level 5	Age	Married	Educational level	Years of Farming Experience
ICT score at Basic level (Level 2)		1							
		.							
ICT score at semi-moderate level (Level 3)	r	.422*	1						
	p	.012	.						
ICT score at moderate level (Level 4)	r	.042	.569**	1					
	p	.812	.000	.					
ICT score at advanced level (Level 5)	r	.051	.569**	.998**	1				
	p	.771	.000	.000	.				
Age	r	-.572**	-.930**	-.553**	-.551**	1			
	p	.000	.000	.001	.001	.			
Current marital status (in marriage or not)	r	-.032	-.223	-.179	-.179	.159	1		
	p	.854	.198	.303	.303	.360	.		
Educational level	r	.224	.752**	.616**	.616**	-.729**	-.179	1	
	p	.196	.000	.000	.000	.000	.304	.	
Years of Farming Experience	r	-.380*	-.741**	-.560**	-.559**	.729**	.258	-.584**	1.
	p	.025	.000	.000	.000	.000	.134	.000	.

Note. Level 1 was omitted because all SHFs had 100% ICT literacy proficiency at the level.
N =35
r = rho (ranges between -1 and +1)
* P = p-value<0.05; ** P< 0.01

As shown in Table 7.6, the results indicate that there is a positive and significant relationship between the second and third levels of SHFs' ICT literacy ($r = 0.422$; $p = 0.012$.). This could further mean that, the higher the level of ICT literacy that the SHFs attained at second level, the higher the skill is likely to be at the third level. However, this relationship differs at the fourth and fifth level. Though the relationships between the second and fourth as well as the fifth level are positive, they are insignificant because the p-values are greater than 0.05 ($r = 0.042$, $p = 0.812$ and $r = 0.051$, $p = 0.771$ respectively). This suggests that, since the ICT literacy is high at second and third level, it may unlikely to be at the fourth and fifth level. Further, the findings show that there is a positive and significant relationship between third and fourth levels ($r = 0.569$, $p < 0.001$). This implies that the SHFs' ICT literacy at fourth level will be highly influenced by literacy at the third level. Furthermore, the relationship between the third and fourth levels appears to be replicated at the fifth level. Additionally, the results show that SHFs' ICT literacy at fourth level was significantly and positively related to the fifth level ($r = 0.998$, $p < 0.001$). This further suggests that the SHFs' ICT literacy at fourth level is likely repeated at the fifth level too.

To understand the connection between the uMsinga SHFs' demographic factors and their ICT literacy proficiency, the SHFs' ICT scores were related to age, marriage, educational level and year of farming experience. The findings show that the age of SHFs was negatively and significantly related to their ICT literacy at all levels (r = -.572, -.930, -.553 and -.551 respectively at $P < 0.01$). This suggests that as the uMsinga SHFs' age increases, their ICT literacy proficiency decreases. Further, the findings show that marital status (whether SHFs are married or single) has no correlation with their ICT literacy proficiency. However, the findings reveal that the SHFs' ICT literacy proficiency was positively and significantly related to their educational level at all levels (r = 0.752, 0.616 and 0.616 respectively at $p <0.05$), except at the second level. This suggests that the higher the level of education acquired by the SHFs, the higher is their ICT literacy proficiency.

The result also shows that the SHFs' years of farming experience were negatively and significantly correlated with their ICT literacy from the first to fifth level (r = -0.380, -0.741, -0.560 and -0.559 respectively at $p<0.05$). This links directly to age as the more years of farming experience you have, the older you are as they aren't mutually exclusive. This correlation is similar to that between the SHFs' age groups and their ICT literacy at all the levels. This implies that the age of SHFs may strongly determine their years of farming experience.

It is significant to note that it is only the SHFs' age and educational level that seem likely to significantly affect their ICT adoption.

In summary, the findings show that age and years of farming experience of SHFs are negatively and significantly related to their ICT literacy; being married or being single have nothing to do with SHFs' ICT literacy; and the SHFs' educational level is positively and significantly related to their ICT literacy proficiency. These findings suggest that, as the educational level of SHFs increases, their ICT literacy proficiency increases. However, the ICT proficiency of the SHFs decreases as their age and years of farming increase. This means that increased ICT adoption may be possible if the SHFs' level of education is increased; and this may be more applicable to younger SHFs.

The concern in the next section is to critically explore the extent to which the two factors, age and educational background of SHFs, will affect their ability to adopt ICT tools to their agricultural practices.

7.3 The implications of age and educational background of SHFs for ICT adoption

This section presents the influence the uMsinga SHFs' demographic factors (e.g. age and educational level) may have on ICT adoption. The data were obtained from the previous subsection to analyse how the SHFs' demographic factors relate with ICT literacy proficiency at each level of ICT literacy. This section is therefore in twofold:

- Subsection 7.3.1 presents the relation between the SHFs' age groups and their ICT literacy
- Subsection 7.3.2 presents the relation between the SHFs' educational levels and their ICT literacy.

The significance of this for ICT adoption is that SHFs need ICT literacy if they are to adopt ICT tools. Having ICT literacy, though, does not guarantee that they will adopt ICT, rather, it is a necessary condition.

7.3.1 The relation between the SHFs' age group and ICT literacy

The findings in the previous subsection 7.2.2 show that uMsinga SHFs' age and years of farming experience are negatively and significantly related to their ICT literacy. The findings further indicated that being married or single have nothing to do with SHFs' ICT literacy, but the educational level of the SHFs is positively and significantly related to their ICT literacy proficiency. These suggested that, as the SHFs increase their level of education, ICT literacy proficiency increases. However, proficiency is negatively correlated with greater age and greater years of farming experience. The concern being addressed in this subsection is therefore to understand how these findings may limit the SHFs' ICT adoption. The data generated in subsection 7.2.2 were used to cross-tabulate the SHFs' age groups against their ICT literacy proficiency from first to fifth level. It is necessary at this point for the readers to know the age classification and their percentages as presented in Table 7.8.

Table 7. 8 The uMsinga SHFs' age classification and percentages

Age Group	SHFs	SHFs%
<40	5	14.3
40-49	17	48.6
50-59	9	25.7
>=60	4	11.4
Total	35	100.0

Table 7.8 shows the age group of the SHFs as less-than 40, between 40 and 49, 50-59 and 60 years and above, representing, 14.3%, 48.6%, 25.7% and 11.4% respectively. The SHFs within age group 40-49 (48.6%) are in the majority. The age group will further be required in the subsequent analysis.

The analysis indicating influence of uMsinga SHFs' age group on ICT adoption is presented in five sub-subsections from 7.3.1.1 to 7.3.1.5. These sub-subsections are discussed in detail as follow.

7.3.1.1 The implication of the SHFs' age group on ICT literacy at the first level

This sub-subsection presents the analysis of influence of uMsinga SHFs' age on ICT literacy at the first level. The data were analysed by cross-tabulating the SHFs' age against their ICT literacy proficiency at the first level and the result is presented in Table 7.9.

Table 7. 9 The influence of the SHFs' age groups on ICT literacy at the first level

Age Group			Level 1 High	Total
	<40	Count	5	5
		% within age group	100.0%	100.0%
	40-49	Count	13	13
		% within age group	100.0%	100.0%
	50-59	Count	12	12
		% within age group	100.0%	100.0%
	>=60	Count	5	5
		% within age group	100.0%	100.0%
Total		Count	35	35
		% within age group	100.0%	100.0%

Note. <40 = ages below 40 and >=60 - ages from 60 and above

As shown in Table 7.9, the results reveal that all the SHFs have 100% high level of ICT literacy to identify key symbols on mobile phone across all age groups. Based on this finding, it can be implied that the SHFs have adequate ICT literacy to adopt ICT tools into their practice by using mobile phones, which may mitigate impacts of climate change. The implication of this finding is that uMsinga SHFs' age may not necessarily affect their ICT literacy proficiency and thus ability to adopt ICT with skills at the first level. This means that if an ICT tool is designed with pictorial functionalities, SHFs at all ages would be able effectively use it.

7.3.1.2 The influence of the SHFs' age group on ICT literacy at the second level

This sub-subsection presents the analysis of influence of uMsinga SHFs' age on ICT literacy at the second level. The data were analysed by cross-tabulating SHFs' age against their ICT literacy proficiency at the second level and the result is presented in Table 7.10.

Table 7. 10 The influence of the SHFs' age groups on ICT literacy at the second level

Age Group			Proficiency High	Total
	<40	Count	5	5
		% within age group	100.0%	100.0%
	40-49	Count	13	13
		% within age group	100.0%	100.0%
	50-59	Count	12	12
		% within age group	100.0%	100.0%
	>=60	Count	5	5
		% within age group	100.0%	100.0%
Total		Count	35	35
		% within age group	100.0%	100.0%

Note. <40 = ages below 40 and >=60 - ages from 60 and above

The results in Table 7.10, show a 100% high ICT literacy proficiency in basic ICT using mobile phones, across all age groups. This implies that the SHFs have adequate ICT literacy proficiency to adopt ICT tools in their practices to combat the menace of climate change. Again, this shows that uMsinga SHFs' age is unlikely to affect their ICT literacy proficiency, and thus ICT adoption, at the second level.

7.3.1.3 The influence of the SHFs' age group on ICT literacy at the third level

This sub-subsection presents the analysis of influence of uMsinga SHFs' age on ICT literacy at the third level. The data was analysed by cross-tabulating SHFs' age against their ICT literacy proficiency at the third level and the result is presented in Table 7.11.

Table 7. 11 The influence of the SHFs' age group on ICT adoption at the third level

Age Group		Proficiency			Total
		Low	Moderate	High	
<40	Count	0	0	5	5
	% within age group	0.0%	0.0%	100.0%	100.0%
40-49	Count	0	6	7	13
	% within age group	0.0%	46.2%	53.8%	100.0%
50-59	Count	12	0	0	12
	% within age group	100.0%	0.0%	0.0%	100.0%
>=60	Count	5	0	0	5
	% within age group	100.0%	0.0%	0.0%	100.0%
Total	Count	17	6	12	35
	% within age group	48.6%	17.1%	34.3%	100.0%

Note. <40 = ages below 40 and >=60 - ages from 60 and above

The analysis in Table 7.11 reveals that the uMsinga SHFs within the age group of less than 40 (14.3%) had 100% high proficiency. The 40-49 age group (48.6%) had 53.8% high proficiency and 46.2% moderate proficiency. However, the 50 and above age groups (37.1%) had 100% low ICT literacy proficiency in basic ICT using mobile phones. In summary, uMsinga SHFs have 48.6% low, 17.1% moderate and 34.3% high ICT literacy across all age groups. Based on this result, it can be argued that the SHFs within the age group 50 and above require considerable ICT literacy development at the third level in order to adopt ICT tools into their agricultural practices. The implication is that third level ICT adoption in uMsinga will be negatively affected if the ICT literacy proficiency of SHFs aged 50 and above is not developed.

7.3.1.4 The influence of the SHFs' age group on ICT literacy at the fourth level

This sub-subsection presents the analysis of influence of uMsinga SHFs' age on ICT literacy at the fourth level. The data were analysed by cross-tabulating uMsinga SHFs' age against their ICT literacy proficiency at the fourth level and the result is presented in Table 7.12.

Table 7. 12 The influence of the SHFs' age groups on ICT literacy at the fourth level

Age Group		Proficiency			Total
		Low	Moderate	High	
<40	Count	1	1	3	5
	% within age group	20.0%	20.0%	60.0%	100.0%
40-49	Count	13	0	0	13
	% within age group	100.0%	0.0%	0.0%	100.0%
50-59	Count	12	0	0	12
	% within age group	100.0%	0.0%	0.0%	100.0%
>=60	Count	5	0	0	5
	% within age group	100.0%	0.0%	0.0%	100.0%
Total	Count	31	1	3	35
	% within age group	88.6%	2.9%	8.6%	100.0%

Note. <40 = ages below 40 and >=60 - ages from 60 and above

The analysis in Table 7.12 reveals that the SHFs within the age group less than 40 (14.3%) had 60% high, 20% moderate and 20% low proficiency; whilst those within the age groups above 40 (85.7%) had 100% low ICT literacy proficiency in medium ICT skills using mobile phones.

In summary, the findings show that the SHFs have 88.6% low, 2.9% moderate and 8.6% high ICT literacy proficiency across the age groups. It can therefore be argued that the majority of SHFs across age groups have very low ICT literacy proficiency. This means that all the SHFs need ICT literacy proficiency development at the fourth level in order to adopt ICT tools in their agricultural practices. The implication is that the SHFs' existing ICT literacy proficiency across all age group will negatively affect their ICT adoption at the fourth level.

7.3.1.5 The influence of the SHFs' age groups on ICT literacy at the fifth level

This sub-subsection presents the analysis of influence of uMsinga SHFs' age on ICT literacy at the fifth level. The data were analysed by cross-tabulating SHFs' age against their ICT literacy proficiency at the fifth level and the result is presented in Table 7.13.

Table 7. 13 The influence of the SHFs' age groups on ICT literacy at the fifth level

Age Group		Proficiency			Total
		Low	Moderate	High	
<40	Count	1	3	1	5
	% within age group	20.0%	60.0%	20.0%	100.0%
40-49	Count	13	0	0	13
	% within age group	100.0%	0.0%	0.0%	100.0%
50-59	Count	12	0	0	12
	% within age group	100.0%	0.0%	0.0%	100.0%
>=60	Count	5	0	0	5
	% within age group	100.0%	0.0%	0.0%	100.0%
Total	Count	31	3	1	35
	% within age group	88.6%	8.6%	2.9%	100.0%

Note. <40 means age below 40 and >=60 means ages from 60 and above

The analysis in Table 7.13 reveals that the SHFs within the age group less than 40 had 20% low, 60% moderate and 20% high proficiency; whilst the SHFs within the age group above 40 had 100% low ICT literacy proficiency in advanced ICT skills using smart phones.

In summary, the findings show that the SHFs have 88.6% low, 8.6% moderate and 2.9% high ICT literacy proficiency across all the age groups. Based on this finding, it can be concluded that uMsinga SHFs across all age groups need ICT literacy proficiency development at the fifth level in order to adopt ICT tools in their agricultural practice. The implication is that the SHFs' ICT literacy proficiency across all age groups will negatively affect their ICT adoption at the fifth level.

In conclusion, the results shown in Tables 7.9 to 7.13 clearly reveal that uMsinga SHFs' age is not related to their ICT literacy proficiency and ICT adoption at the first and second levels but the SHFs' age is related to their ICT literacy proficiency and ICT adoption at the third to fifth levels. This implies that the SHFs might require training from the third level across all age groups in order for them to effectively adopt ICT tools into their agricultural practices. Therefore, using UTAUT, age can be classified as a moderating variable that negatively but significantly informs uMsinga SHFs' ICT literacy need.

The SHFs' educational level is considered in the next section.

7.3.2 The influence of the SHFs' educational level on ICT literacy

The previous section presented the findings of influence uMsinga SHFs' age groups had on ICT literacy. The section concluded by revealing that the SHFs lacked ICT literacy proficiency across all age groups, ranging from the third to fifth level, to adopt ICT tools into their CSA practices.

As presented in subsection 7.2.2, uMsinga SHFs' educational levels are significantly related to their ICT literacy proficiency scores. Therefore, the concern in this subsection, is to understand the influence that the educational level has on the SHFs' ICT literacy. It is necessary at this point to inform the readers on the educational level of the SHFs, as presented in Table 7.14.

Table 7. 14 uMsinga SHFs' educational level

Education Level	SHFs	SHFs%
None	20	57.1
Primary	10	28.6
Secondary	2	5.7
Matric	2	5.7
Higher	1	2.9
Total	35	100.0

Table 7.14 shows that the uMsinga SHFs' educational levels are distributed as follows: 57.1%, 28.6%, 5.7%, 5.7% and 2.9% for no formal educational background, primary, secondary, matric and higher education, respectively. The findings indicate that SHFs with no formal education are in the majority. Thus, these findings are required in the analysis of results to understand the influence that the SHFs' levels of education have on their intention to adopt ICT. The data generated in subsection 7.2.2 was used to cross-tabulate the SHFs' educational level against their ICT literacy proficiency from the first to the fifth level. The analysis is presented in five sub-subsections from 7.3.2.1 to 7.3.2.5. These sub-subsections are discussed in detail as follow.

7.3.2.1 The influence of the SHFs' educational level on ICT literacy at the first level

This sub-subsection presents the analysis of influence of the uMsinga SHFs' educational level on ICT literacy at the first level. The data in this sub-subsection was analysed by cross-tabulating SHFs' educational level against their ICT literacy proficiency at the first level to determine the effect on ICT literacy. The result is presented in Table 7.15.

Table 7. 15 The influence of the SHFs' educational level on ICT literacy at the first level

Educational Level		Proficiency High	Total
None	Count	20	20
	% within Educational Level	100.0%	100.0%
Primary	Count	10	10
	% within Educational Level	100.0%	100.0%
secondary	Count	2	2
	% within Educational Level	100.0%	100.0%
Matric	Count	2	2
	% within Educational Level	100.0%	100.0%
Higher	Count	1	1
	% within Educational Level	100.0%	100.0%
Total	Count	35	35
	% within Educational Level	100.0%	100.0%

As shown in Table 7.15, the results reveal that all the SHFs have 100% high proficiency in identifying key symbols on mobile phones, across all education backgrounds. This means that the SHFs' educational level has no negative effect on their ICT literacy proficiency at the first level. The implication is that, irrespective of the SHFs' educational level, they could use ICT literacy at the first level and adopt ICT into their agricultural practice. This means that the use of symbol as functionalities may aid SHFs' adoption of ICT tools, regardless of their educational level.

7.3.2.2 The influence of the SHFs' educational level on ICT literacy at the second level

This sub-subsection presents the analysis of influence of the uMsinga SHFs' educational level on ICT literacy at the second level. The data in this sub-subsection was analyzed by cross-tabulating uMsinga SHFs' educational level against their ICT literacy proficiency at the second level to determine the possible effect on the adoption of ICT tools. The results are presented in Table 7.16.

Table 7. 16 The influence of the SHFs' educational level on ICT literacy at the second level

Educational Level		Proficiency High	Total
None	Count	20	20
	% within Educational Level	100.0%	100.0%
Primary	Count	10	10
	% within Educational Level	100.0%	100.0%
Secondary	Count	2	2
	% within Educational Level	100.0%	100.0%
Matric	Count	2	2
	% within Educational Level	100.0%	100.0%
Higher	Count	1	1
	% within Educational Level	100.0%	100.0%
Total	Count	35	35
	% within Educational Level	100.0%	100.0%

As shown in Table 7.16, all the SHFs have 100% high ICT literacy proficiency in basic ICT using basic mobile phone, across all educational levels. This means that the uMsinga SHFs' educational level has no negative effect on their ICT literacy proficiency at the second level, and thus on their ability to adopt ICT tools in their agricultural practices. The implication is that, irrespective of the SHFs' educational level, they have the ability that would enable them to adopt ICT tools in their agricultural practice to mitigate impacts of climate change at the second level of ICT literacy.

7.3.2.3 The influence of the SHFs' educational level on ICT literacy at the third level

This sub-subsection presents the analysis of influence of the uMsinga SHFs' educational level on ICT literacy at the third level. The data in this sub-subsection were analysed by cross tabulating uMsinga SHFs' educational level against their ICT literacy proficiency at the third level, to determine the possible effect on the adoption of ICT tools. The result is presented in Table 7.17.

Table 7. 17 The influence of the SHFs' educational level on ICT literacy at the third level

Educational Level		Proficiency			Total
		Low	Moderate	High	
None	Count	15	3	2	20
	% within Educational Level	75.0%	15.0%	10.0%	100.0%
Primary	Count	2	3	5	10
	% within Educational Level	20.0%	30.0%	50.0%	100.0%
secondary	Count	0	0	2	2
	% within Educational Level	0.0%	0.0%	100.0%	100.0%
Matric	Count	0	0	2	2
	% within Educational Level	0.0%	0.0%	100.0%	100.0%
Higher	Count	0	0	1	1
	% within Educational Level	0.0%	0.0%	100.0%	100.0%

Total	Count	17	6	12	35
	% within Educational Level	48.6%	17.1%	34.3%	100.0%

As revealed in Table 7.17, the SHFs with no formal educational background (57.1%) have 75% low, 15% moderate and 10% high ICT literacy proficiency. Those with primary education (28.6%) have 20% low, 30% moderate and 50% high ICT literacy proficiency. The SHFs with secondary education, matric and higher education (14.3%) have 100% high proficiency in basic ICT and thus the ability to adopt ICT tools.

7.3.2.4 The influence of the SHFs' educational level on ICT literacy at the fourth level

This sub-subsection presents the analysis of influence of the uMsinga SHFs' educational level on ICT literacy at the fourth level. The data in this sub-subsection were analysed by cross tabulating the SHFs' educational level against their ICT literacy proficiency at the fourth level to determine the effect on adoption of ICT tool. The result is presented in Table 7.18.

Table 7. 18 The influence of the SHFs' educational level on ICT literacy at fourth level

Educational Level		Proficiency			Total
		Low	Moderate	High	
None	Count	20	0	0	20
	% within Educational Level	100.0%	0.0%	0.0%	100.0%
Primary	Count	10	0	0	10
	% within Educational Level	100.0%	0.0%	0.0%	100.0%
Secondary	Count	1	1	0	2
	% within Educational Level	50.0%	50.0%	0.0%	100.0%
Matric	Count	0	0	2	2
	% within Educational Level	0.0%	0.0%	100.0%	100.0%
Higher	Count	0	0	1	1
	% within Educational Level	0.0%	0.0%	100.0%	100.0%
Total	Count	31	1	3	35
	% within Educational Level	88.6%	2.9%	8.6%	100.0%

As shown in Table 7.18, the SHFs with no formal educational background (57.1%) have 100% low ICT literacy proficiency. Those with primary education had 100% low; whilst the SHFs with secondary education, had 50% low and 50% moderate ICT literacy proficiency. However, the SHFs with matric and higher education (8.6%) have 100% high ICT literacy proficiency. This means that all the SHFs with educational levels below matric lacked the proficiency to use SPs in order to perform operations like sending audio and video messages, as well as accessing audio and video messages received.

In summary, the findings show that the level of education possess by uMsinga SHFs produced 8.6% with high, 2.9% with moderate and 88.6% with low ICT literacy proficiency at the fourth level. Since the majority of the SHFs have low ICT literacy proficiency at this level, it could be argued, therefore, that their educational level might affect the SHFs' adoption of ICT tools into agricultural practice. This means that uMsinga SHFs' ICT literacy proficiency at the fourth level might have to be developed in order for them to adequately adopt ICT into their agricultural practice to mitigate the impacts of climate change.

7.3.2.5 The influence of the SHFs' educational level on ICT literacy at the fifth level

This sub-subsection presents the analysis of influence of the uMsinga SHFs' educational level on ICT literacy at the fifth level. The data in this sub-subsection was analysed by cross tabulating the SHFs' educational level against their ICT literacy proficiency at the fifth level to determine the possible effect on the adoption of ICT tools. The result is presented in Table 7.19.

Table 7. 19 The influence of the SHFs' educational level on ICT literacy at the fifth level

Educational Level		Proficiency			Total
		Low	Moderate	High	
None	Count	20	0	0	20
	% within Educational Level	100.0%	0.0%	0.0%	100.0 %
Primary	Count	10	0	0	10
	% within Educational Level	100.0%	0.0%	0.0%	100.0 %
Secondary	Count	1	1	0	2

	% within Educational Level	50.0%	50.0%	0.0%	100.0 %
Matric	Count	0	2	0	2
	% within Educational Level	0.0%	100.0%	0.0%	100.0 %
Higher	Count	0	0	1	1
	% within Educational Level	0.0%	0.0%	100.0%	100.0 %
Total	Count	31	3	1	35
	% within Educational Level	88.6%	8.6%	2.9%	100.0 %

As shown in Table 7.19, uMsinga SHFs no formal educational background (57.1%) have 100% low ICT literacy proficiency. The SHFs with primary education (28.6%) have 100% low, whilst those with secondary education (5.7%), have 50% low and 50% moderate ICT literacy proficiency. However, the SHFs with matric (5.7%) have 100% moderate proficiency whilst the one with a higher certificate (2.9%) has 100% high ICT literacy proficiency in the use of SP. This means that the SHFs with educational level below matric lacked the capacity to use SP to activate mobile phones to access the Internet, browse the Internet with a mobile phone, use a mobile phone to set GPS application to navigate a route, check weather forecasting information, send and check email, and use Google Play Store to download apps from the Internet.

In summary, the findings reveal that, of the SHFs, 88.6% have low, 8.6% have moderate and 2.9% have high ICT literacy proficiency. Since the majority of the SHFs have low ICT literacy proficiency, I therefore argue that their educational level might limit their adoption of ICT tools into CSA practice. As such, the SHFs' ICT literacy proficiency at the fifth level would have to be developed to adequately adopt ICT into their agricultural practice in order to mitigate the impacts of climate change. Therefore, using UTAUT, the educational level can be classified as moderating variable that positively and significantly inform uMsinga SHFs' ICT literacy need.

In conclusion, the findings in this subsection have shown that both SHFs' age and educational level affected the uMsinga SHFs' ICT literacy. The SHFs' ICT literacy proficiency might have to be developed in order for the SHFs to adequately adopt ICT tools into their agricultural practices so as to mitigate and adapt to impacts of climate change in uMsinga. Using UTAUT2, age and educational level can be classified as moderating variables.

7.4 Summary of the main study phase one findings

This chapter has presented the analysis of the first research question of the main study. The concern addressed in the chapter includes:

- The level of ICT literacy possessed by the SHFs in uMsinga;
- Trends stemming from the analysis of SHFs' ICT literacy level;
- Factors affecting the SHFs' ICT literacy levels;
- The relation between the identified factors and ICT adoption; and
- The type of ICT literacy needed by the uMsinga SHFs if they are to incorporate ICT into their CSA practices in the face of climate change for food production.

The findings in this study shows that uMsinga SHFs possess sufficient ICT literacy to operate ICT at first level. However, the ICT proficiency of the SHFs drops sharply as the operation of ICT moves from the second to the fifth level. Therefore, the finding indicates that uMsinga SHFs lack adequate ICT literacy proficiency to interface between ICT and their agricultural practices. The study further interrogates the findings to understand the trend of this decline in order to ascertain what factors are associated with the SHFs' low ICT literacy proficiency. The graph in Figure 7.6 indicated that, as testing of the SHFs progressed from first to fifth level, they scored lower and lower on ICT literacy. This trends clearly revealed that the uMsinga SHFs have inadequate ICT literacy to interface between ICT and CSA.

Additionally, the study proceeded to explore the SHFs' demographical factors that might likely be responsible for the trends. Factors like age, educational level and years of farming experience are significantly associated with the SHFs' ICT literacy proficiency. The results furthermore showed that the age group of the SHFs is negatively and significantly related to their ICT literacy; being married has no correlation with their ICT literacy; the SHFs' educational level, positively and significantly related to their ICT literacy proficiency; as well as the SHFs' years of farming experience negatively and significantly correlated with their ICT literacy. The findings suggested that, the higher the level of education of the SHFs, the higher their ICT literacy proficiency, but proficiency decreases with age and years of farming experience. It can therefore imply that the SHFs' age and years of farming experience are negatively and inversely proportional to their ICT literacy proficiency whilst, the SHFs' educational level is directly proportional to their ICT literacy proficiency.

As revealed in this study, ICT literacy proficiency development is needed to move SHFs from low or medium levels to advanced ICT literacy for adoption of ICT tools in the SHFs' agricultural practices in the face of climate change to be possible. In addition, using UTAUT to explain factors informing uMsinga SHFs' ICT literacy need, two motivating factors come to light, educational level and age. Thus, the age factor can be classified as a moderating variable that negatively and significantly informs uMsinga SHFs' ICT literacy need. Furthermore, using UTAUT, educational level can be classified as a moderating variable that positively and significantly informs uMsinga SHFs' ICT literacy needs. Therefore, the next chapter, Chapter 8, will present the findings on how uMsinga SHFs were developed using Community Based Participatory Action Research (CBPAR) to prepare the SHFs for the intersection between ICT and CSA to combat the impacts of climate change.

CHAPTER 8

MAIN STUDY PHASE 2

ANALYSIS OF SHFS' INTERVENTION PROGRAMME USING CBPAR

The previous chapter, Chapter 7, explored the level of ICT literacy possessed by the uMsinga SHFs and the type of literacy they need if they are to incorporate ICT into their agricultural practices in the face of climate change for food production. There are five (5) levels of ICT literacy, namely:

- First level of ICT literacy - mobile phone symbol identification literacy;
- Second level of ICT literacy - basic ICT literacy;
- Third level of ICT literacy - semi-medium-level ICT literacy;
- Fourth level of ICT literacy - medium-level ICT literacy; and
- Fifth level of ICT literacy - advanced ICT literacy.

The findings revealed that the SHFs lacked adequate ICT literacy proficiency for the intersection between ICT and their agricultural practices. Furthermore, the findings showed that ICT literacy proficiency development is needed for the SHFs to integrate ICT into their agricultural practices in the face of climate change for food production. This implies that an intervention programme needs to be planned and implemented, for the ICT literacy capacity building of the uMsinga SHFs, so that they can integrate an ICT-based agro-weather tool in their practices. Therefore, the main and secondary concerns of this chapter are:

How can the ICT literacy levels be developed to incorporate the integrated use of ICT devices and CSA using CBPAR?

(i) To know what kind of functionalities would uMsinga SHFs wish to include in the ICT-based agro-weather tool, interfaced with CSA, to adapt to the impacts of climate change on food production?
(ii) To establish how uMsinga SHFs would use these functionalities, and why?

This requires employing the use of CBPAR (community based participatory action research) to bring about uMsinga community development /capacity building, so that the SHFs' levels of ICT literacy are developed in order to incorporate the integrated use of ICT devices and CSA using CBPAR.

As discussed in section 4.4.2.2 of Chapter 4, CBPAR consists of five (5) stages, namely:

(i) Design and implementation of intervention programme with SHFs (1st stage);
(ii) SHFs' engagement (2nd stage);
(iii) Data collection (3rd stage);
(iv) Data analysis (4th stage); and
(v) Reporting the findings (5th stage) (Burns et al., 2011, p. 11).

The above five stages were rearranged and used in this study to guide the constitution of data on the SHFs' ICT literacy development. However, these five stages were facilitated using 10 living theory (LT) action reflection cycle questions, namely:

(i) What was my concern?
(ii) Why was I concerned?
(iii) What experiences can I describe to show why I was concerned?
(iv) What did I do about my concern?
(v) What did I do about it?
(vi) What kind of data did I gather to show the situation as it unfolded?
(vii) How did I explain my educational influences in learning?
(viii) How did I show that any conclusions I came to were reasonably fair and accurate?
(ix) How did I evaluate the evidence-based account of my learning?
(x) How did I modify my concerns, ideas and practices in the light of my evaluations? (McNiff & Whitehead, 2006, p. 3; Whitehead & McNiff, 2006, p. 89).

The detail of each living theory action reflection cycle was discussed in section 4.4.2.3 of Chapter 4. In this study, the above 10 action reflection cycle questions were used to facilitate the five stages of CBPAR as presented in Table 8.1. This living theory explains my influence on the SHFs' learning of ICT to be able to integrate ICT into their agricultural practice through adoption of ICT initiatives like a weather application (app) on smartphones (SP) (Whitehead, 2008, p. 104; 2014, p. 3).

Table 8. 1 The relationship between CPBAR and living theory (LT)

CBPAR Stages	LT Action Reflection Cycle
Designing and implementation of intervention programme (1st stage)	What was my concern?
	Why was I concerned?
	What experiences can I describe to show why I was concerned?
	What did I do about my concern?
	What did I do about it?
Engagement stage (2nd stage)	What was my concern?
Data collection stage (3rd stage)	What kind of data did I gather to show the situation as it unfolded?
Data analysis stage (4th stage)	How did I explain my educational influences in learning?
Reporting of findings (5th stage)	How did I show that any conclusions I came to were reasonably fair and accurate?
	How did I evaluate the evidence-based account of my learning?
	How did I modify my concerns, ideas and practices in the light of my evaluation?

As revealed in Table 8.1, the first five questions of the action reflection cycle were used to facilitate the first stage, designing and implementation of intervention programme with SHFs. At the engagement stage (2nd stage), the first question was employed to get the attention of an advisor who was overseeing a group of SHFs through email and phone calls. The information was communicated to the SHFs and their consent for a meeting was sought. The engagement stage of CBPAR was used as the first stage in this study to guide the preliminary phase. This was used to provide a robust base for the main study. Similarly, the sixth question was used to facilitate the data collection stage (3rd stage). The question guided how our data were collected. In addition, the seventh question was used to facilitate the data analysis stage. The question provided a guide on the explanations expected on the data collected. Finally, the last three questions of the action reflection cycle were used to facilitate reporting of our findings. The questions helped to get essential points to be reported at the fifth stage of CBPAR. This chapter is thus divided into seven sections, namely:

- Section 8.1 will explore the SHFs' engagement (2nd stage);
- Section 8.2 will describe and explain the design and implementation of the intervention programme with SHFs (1st stage);
- Section 8.3 will explain SHFs' addition of functionalities into the ICT-based agro-weather tool
- Section 8.4 will describe my understanding of how uMsinga SHFs would use these functionalities and the reasons
- Section 8.5 will provide a summary of the main study phase two findings.

8.1 The engagement with uMsinga SHFs (2nd stage)

This second stage of CBPAR (Burns et al., 2011) to the form of the first stage in this study. The aim of this section is to get the "community buy-in" by presenting the findings from section 7.1 of Chapter 7 to the uMsinga SHFs. A meeting was held with project stakeholders, consisting of 35 SHFs, one advisor, two assistant researchers and the researcher. This engagement stage provided a basis for planning on our collective concerns. These concerns could be referred to as the fear, anxiety, or worry that the SHFs exhibited regarding the integration of ICT into CSA. They are revealed in the in-depth view of the SHFs that emerged from the outcome of their ICT literacy proficiency previously discussed in section 7.1 of Chapter 7. The detail of the planning on our concern is discussed below.

8.2 The design and implementation of the intervention programme with SHFs (1st stage)

In this section, this first stage of CBPAR is regarded as second for planning and implementation of the intervention programme. The stage is twofold, namely:

- Planning of intervention programme, and
- Implementation of intervention programme.

8.2.1 Planning of an intervention programme with SHFs

The subsection involves thorough dialogue with the uMsinga SHFs regarding the intervention programme. This is with the aim of conducting a fruitful ICT training workshop for the SHFs, to understand areas of concern and to proffer possible solutions to the identified concerns, before the implementation stage. The first question of the LT action reflection cycle addresses the main focus of this section, which is to understand how the SHFs' ICT literacy will be developed. This became a concern to us as a team because the outcome of the SHFs' ICT literacy proficiency was generally low, as presented in Chapter 7. This finding became a point of our discussion at the community forum meeting which was facilitated using the SHFs' ICT Literacy Development Protocol (SHFLDP) (see appendix D). It should be noted that the data were collected through frequency count[13]. The reason for adopting this method was to see how the uMsinga community can be developed through the capacity building of SHFs. The SHFs share similar interest and experiences. In our forum meeting, an intervention programme was agreed to be organised to develop the low ICT literacy levels of uMsinga SHFs. However, four categories of concern about the intervention programme were raised and agreed upon at the community forum meeting. These concerns are:

- Perceived usefulness of the intervention programme;
- Anxiety regarding poor eye sight and inability to read due to age;
- Duration and date (Mondays being preferable); and
- Venue for the implementation of the intervention programme.

The above four concerns were extracted from the uMsinga SHFs' comments during our forum meeting. For example, the SHFs commented that *I would need training ... I will not have time since I am always busy.* These comments indicate the worry of the SHFs for the relevance and duration of the intervention programme. These could be regarded as concerns because it was somewhat difficult for the SHFs to leave their work and attend to meeting, since they are passionate about their farming activities. In addition, the SHFs raised anxiety regarding their sight that *we can't see we are old now, I can't read.* This becomes an issue because the SHFs were considering the visibility of characters on mobile phone screens. The SHFs commented that *If they should come next week Monday, can we learn?* This indicated their concern for the

[13] The frequency count, in this study, does not refer to the numbers of SHFs that participated in the study, but rather, the number of times an item (category) was raised in the forum discussion. The item (category) raised was agreed upon collectively by the SHFs.

date for the intervention programme. Similarly, the issue of where to use as a venue for the workshop in the field became a concern, so they suggested a shipping container as *a hall up there*. This was a concern because the SHFs are busy on farming activities and the suggested venue may be unsuitable. These four category of concerns above are evident in the excerpts below:

Ngizodinga uqeqesho kodwa ngikakubona nini njemgoba ngingenasikhathi ngihleli ngimatasatasa...
I would need training, but when can I see you, as I will not have time since I am always busy…
Eh ndodana asisaboni sesibadala manje. Angikwazi nokufunda, ngingakhumbula?... uma ungasifundisa!
Ah my son, we can't see we are old now, I can't read. Is it easy, will I remember? …If you can teach us!
Abantu ababengemumva bavuma ukuthi kubalulekile ukuba nalolulwazi.
The SHFs chorused in the back agree that it is important to have this knowledge.
… Uma bengafika ngeviki elilandelayo ngomsombuluko singafunda? Yebo…. Ngakho ngeviki elilandelayo bayabuya ukuzosifundisa bangani.
…. If they should come next week Monday, can we learn? Yebo (yes) ….. So, next week they are coming back to teach us friends.
... Kunehholo elingenhla, bazobuya nini?
... …there is a hall (shipping container) up there, when will they come? ...

The analysis shows that an overwhelming majority of the uMsinga SHFs bought into the idea of the ICT literacy proficiency intervention programme. The SHFs raised four concerns about the ICT literacy intervention programme, namely: perceived usefulness of the intervention programme, anxiety regarding poor eye sight and inability to read due to age; duration and date for the intervention, and venue. These concerns align with the finding of Mayhorn, Stronge, McLaughlin, and Rogers (2004), whose participants felt worried about damaging ICT facilities during the intervention programme. The implication is that the SHFs' ICT literacy anxiety might negatively inform their participation in the intervention programme.

This suggests that the teaching method to be adopted should encourage the SHFs' learning of ICT in order to bring about improvement in their (CSA) practices. The method of teaching adopted in this study might possibly alleviate the anxiety of the SHFs by allowing them to interact with each other in their groups, permitting them to touch and work with the iPad as well as smartphones used for demonstrations. In addition, this also has implications for the proposed design of the ICT-based agro-weather app which will solve the anxiety over poor eye sight due to age. In addition, the proposed venue should be should be close to the farms to enable the SHFs to perform some farming activities during the day.

8.2.2 Implementation of ICT literacy intervention programme

This section presents the activity carried out during the intervention programme to show how the uMsinga SHFs' ICT literacy levels were developed, being guided by the four stages of CBPAR, namely:

- intervention programme implementation (1st stage);
- data collection (3rd stage);
- data analysis (4th stage); and
- reporting of findings (5th stage) (Burns et al., 2011, p. 11).

The four stages of CBPAR above were employed in the uMsinga SHFs' ICT literacy proficiency intervention programme, as discussed in the details below.

Intervention programme implementation (1st stage)

This first stage in this study refers to execution of the planning discussed in the previous section. According to Burns et al. (2011), intervention programme implementation means the issues that can possibly be acted upon amongst community members like SHFs. The uMsinga SHFs who volunteered to be part of this project, also agreed to participate in the ICT literacy proficiency development. At the training, 25 out of the initial 35 SHFs who started the study, one extension officer (advisor), one research assistant and the researcher attended the intervention programme. The reason for the reduction in the number of the SHFs was that, ethically, the participants have freedom to withdraw from the study at any time without being put under pressure, as discussed in section 4.7, Chapter 4. The SHFs left their farming activities to attend the training at about 10 a.m. in a venue on the field, as agreed upon at our previous planning meeting.

The 4th question of action reflection cycle in LT, namely: *what did I do about my concern?* was employed to facilitate this phase of the implementation stage. The action reflection cycle explains the actions regarding what I did about my aim to develop the SHFs' ICT literacy levels (McNiff & Whitehead, 2006). Therefore, the activities carried out to develop the uMsinga SHFs' ICT literacy levels are presented in Table 8.2.

Table 8. 2 SHFs' intervention activities and purpose of action

Actions Performed	Reasons
Identifying the SHFs with smartphones (SPs) – Only two had SPs	This was done in order to determine the number of groups that will be created based on available ICT infrastructure. This is to enhance continuous learning after the intervention programme within the groups
Grouping the SHFs into two groups of 13 based on the available SPs	The SHFs were put into two groups because of shortage of ICT facilities (full connectivity is only possible on SPs while it is absent in basic mobile phones) and to enhance group learning among the SHFs.
Assigning SHFs with SPs as group leaders	It was agreed by all participants that each SP owner would head a group because they would have a better understanding on to handle the device
Using researcher iPad as hotspot for the smartphones to access the Internet	The iPad was used to connect the available SPs to access the Internet. In addition, data bundles were available only on the iPad.
Accessing demo weather app (www.weather.com) by connecting SPs via the hotspot to the Internet (with the support of research assistants)	The weather app was used for demonstration since there was no local app for similar purposes.

Identifying weather icons and symbols on the app in order to interpret the information (graphic) e.g. partly cloudy, cloudy, showers and sunny among others,	The weather icons were identified because the SHFs can easily recognise or understand symbols. This enables the SHFs to learn the features on the web by themselves.
Locating their locale in order to access the weather forecast specific to their area,	To learn functions of the demo app
Homework task – application of what was learnt during the workshop in daily life in their respective groups. SHFs were to apply the knowledge and provide feedback to the extension officer (advisor) on progress made.	To enable SHFs to apply the knowledge gained

The first three steps above were achieved by dividing all the 25 SHFs who participated in the training into two groups (McNiff & Whitehead, 2006; Waddell & Vartuli, 2015). The training took place in an open field where the SHFs farm. This was because the SHFs were busy with their agricultural activities. So, it was practically impossible for the SHFs to use a venue far away from their primary place of work, as agreed upon in our intervention planning meeting.

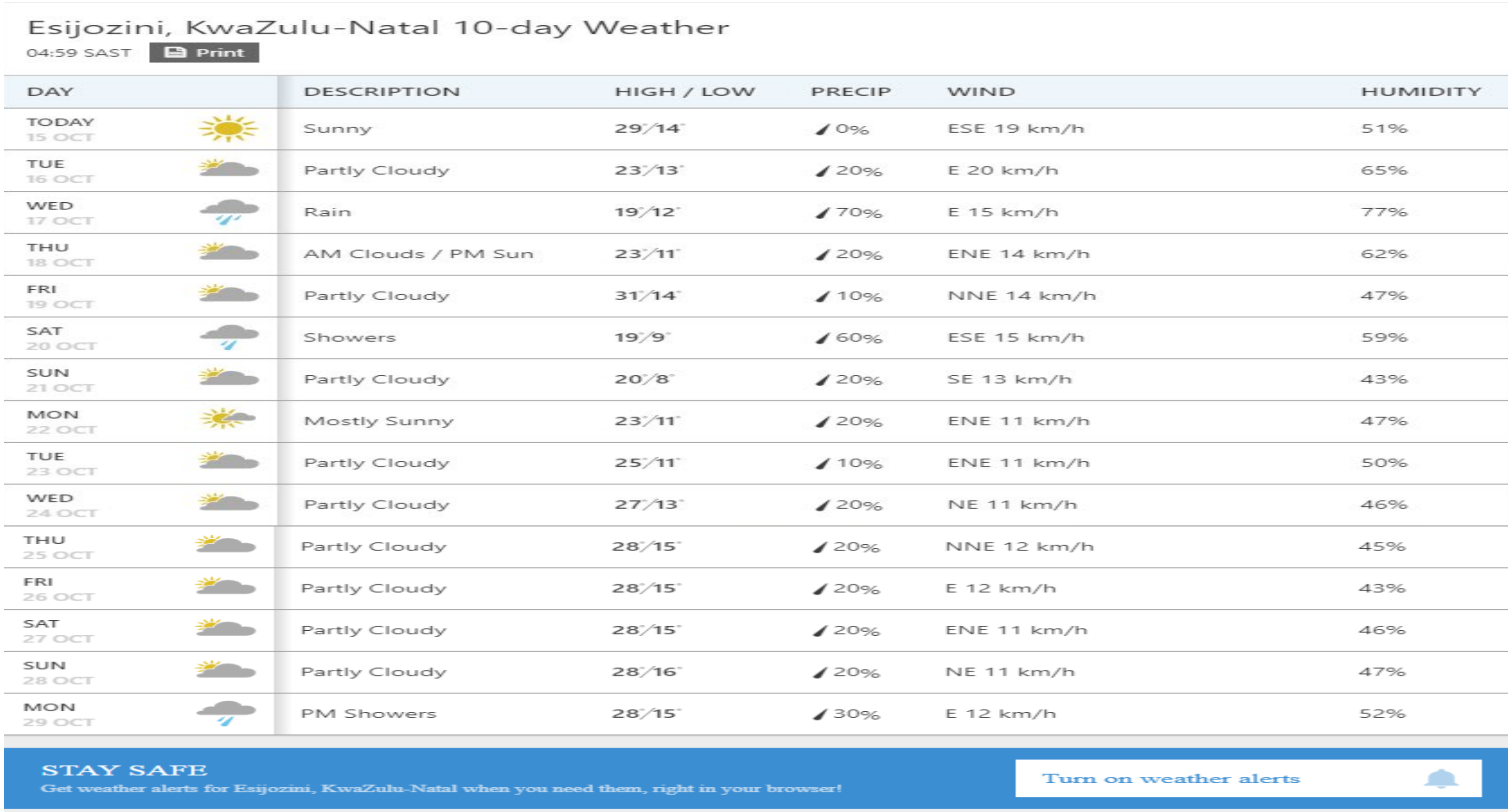
The strategy of grouping the SHFs into two was adopted because of the limited number of resources such as computers, SPs, access to the Internet, electricity to power computers and overhead projector in the field for the intervention programme. It also served to make learning easy for those SHFs who may find other strategies (like actively rehearsing, summarising, paraphrasing, imaging, elaborating, and outlining among others (Weinstein, 1988)) difficult. This method afforded the SHFs the opportunity to interact and share knowledge gained among themselves. To understand the number of available ICT facilities to work with during the workshop and after, the SHFs were asked if they own SPs. Only two amongst 25 SHFs that attended the workshop own a SP. It was suggested that the SHFs should be grouped based on the available ICT facilities to work with. Therefore, two groups were created through assigning number one or two to each participant. All the SHFs who were assigned one were allocated to group1 whilst those with two were allocated to group2. It was suggested that the two SP owners should be leaders to co-ordinate learning activities of each group. The SHFs agreed to the nomination of the SP owners as each group leader, as illustrated in the excerpt below:

Siyavuma sizobuza nakubona ngoba asinabo omakhalekhokhwini ukuze besisize ngokusitshela ukuze singajovi uma lizona
…we agree, we will also ask them because we do not have these type of cell phone (smartphone), so that they (group leaders) can tell us weather information so that we will not irrigate while it is going to rain
Sizosebenzisa umnikazi we-smartphone njengabaholi beqembu ...sizoyithatha inombolo eyodwa, amabili... Ngicela ungisize ngibanike izinombolo eyodwa, ezimbili, eyodwa, ezimbili ukuze lapho singazihlukanisa ngamaqembu bese siqala ukuqeqeshwa.
We are going to use the smartphone owner as group leaders …we are going to take number one, two… Please help me give them numbers one, two, one, two so that from there we can divide them into the groups and then we start the training.

The analysis of finding shows that uMsinga SHFs were grouped into two as the two SP owners were appointed as group leaders. This was because the majority of the SHFs only have basic mobile phones, which can barely perform web based operations. The implication of this division is that the groups might be coordinated to learn the use of ICT in relation to CSA practices amongst the SHFs, both during and after the training exercise.

Data collection (3rd Stage)

The phase of the intervention stage deals with how data were collected during the training. The 4th to 7th actions in Table 8.2 were carried out to gather the responses of uMsinga SHFs to learning the use of ICT. The researcher's iPad was used as a hotspot for the SPs to access the Internet. With the support of the research assistant, the demo weather app on the URL (universal resource locator) www.weather.com was accessed. The essence of using the site as a demo was to know the thought of the SHFs about the app, how it could be applied in their CSA practices and what could be added to the app in order to develop a substantive ICT-based agro-weather app that was proposed to be designed for their use. The demo app has the capacity to predict the complex weather conditions of the SHFs' environment where they farm. The snapshots of the demo app are presented in Figures 8.1 and 8.2.



Esijozini, KwaZulu-Natal 10-day Weather

04:59 SAST Print

DAY		DESCRIPTION	HIGH / LOW	PRECIP	WIND	HUMIDITY
TODAY 15 OCT		Sunny	29°/14°	0%	ESE 19 km/h	51%
TUE 16 OCT		Partly Cloudy	23°/13°	20%	E 20 km/h	65%
WED 17 OCT		Rain	19°/12°	70%	E 15 km/h	77%
THU 18 OCT		AM Clouds / PM Sun	23°/11°	20%	ENE 14 km/h	62%
FRI 19 OCT		Partly Cloudy	31°/14°	10%	NNE 14 km/h	47%
SAT 20 OCT		Showers	19°/9°	60%	ESE 15 km/h	59%
SUN 21 OCT		Partly Cloudy	20°/8°	20%	SE 13 km/h	43%
MON 22 OCT		Mostly Sunny	23°/11°	20%	ENE 11 km/h	47%
TUE 23 OCT		Partly Cloudy	25°/11°	10%	ENE 11 km/h	50%
WED 24 OCT		Partly Cloudy	27°/13°	20%	NE 11 km/h	46%
THU 25 OCT		Partly Cloudy	28°/15°	20%	NNE 12 km/h	45%
FRI 26 OCT		Partly Cloudy	28°/15°	20%	E 12 km/h	43%
SAT 27 OCT		Partly Cloudy	28°/15°	20%	ENE 11 km/h	46%
SUN 28 OCT		Partly Cloudy	28°/16°	20%	NE 11 km/h	47%
MON 29 OCT		PM Showers	28°/15°	30%	E 12 km/h	52%

STAY SAFE

Get weather alerts for Esijozini, KwaZulu-Natal when you need them, right in your browser!

Turn on weather alerts

Figure 8. 1 demo of ICT-based agro-weather app

Note. app = application; Source: Adopted from www.weather.com

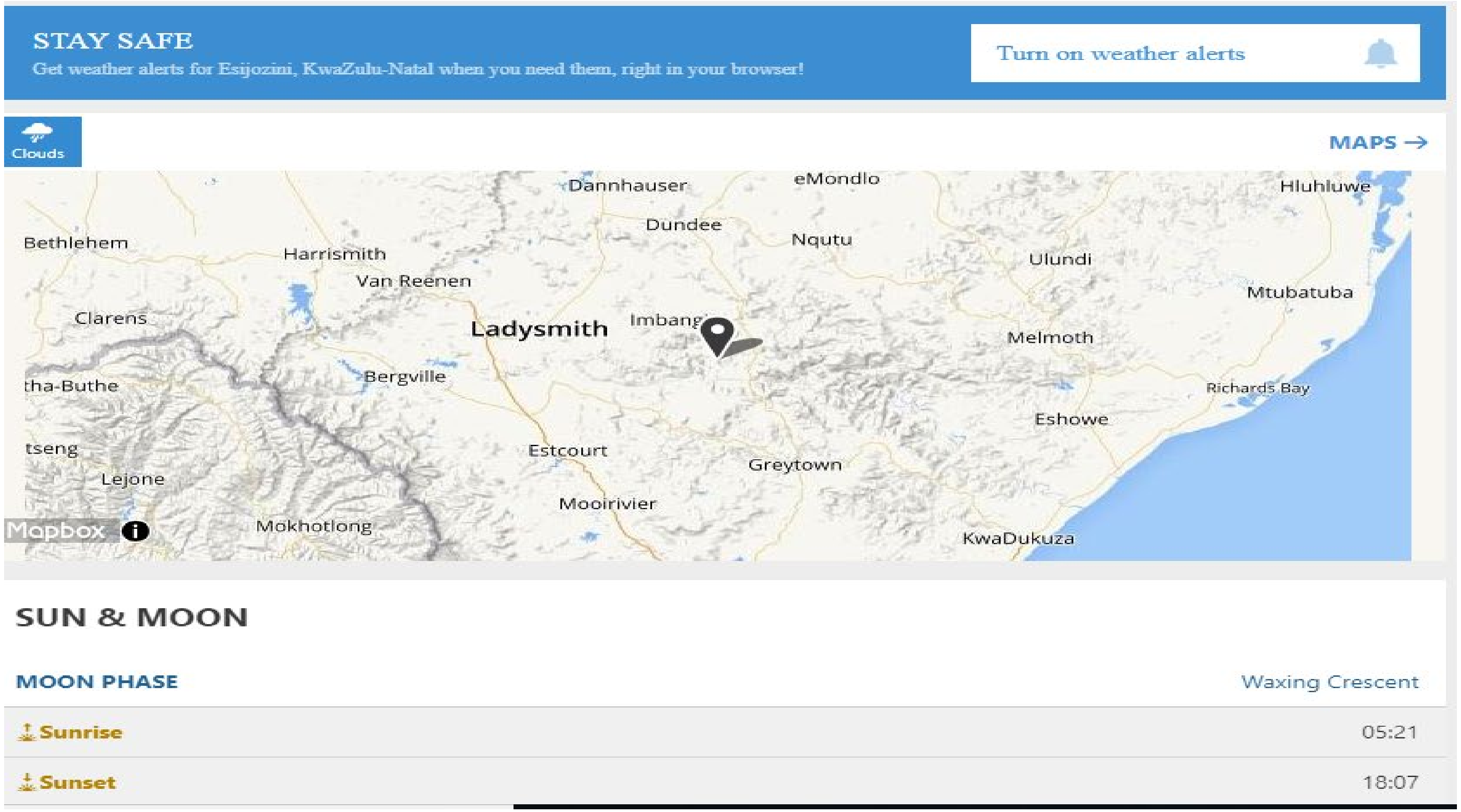


Figure 8. 2 ICT literacy intervention programme venue

Note. Adopted from www.weather.com

As shown in Figure 8.1, the demo app shows days of the week with corresponding weather signs depicting sunny, partially clouded, rain, and shower conditions, amongst others. This was used as a teaching aid during the training. Figure 8.2 shows the location where the intervention took place. This image was used for the SHFs to understand the functions related to their farm area on weather apps.

The 6th and 7th actions in Table 8.1 were performed by the SHFs' through interacting with the demo app on the SPs as shown in Figure 8.1. The SHFs were asked to study the weather icons on the app in order to interpret the information (graphic) that the symbols, convey like partly cloudy, cloudy, showers and sunny. The group leaders ensured that each group member was able to see and identify those functionalities. The SHFs spent about 10 minutes to study the functionalities on the demo app as the research assistant and researcher moved around to facilitate their learning. In addition to the functionalities identified, the SHFs used the demo app to locate their area, select the number of days or weeks on which weather information is required to display and observe weather information on each day as shown in Figure 8.2. This is to ensure that the SHFs take the right weather conditions of their locale into account in taking the right decision on CSA practices.

Data analysis (4th stage) of SHFs' ICT literacy intervention programme

This stage reveals the analysis of data gathered during the SHFs' ICT literacy intervention programme. The audio recorded data was transcribed and sorted, as discussed in section 4.8, Chapter 4. The analysis of this study shows that the uMsinga SHFs' learning during the intervention appeared to have improved the SHFs' understanding of using SP to access weather app. In addition, it was evident in the excerpts below that the SHFs were unable to use a weather app before the intervention. However, the analysis of finding indicates that the SHFs were able to deduce the usefulness of the ICT literacy intervention programme, which connects the use of ICT to their existing agricultural practices, as illustrated in the excerpts below:

O Jehova. Uma kuphela sasinefoni yethu siqu, kodwa sizozithenga. Ngakho le divayisi ifana nethelevishini. Ngakho-ke, kusho ukuthi uma unayo le divayisi ngeke ujobe izitshalo ukuthi uyazi ngoba imvula izosusa amakhemikhali. Yingakho basifundisa ngakho sazi ukuthi kufanele basebenzise amakhemikhali futhi ngezikhathi ezifanele.

Oh Jehovah! If only we had our own cell phone, but we will buy them. So this device is like a television. It means that, if you have this device you will not inject the plants knowing it is going to rain, because the rain will wash away the chemicals. This is why they are teaching us so we know when to use the chemicals and at the right times.
Yebo sibonile isilekelela, ingakho ke sikudinga ukuthi Sibe nayo, ngoba sesiyakwazi ukubona imvula uma izo Netha noma ingazonetha.
Yes, we have seen that the weather app is helpful, that is why we need to own it, since we now can see when it will rain or not.
Njengesimo sezulu bengingazi ukuthi umakhalekhukhwini uyatshengisa isimo sezulu. Namhlanje ngibonile ukuthi isimo sezulu ngingakwazi ukusithola kumakhalekhukhwini. Nomi mase ngine data ngizokwazi ngibavulele ngibatshengise isimo sezulu.
Like the weather forecast, I didn't know that a cell phone can show us the weather, but today I have learnt. Also when I have data I will be able to open for them and show them the weather forecast.

This finding reveals that the SHFs now know how the demo app can be applied to help them understand when to fumigate their crops in order to prevent the chemical being washed away by rain. This is consistent with the findings of Pięta (2018), which revealed that the majority of the participants were satisfied with the training. Similarly, the study is consistent with the findings by Yueh, Chen, Chiu, and Lin (2013) that ICT training conducted in Taiwan improved the farmers' ICT literacy.

It was also evident in the excerpt that the *"weather app is helpful, that is why we need to own it, since we now can see when it will rain or not"*. This finding shows that the SHFs were able to think and plan to have a weather app which could be applied in their CSA practices. McNiff and Whitehead (2006) argue that when any learner reflects upon learning, it means learning has taken place and knowledge has improved. This therefore implies that the SHFs might find it easy to implement what they have learnt in the intersection between ICT and their CSA practices.

Furthermore, the analysis indicates that the SHFs are thinking of applying the app to combat the impacts of climate change (McDonagh, 2007). This capacity demonstrated by the

SHFs to have understood the implication of using the app on their practice is an indication that their climate change education (CCE) has improved. The unintended challenges arising from CSA practices identified in Chapter 5 have necessitated the need for adoption of this app and development of ICT capability in the SHFs. The implication of this finding is that the SHFs' ICT literacy intervention may inform their adoption of ICT into their CSA practice.

Reporting of findings (5th stage)

This stage reveals the evaluation of the uMsinga SHFs' ICT literacy intervention programme. This was done by using the last action in Table 8.1. In this situation, the intervention programme was evaluated by giving a homework task to the uMsinga SHFs to apply what was learnt during the workshop in daily life in their respective groups. The SHFs were expected to apply the knowledge and provide feedback to the extension officer (advisor), on progress made. This was achieved through the report back (6 months later) attended by the extension officer and SP owners (group leaders). The following questions were addressed:

- What was the SHFs' experience of the intervention?
- What improvement did the intervention bring to their CSA practices?
- What could be added to the demo app to make it appropriate for CSA integration by the uMsinga SHFs?

To answer the three questions above, the 8th to 10th action reflection cycle of LT were used to facilitate the fifth stage of the CBPAR to engage representatives of the SHFs at a stakeholder meeting which consisted of the extension officer and the two group leaders mentioned in the previous section. The action reflection cycle questions are:

- How did I show that any conclusions I came to were reasonably fair and accurate?
- How did I evaluate the evidence-based account of the SHFs' learning? and
- How did I modify our concerns, ideas and practices in the light of my evaluation?

A positive response to the first question, *how did I show that any conclusions I came to were reasonably fair and accurate?* requires confirming that the uMsinga SHFs who participated in the intervention programme learnt. The analysis of the uMsinga SHFs' post-intervention programme report shows four (4) main categories of evaluation, namely:

- SHFs' satisfaction at the intervention
- improvement in the uMsinga SHFs' ICT literacy
- the uMsinga SHFs' ability to use demo weather app,
- improvement in their CSA practices.

The four categories help in drawing conclusions and validates the account of the uMsinga SHFs' learning of ICT as they try to adopt the demo ICT-based weather app into their CSA practices. These four categories of evaluation are evident in the comments of the SHFs' representatives made at the stakeholder meeting which took place at about six months after the intervention programme. The SHFs evaluated the training in terms of farming experiences before and after the intervention programme to indicate their satisfaction regarding training and knowledge gained. According to comments of the SHFs, the *training went very well,* meaning successful and *helpful.* This could mean that the training was useful and satisfactory. In addition, the SHFs reveal that there is an improvement in their practice after applying the ICT literacy knowledge gained at the training on the field. For example, the SHFs commented that the *difference that I saw after the training is that, like concerning the issue of excess water on crops, now we are no longer experiencing that, because before there was flooding of our crops.* These are evident in the excerpts below:

Ukuqeqeshwa kwahamba kahle kakhulu, izinto eziningi esasikwazi ukuzenza njengokuhlola uhlelo lokusebenza sezulu. Yebo, kwakusizo. Umehluko engiwubonile emva kokuqeqeshwa yilokho, njengokuphathelene nokukhishwa kwamanzi (amanzi angaphezu kwamanzi) ezitshalweni, manje asisakwazi lokho, ngoba ngaphambi kokuba kube nokukhukhula ezitshalweni zethu.
The training went very well, most of the things we were able to do like checking the weather app. Yes, it was helpful. The difference that I saw after the training is that, like concerning the issue of water flowing (excess water) to crops, now we are no longer experiencing that, because before there was flooding (waterlogging) in our crops.

Similarly, the uMsinga SHFs' applied the demo weather app to inform their decision to perform some agricultural activities. The analysis of the excerpts below indicates that the SHFs use the demo app twice daily to be sure of the decision to take. In addition, the SHFs found use of the app ease as illustrated in the excerpts below:

It was evident in the findings in section 7.1, Chapter 7, before the intervention programme, that uMsinga SHFs lacked the ICT literacy proficiency to use ICT, especially the web based weather app. The analysis of findings above shows that the uMsinga SHFs found the intervention useful. The finding also indicated that the SHFs' level of ICT literacy has improved.

The findings further show that the SHFs now possess the ICT literacy to use the demo

Question	*Response*
Zingaki izikhathi ongena ngazo ukungena ngemvume kusimo sezulu sosuku ngosuku?	*Kabili ngosuku*
How many times do you approximately log onto weather app a day?	*Twice a day*
Owo, ukuqinisekisa ukuthi ngabe le wether ayikashintshi Yini?	*Yebo ukuqinisekisa ukuthi ngabe kusayiyo ngqo yini*
Okay, you do that to make certain that the weather has not changed?	*Yes, to make sure that it is still the same or if it has changed*
Ngabe I weather app iyayiveza yini indawo ohlala kuyo Ngqo, iveze ukuthi UThukela Fairy? ...	*Yebo iyakuveza*
Does the weather app precisely recognize and show the area you live in, UThukela fairy?	*Yes, it does*
Owo, ngakho kulula ke ukuthi ubone ukuthi ngempela Isimo sezulu sizobe sinje la endaweni yami	*Yebo*
Okay, it is thus easy to be sure to see that the weather will be so, in my area	*Exactly*

weather app to mitigate climate change. This was because, the SHFs use the app twice daily and they do that to ascertain that their decision to perform any agricultural activity is guaranteed. This finding is inconsistent with the previous study in Greece (Botsiou & Dagdilelis, 2013) who found Greek farmers that attended ICT training but never acquire ICT skills because of the farmers attitude to ICT use. According to the authors, some of farmers feel they hardly need ICT in their agricultural business and if they do, services of individuals who had the skill would be employed. In this present study, the evidences in the above excerpts show that the conclusion drawn is fair and accurate. By using UTAUT2, the satisfaction or perceived usefulness of the intervention as well as the improvement in ICT literacy and CSA practices can be classified as performance expectancy, whilst the SHFs' ability to use the demo weather app is classified as effort expectancy that informs the uMsinga SHFs' evaluation of the ICT literacy development.

To respond to how did I evaluate the evidence-based account of the SHFs' learning, the results were subjected to the scrutiny of my supervisor as an expert who critiqued the findings (Whitehead & McNiff, 2006). The suggestions of my supervisor were considered and implemented.

The evaluation of the uMsinga SHFs indicated that CSA practices among the SHFs have improved. This was evident in their comment that, *now we are no longer experiencing that, because before there was flooding of our crops.* However, there is need to modify our concern to address the unintentional challenge resulting from the use of ICT tools, as presented in section 6.1, Chapter 1. This concern is addressed in the subsequent section.

8.3 The SHFs' addition of functionalities into the ICT-based agro-weather tool

The previous section presented the findings of the uMsinga SHFs' ICT literacy intervention programme. The SHFs raised four concerns regarding the ICT literacy intervention programme, namely: perceived usefulness of the intervention programme, anxiety regarding poor eye sight and inability to read due to age; duration and date for the intervention, and venue. The findings further indicated nine activities carried out to reveal how the uMsinga SHFs' ICT literacy intervention programme was performed. The findings show that the ICT literacy of the uMsinga SHFs was developed using CBPAR and improved to integrate ICT into their CSA practices. These were evident in the four categories of evaluation of the SHFs. However, the findings in section 6.1, Chapter 6, revealed the lack of local ICT-based agro-weather apps as an unintended challenge that might militate against adoption of ICT into CSA practices. To address this challenge, the 10th question of the LT action reflection-cycle, namely: *how did I modify my* *concerns, ideas and practices in the light of my evaluations?* was used as a guiding question. This question implies that the analysis of evaluation presented previously should guide areas to be modified in our thinking. Thus, the concern in this section is twofold:

- *To know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool, interfaced with CSA, to adapt to the impacts of climate change on food production;*
- *To understand how uMsinga SHFs would use these functionalities and the reasons.*

To address these concerns, a frequency count was used. The latter refers to the number of times an item (category) was raised in our forum discussion, guided by an instrument (see appendix E for Smallholder Farmers Functionalities Inclusion Discussion Protocol (SHFFIDP)). The item (category) raised was agreed upon collectively by the SHFs.

To respond to the first concern, five categories of functionality were suggested and these are:

- access to agro-stores
- agro-marketing
- pictorial representation of activities
- crop diagnostics
- weather info and hotline.

The above five categories of functionality were raised at our forum meeting, as illustrated in the excerpts below. Access to agro-stores and agro-marketing were raised once, whilst pictorial representation of activities, crop diagnostics as well as weather info and hotline were raised twice.

In the following section each of the five categories of functionality is discussed in details.

8.3.1 Access to agro-stores

This category refers to the facility that provides SHFs with the information linking dealers of farm inputs (like improved seedlings, fertilizer, pesticides and insecticides among others) using mobile apps. This study found uMsinga SHFs suggesting the inclusion of online information to link to agro-stores or shops on the proposed app. A number of studies (Bhave, Joshi, & Fernandes, 2014; Sharma, Patodkar, Simant, Shah, & Godse, 2015; Walikar, Kadam, Powar, Pol, & Phule, 2018) in India have shown farmers being provided online information via an app on how to access dealers of farm inputs like fertilizer, chemicals, and improved seedlings for planting.

This finding shows that the uMsinga SHFs suggested inclusion of pictures like crops, pests and insects) as one of the functionalities on the proposed ICT-based agro-weather app. The SHFs commented that they would like to access farm inputs such as *manure, the fertilizers… the crops (improved seedlings)* on the app as illustrated in the excerpt below.

Okumele wengezwe ku-app kukhona umgquba womanyolo... izitshalo (izithombo ezithuthukisiwe)... yilokho esingayisebenzisa...
What to be added to the app are the manure, the fertilizers …the crops (improved seedlings) …that are the things we can use …

8.3.2 Agro-marketing

This category refers to a facility that provides SHFs with the information linking them to markets where farm produce could be sold. This study found that uMsinga SHFs suggested the inclusion of online information to link to markets on the proposed app. A number of studies (Karkhile & Ghuge, 2015; Wawire et al., 2017) in India have shown that farmers access markets through a mobile app.

In this study, the representive of the SHFs who spoke on their behalf suggested inclusion of access to marketing on the app. The SHFs felt the inclusion of market on the app may possibly improve sales of their farm produce, as illustrated in the excerpt below. When this happens, it could improve the income generation of the SHFs and consequently sustain the livelihood of their families.

... imakethe kufanele ifakwe ku-app ukusisiza. Kuyoba ngcono....
...the market should be included in the app to help us. It will be better ……

8.3.3 Pictorial representation of activities

This category refers to use of pictures or images that provide SHFs with the information needed on how to perform some tasks relating to agricultural activities using mobile apps. The tasks that SHFs may want to carry out include; checking where to sell farm produce, buying farm inputs, getting weather forecast information and disseminating information to fellow farmers, among others. This study found that uMsinga SHFs suggested the inclusion on the proposed app of online information to link to agro-stores or shops. A number of studies (Choudhari & Kute, 2014; Khadse, Raut, & Raut, 2015; Mahajan, Abrol, & Lehana, 2016) in India present information to farmers on crop diseases and pests, using apps.

The uMsinga SHF who represented others suggested the inclusion of pictures like crops, pests and insects as one of the functionalities on the proposed ICT-based agro-weather app. The SHFs commented that "w*e also wish that photos of bugs or insects that usually create holes or pores in our crops*" should be used. This may possibly help the SHFs to remember the functions be performed through use of images, as illustrated in the excerpts below. This implies that the SHFs preferred pictorial representation of all features as an icon in the application package and links. It further means that the pictorial representation of activities on the app may facilitate the SHFs' usage. It may provide information needed by the SHFs at a glance, to help them to decide their next action to execute on the field, since they do not have time to read too many details.

(i-app) kufanele inikeze izitshalo zezitshalo, ulwazi mayelana nezifo zezitshalo, kanye nesimo sezulu sezulu endaweni yethu.
It (app) should provide crops pictures, information about crop diseases, and the weather forecast of our area/place.
Sifisa ukuthi uhlelo lokusebenza lunezithombe zezifo noma izimbungulu ezivame ukuhlasela noma izitshalo ensimini yethu. Izifo ezinjengalezi (ezijengekhasi ne-isikhunta) ezivame ukubonakala ezitshalweni zethu njenge-butternut. Okubaluleke kakhulu (ikhasi) eliyithinta kakhulu utamatisi bethu namazambane ethu. Sifisa nokuthi izithombe zezimbungulu noma izinambuzane ezivame ukudala izimbobo noma izimboni ezitshalweni zethu esivame ukubiza (ukungabonakali)

We wish the application had photos of diseases or bugs that usually attack crops in our field. Diseases like (ezijengekhasi and isikhunta) which are usually evident in our crops like butternut. Most importantly the (ikhasi) which is the one that most affects our tomatoes and our potatoes. We also wish to see photos of bugs or insects which usually create holes or pores in our crops, which we usually call (nonqophi)
... inombolo yakhe (othintana naye) kufanele igcinwe njengotamatisi isithombe, ngalokho, ngizokhumbula ukuthi ikhasimende
.... his number (contact) should be saved as a picture of tomatoes, so that I will remember that customer.

8.3.4 Crop diagnostics

This category refers to use of features that provide information to SHFs, providing them with steps on how to overcome challenges of crop diseases, pests, insects and others, using mobile apps. This study found uMsinga SHFs suggesting the inclusion of crop diagnostics on the proposed app. A number of studies (Choudhari & Kute, 2014; Khadse et al., 2015; Mahajan et al., 2016) of Indian designed apps included how crop diseases could be treated by farmers. The apps were designed because recent diseases are complex and require going beyond traditional methods of crop diagnosis (Khadse et al., 2015).

In this study, uMsinga SHFs suggested the inclusion of crop diagnosis as functionalities in the proposed app. This suggestion is evident in the SHFs' comment that *we also wish that when we press or torch a picture on app it must show or display to us medicines or cure which can help with our crops.* The purpose of the crop diagnostic is to help the SHFs reveal ways to treat crop pests, diseases and, as well, link them to dealers who sell cheaper chemicals for such challenges, as illustrated in the excerpt below:

..... Sifisa futhi ukuthi uma sicindezela noma sivutha isithombe ku-app kumele sibonise noma sibonise imithi noma ukwelashwa okungasiza ngezitshalo zethu ... Ngisho noma uma ucindezela inambuzane noma bug, kungabonisa imithi kanye nokuphulukiswa okwenziwa yiloyo bug noma insect. Uma sicindezela ku-bug noma izinambuzane, sibhaliwe noma siboniswa imithi yokwelapha ngezansi ngolimi esingakwazi ukukuqonda ngokucacile kanye nenani lomuthi wokusetshenziswa kwemithi kanye nevolumu lethu lama-litre angu-20.

….. We also wish that when we press or torch a picture on app it must show or display to us medicines or cure which can help with our crops..…. Even whereby when you press on the insect or bug, it may show the medicines and cures done by that bug or insect. When we press on the bug or insect, we are written or displayed the medicines to cure below in a language we may be able to understand clearly and the volume of the medicine use and our volume of 20 litre.

8.3.5 Weather info and hotline

This category refers to use of dedicated communication lines that provide information to SHFs on how to overcome challenges using mobile devices. This study found uMsinga SHFs suggesting the inclusion of weather updates on the proposed app and a local hotline where SHFs could enquire for agro information. A number of studies (Karkhile & Ghuge, 2015; Walikar et al., 2018) in India have shown that farmers' access to hotlines and weather updates are necessary. For example, Walikar et al. (2018) argue that the farmers need a call centre where they can request agro-information using local languages. This makes adding a hotline for SHFs to access agro or weather information on the app important. Likewise, Karkhile and Ghuge (2015) report that Indian farmers have access to weather updates on apps.

In this study, uMsinga SHFs suggested the inclusion of weather information on the proposed app as well as providing a hotline to call. The SHFs commented that the app should contain "*…. the weather forecast of our area/place.* The reason for this suggestion may possible be because of the challenges the SHFs encountered while watching TV for weather forecasts. The SHFs commented that they fall asleep or get distracted by children during the news. In addition, the SHFs commented that they need phone lines that can be called for agricultural information, as illustrated in the excerpts below. Therefore, it can be inferred from the analysis that uMsinga SHFs need a source of weather information that is accurate and accessible.

(i-app) kufanele inikeze izitshalo zezitshalo, ulwazi mayelana nezifo zezitshalo, kanye nesimo sezulu sezulu endaweni yethu.
It (app) should provide crops pictures, information about crops diseases, and the weather forecast of our area/place.
Sidinga izinombolo esingasisebenzisa ukufaka ifoni lapho singathola khona usizo.....
We need the numbers that we can use to phone places where we can find the help. ….

.... Kukhona ithelevishini ekhaya futhi...... kodwa inguqulo endala yama-grannies.... Ngezinye izikhathi asiqapheli lapho izindaba zimemezela isimo sezulu...... Ngokusekelwe kokuthi awubukeli ukuthola ulwazi olulandelayo futhi unisela... kuyinkinga kodwa uma unayo ubukele ukuze uthole ulwazi, kunesiqiniseko.......
... there is a television at home and .... but it's the old version for grannies.... At times we don't notice when the news announces weather forecast...Based on that you are not watching to get information for the next day and you irrigate ...it is a problem but when you have watched it to get the information, it provides assurance. ...

8.4 How uMsinga SHFs would use these functionalities, and the reasons

The previous section presented the functionalities that uMsinga SHFs recommended adding to the web-based agro-weather app. Five categories of functionality were suggested, namely: access to agro-stores; agro-marketing; pictorial representation of activities; crop diagnostic; and weather info and hotline. This section therefore, presents how the categories of functionality will be used and factors that inform the uMsinga SHFs' suggestions.

To address how the uMsinga SHFs would use these functionalities, four categories of functionality use were raised by the SHFs at our forum meeting, namely:

- Using images/pictures on the agro-weather app
- Using the app to access agro-stores/markets
- Using crop diagnostics on the app
- Accessing agro-info with the app.

The above four categories of functionality use were raised at our forum meeting, as illustrated in the excerpts below. Using images/pictures on agro-weather app and using an app to access agro-store/market were raised twice each, whilst using the crop diagnostic on the app and accessing agro-info with the app were raised once each. The result shows that the first two categories of the four functionality use are prevalent amongst the uMsinga SHFs' suggestions.

In the following section each of the four categories of use of suggested functionality is discussed in detail.

8.4.1 Using images/pictures on the agro-weather app and suggested reasons

This category in this study refers to use of images or pictures of objects (like crops, insects and chemicals, amongst other) in an app for uMsinga SHFs to easily interact with and to integrate into their use of CSA. The SHFs suggested pictorial representation of substances like crops, insects and chemical as functionalities on the proposed app. A study (Smith et al., 2017) in Vietnam has shown that farmers prefer pictures of objects on the agro-web for ease of interaction. As argued in Smith et al. (2017), farmers have limited time to read lengthy text on an agro app. This therefore suggests that the use of large icons or images will be an added advantage to SHFs with visual disabilities, enabling them to integrate the agro-weather app into agricultural practices.

In this study, uMsinga SHFs wish that when a button is pressed or torched, a picture of what they expect should be displayed. The reason the SHFs gave was that some of them have eye impairments due to age. Likewise, the SHFs commented that failure to implement the suggested functionalities might render the app useless and permit crop damage, as illustrated in the excerpts below.

Sifisa ukuthi uma sicindezela noma sitshisa isithombe kufanele sibonise noma sibonise imithi (amakhemikhali) noma ukwelashwa okungasiza izitshalo zethu.... Ngisho noma ucindezela isithombe sesinambuzane noma isikhutha kufanele sibonise imithi nendlela yokwelapha leyo bug noma insect.
We wish that when we press or touch a picture it must show or display to us medicines (chemical) or cure which can help our crops. .... Even when you press an image of the insect or bug it should show the medicines and how to cure that bug or insect.
Uma othile ethengile utamatisi, inombolo yakhe (othintana naye) kufanele igcinwe njengesithombe sesitamatisi, ngalokho, ngizokhumbula ukuthi ikhasimende.
When somebody has bought tomatoes, his number (contact) should be saved as a picture of tomatoes, so that I will remember that customer.
........, izingane zingisiza nje kancane, ngoba ngezinye izikhathi ngangizikhandla ngokubona
…., the children just help me a little, because at times I would struggle with seeing
…. if what we suggested is not in the app, ...The crops will be damaged and we will not use the app

The analysis of the findings shows that uMsinga SHFs want a friendly interactive web-based weather app that, at the touch of a picture, would guide their decisions. The finding therefore emphasises the importance that the SHFs place on the implementation of their suggestions. Further, failure to incorporate the functionalities in the proposed app may lead to the abandoning of the app, which may result into damage of crops. Thus, this implies that the pictorial representation of activities on the app will facilitate the SHFs' usage of the app. This will further provide information needed by the SHFs at a glance to decide the next action to be executed on their field, as they do not have time for reading too many details. The reason behind the avoidance of unusable apps aligns with the study of Mythili, Mishtra, and Singh (2018), who argue that an app may be unusable when the icon/text is small for users with poor eyesight and the inability to read due to age. It further implies that pictorial representation of activities on the app may be one of the best languages the SHFs understand to effectively utilise the ICT-based agro-weather app. Thus, using UTAUT2, images/pictures on agro-weather app can be classified as an effort expectancy that the uMsinga SHFs suggested to mitigate the challenge of eye impairment due to age and to prevent the abandonment of the app.

8.4.2 Using an app to access agro-stores and markets, as well as suggested reasons

This category means creating a link on a web based agro weather app for uMsinga SHFs to access agro stores and markets. The findings in this study show that the SHFs suggested a link on the proposed app to showcase their farm produce to customers as well being able to access farm inputs like chemicals. A number of studies (Beza et al., 2017; Kacharo, 2016) in India, Ethiopia and Honduras have shown that farmers get access to market through phone calls.

The analysis of findings in this study reveals that uMsinga SHFs suggested inclusion of access to agro stores and market on the proposed app. This was evident in an SHF's comment that the app "*should suggest the chemicals/cure that are not expensive in price because here … we get them at expensive prices*, as illustrated in the excerpts below. This implies that the SHFs need an app that could possibly link them to agro stores where cheaper chemicals like fertilizers could be purchased or ordered for online. In addition, the SHFs commented that access to markets where they could sell their farm produce has been challenging. Based on this facts, the SHFs desire links on the app to market and agro-store because they could not get sufficient produce buyer and agro chemicals in their locale are too expensive.

Kumele kusiphakamise amakhemikhali / ukwelashwa okungekho abizayo ngentengo ngoba lapha lapho sithola amakhemikhali, siwafumana ngentengo ebiza.
It should suggest the chemical/cure which are not expensive in price because here when we get the chemicals, we get them at expensive prices..
Uma omunye efika ezozothenga izitolo futhi uthi efonini kumele ngisindise ama-mealies lapho ebiza ukuthi ngiyakhumbula ukuthi nguye owathengile ukudla. Uma ama-cabbages ayo abe iklabishi futhi lokho kusho ukuthi yithengi iklabishi.
When another one is coming to buy mealies and he speaks on the phone I must save it under the name Mealies. Then when he calls I remember that it is the one who bought mealies. If it's cabbages he is Cabbage; that means it is the one who bought cabbages.

Thus, using UTAUT2, having an app to access agro-stores and markets can be classified as an effort expectancy that the two representatives of uMsinga SHFs suggested to mitigate the challenges of expensive chemical and lack of markets to sell farm produce, through the use of mobile phones.

8.4.3 Using crop diagnostics on the app and suggested reasons

This category refers to a link in an app which has information on various diseases that affect crops within the locality, that uMsinga SHFs could use for finding help. The results in this study show that uMsinga SHFs wish a crop diagnostic facility to be created on the proposed app, to allow SHFs to access ways to mitigate diseases and plant pests. A number of studies (Karkhile & Ghuge, 2015; Walikar et al., 2018) in India have suggested that farmers should use such functionalities in apps. However, the use of pictures was adopted in India (Mahajan et al., 2016) by farmers using a three dimensional (3D) insect image on apps.

One uMsinga SHF suggested that *we wish that whenever we press the image for a particular disease affecting crops, then the medicines (chemicals) to cure it should appear.* The hope was that this would give the SHFs access to solutions to cure complex crop diseases, which may be difficult using traditional methods, as illustrated in the excerpt below:

Sifisa ukuthi noma yisiphi isifo esithile esithinta izitshalo sivela uma sicindezela isithombe, imithi (amakhemikhali) ukuphulukisa kubonakala ukuthi singayisebenzisa ngaleso sikhathi kuya....... Uma sicindezela ku-bug noma izinambuzane sibhaliwe noma siboniswa imithi yokwelapha ngezansi ngolimi esingakwazi ukukuqonda ngokucacile kanye nenani lomuthi wokusetshenziswa kwemithi kanye nevolumu lethu lama-litre angu-20.
We wish that, whenever we press the image for a particular disease affecting crops, then the medicines (chemical) to cure it should appear. So we can use it at that time to cure ...When we press on the bug or insect, the medicines to cure this should be displayed below in a language we may be able to understand clearly, and the volume of the medicine use related to our volume of 20 litre.

The analysis of the finding shows that the app should provide an instant solution of how a crop disease should be mitigated with step by step measures. This means that the app will be able to diagnose and prescribe farm inputs (like chemicals and fertilizer among others) to apply on the crop. Khadse et al. (2015) explain that the conventional or traditional way of crop diagnosis is fast becoming unpopular in recent times, possibly because of the complexity of our environment. The implication of this finding regarding the uMsinga SHFs is that they will find activities on the ICT-based agro-weather app friendly and useful when the functionalities are pictorially represented (Choudhari & Kute, 2014; Mahajan et al., 2016). Thus, using UTAUT2, a crop diagnostic facility on the app can be classified as a performance expectancy that the uMsinga SHFs suggested to mitigate the challenges of complex crop diseases, pests and insects through the use of mobile phones.

8.4.4 Accessing agro info with a hotline and suggested reasons

There was a proposal for having a dedicated link to an agro centre where uMsinga SHFs can call to access local agro-information. The findings in this study show that the SHFs suggested a link on the proposed app to showcase their farm produce to customers as well as being able to access farm inputs like chemicals. The finding in this study shows that uMsinga SHFs suggested that a hotline should be available for their call to inquire for help. A number of studies (Angello, 2015; Dube, 2013; Oswald, 2019) in Kenya, Ethiopia and Tanzania show that farmers use mobile phones to get and pass on agro information.

The findings show that uMsinga SHFs desired a dedicated line where the SHFs could call for assistance. The SHFs gave the reason was that they could call someone for help. The hotline could be for the purpose of knowing the current market price of product or knowing where to get their farm produce sold to buyers, as illustrated in the excerpts below:

Sidinga izinombolo zocingo zezindawo lapho singabiza khona ukuthola usizo (umsizi).....
We need the phone numbers of places where we can call to find help (assistant). ....
.....Siyashoda phela ingakho sidinga imakethe, bayathenga uma kutshale abambalwa kodwa uma sitshale sonke ngobuningi bethu......… siyayidinga imakethe...
....We are short of them (buyers), that is why we need marketing, because they buy if it is harvested by one person but if it is all of us as a group..…. we need marketing....
……… .., usinike izinombolo (izinombolo zokuxhumana) okufanele sizishayele
……..., give us the numbers (contact numbers) that we should call.

This finding indicated that the uMsinga SHFs need an agro-hotline to call and ask for helpful information. A number of studies (Beza et al., 2017; Kacharo, 2016) in India, Ethiopia and Honduras have shown that farmers get access to markets through phone calls. The finding is also consistent with the study of Walikar et al. (2018), who stated that India farmers called for a centre in the local language to request for agro-information. This suggests the importance of the need for a hotline where they can find help as one of the functionalities of the app to be used by uMsinga SHFs. Thus, using UTAUT2, the agro info with a hotline can be classified as a social influence that the uMsinga SHFs suggested to mitigate the challenge of limited agro information through the use of mobile phones.

8.5 Summary of the main study phase two findings

The aim of this chapter was to present the findings related to the uMsinga SHFs' ICT literacy proficiency development using CBPAR; to know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool; and to understand how the SHFs would use these functionalities and the reasons. The findings show that the SHFs raised four concerns regarding the ICT literacy intervention programme, namely: perceived usefulness of the intervention programme, anxiety regarding poor eye sight and inability to read due to age; duration and date for the intervention, and venue. It was suggested that the teaching method to be adopted should encourage the SHFs' learning of ICT to alleviate the anxiety of poor eye sight and perceived usefulness of the training. In addition, it proposed that the suggested nearby venue should be utilised to achieve the set objectives of the intervention programme without jeopardizing the planned farming activities of the SHFs for the day.

The findings show nine activities carried out to reveal how the intervention was performed, namely: identifying the SHFs with smartphones (SPs); grouping the SHFs into two groups of 13 based on the available SPs; assigning SHFs with SPs as group leaders; using the researcher's iPad as a hotspot for the smartphones to access the Internet; accessing the demo weather app (www.weather.com) by connecting SPs via the hotspot to the Internet (with the support of research assistants); identifying weather icons and symbols on the app in order to interpret the information; locating the SHFs' locality on the app in order to access the weather forecast specific to their area; and a homework task. The analysis of the intervention data reveals that the SHFs now know how the demo app can be applied to help them understand when to fumigate their crops in order to prevent the chemical being washed away by rain. This finding shows that the SHFs were able to think and plan to have a weather app which could be applied in their CSA practices. The analysis indicates that the SHFs are thinking on applying the app to combat the impacts of climate change on their own.

The analysis of the uMsinga SHFs' post-intervention programme report shows four (4) main categories of evaluation, namely: SHFs' satisfaction or usefulness of the intervention, improvement in the uMsinga SHFs' ICT literacy, the uMsinga SHFs' ability to use the demo weather app and improvement in their CSA practices. The findings show that the uMsinga SHFs' found the intervention useful and that their level of ICT literacy has improved. The findings further show that the SHFs possessed sufficient ICT literacy to use the demo weather app to mitigate climate change after the intervention. This was because the SHFs daily applied the app twice to be sure that the decisions arrived at were in line with the prediction to perform any agro activity.

The findings show that five categories of functionality were suggested by the uMsinga SHFs, namely: access to agro-stores; agro-marketing; pictorial representation of activities; crop diagnostics; and weather info and hotline. The finding further shows that the SHFs suggested four categories of ways in which the functionalities could be used, namely: using images/pictures on an agro-weather app; using the app to access agro-stores/markets; using crop diagnostics on an app;

and accessing agro-info with the app. In addition, the finding show seven categories of factors informing the SHFs' suggestion of the functionalities and use, namely: eye impairment due to age; abandonment of the app due to failure to implement the suggested functionalities; expensive chemicals; lack of access to markets; challenges of complex crop diseases, pests and insects; and limited agro information.

Thus, using UTAUT2, the images/pictures on agro-weather app can be classified as an effort expectancy that the uMsinga SHFs suggested to mitigate the challenge of eye impairment due to age and the possibility of abandoning the app. Furthermore, using UTAUT2, using an app to access agro-stores and markets can be classified as an effort expectancy that the uMsinga SHFs suggested to mitigate the challenges of expensive chemicals and lack of markets to sell farm produce through the use of mobile phones. Likewise, using UTAUT2, crop diagnostics on the app can be classified as a performance expectancy that the uMsinga SHFs suggested to mitigate the challenges of complex crop diseases, pests and insects through the use of mobile phones. In addition, using UTAUT2, agro info with a hotline can be classified as a social influence that the uMsinga SHFs suggested to mitigate the challenge of limited agro information.

CHAPTER 9

DISCUSSION OF FINDINGS

The overall concern of this study is rooted in the literature that points to the uMsinga Municipality as a hotspot for climate change (Sinyolo et al., 2014; Wettasinha & Waters-Bayer, 2010). A previous study show that majority of inhabitants of uMsinga are smallholder farmers (SHFs) (Sinyolo et al., 2014). This implies that the livelihood of uMsinga SHFs might already have been negatively affected by the impact of climate change. Previous studies have indicated that climate smart agriculture (CSA) has been used to help SHFs in various developing countries to mitigate and adapt to impacts of climate change. Despite the usefulness of CSA, research shows that its adoption alone is insufficient to assist SHFs mitigate the impacts of climate change (Sullivan et al., 2012). As such, due to the possible value of ICT in helping farmers understand the complex nature of environment, it has been deployed into Africa, Asia and Latin America for "monitoring, mitigation, adaptation and strategies" (ITU, 2008, p. 2; Ospina & Heeks, 2010, p. 4). However, recent studies reveal that the use of ICT alone is inadequate to help SHFs to combat challenge of climate variability (Misaki et al., 2016; Yohannis et al., 2019). It is in this regard that this study sought to explore the interface between ICT and CSA in the agricultural practices of uMsinga SHFs in the face of climate change for food production. The findings' summary is thus presented in Table 9.1.

In order to explore the proposed interface between ICT and CSA in this study, the following frameworks were employed to guide both the theoretical and methodological aspects of the study. For the theoretical aspects, theories around adaptation strategic tools (AST), such as the theory of irrigators planned behaviour (TIPB) (Wheeler et al., 2013) and the unified theory of acceptance and use of technology (UTAUT2) (Venkatesh et al., 2012) were employed. TIPB and UTAUT were combined and used in this study to allow for the exploration of the factors that mitigate against uMsinga SHFs' application of CSA practices. And, for the methodological aspects, the living theory (LT) by Whitehead and McNiff (2006) and community based participatory action research (CBPAR) as espoused by Burns et al. (2011) were adopted. LT and CBPAR were combined and used in this study to allow for the exploration of the use of community-based development to gain insight into the reality of climate change related issues.

Table 9. 1:

New knowledge inferred from adoption of AST in the study

Research Questions	Focus	New Knowledge1	New Knowledge2	New Knowledge3
Preliminary Study 1. What are the uMsinga SHFs' existing agricultural practices in relation to Climate Change Adaptation?	Practice	Unintended challenges resulting from CSA practices	Unintended capital > initial capital	Factors informing CSA practices, namely: (i) Flooding; (ii) Unpredictable weather conditions; (iii) Drought; (iv) Lack of infrastructure (pump, pipes, etc.); (v) Lack of funds to maintain irrigation farming infrastructure; (vi) Problem of pests and diseases; and (vii) Low crop yields.
2. Do SHF in uMsinga regard the integration of ICT and CSA into their existing agricultural practices as crucial for adequate food productivity and livelihood in the face of Climate Change adaptation? (i) If so, or if not, what informs their perceptions? (ii) If not, what informs their perceptions?	SHFs' regard of ICT	Two unintended challenges resulting from SHFs' decision for intersection between ICT and CSA	The unintended challenges are facilitating conditions and performance expectancy	Seven factors informing SHFs' positive regard for ICT integration into CSA practices
Main Study 1. (i) What level of ICT literacy do SHF in uMsinga have? And	Levels of ICT literacy	SHFs lack ICT literacy from third (semi-medium) to fifth level (advanced)	ICT literacy of SHFs is to be developed from semi-medium level in order to interface between ICT and CSA	Two moderating factors, educational level and age, relate to the ICT literacy of the SHFs.

(ii) What level of ICT literacy do SHF in uMsinga need?				
2. How can the ICT literacy levels be developed to incorporate the integrated use of ICT devices and CSA using CBPAR?	ICT literacy development using CBPAR	Activities required in the training of SHFs	SHFs' application of ICT literacy proficiency in CSA practices	Challenge of indigenous agro weather mobile app
(i) To know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool, interfaced with CSA to adapt to the impacts of climate change on food production; (ii) To understand how uMsinga SHFs would use these functionalities and the reasons.	Inclusion of functionalities	Factors inform SHFs' suggestions of functionalities in a locally designed agro weather app.	Use of functionalities and reasons	Three major classification of functionality needed in design of indigenous ICT-based agro weather app for SHFs

With respect to preliminary study research question 1: *What are the uMsinga SHFs' existing agricultural practices in relation to climate change adaptation,* this research question is further broken down into the following three sub-questions:

- What do they do?
- How do they do it?
- What informs what they do?

The aim of this first preliminary research question was twofold:

(iii) Firstly, it aimed to determine whether indeed the SHFs use climate smart agricultural practices in relation to climate change adaptation.

(iv) Secondly, it aimed to probe on the factors that inform the SHF's current agricultural practices in the face of climate change for food production?

9.1 Discussion of preliminary study research question 1

9.1.1 The relationship between SHFs' use of climate smart agricultural practices and climate change adaptation

With respect to (i) above, the results of the study showed that the following seven CSA strategies are used by the uMsinga farmers:

(i) multiple cropping
(ii) crop rotation
(iii) irrigation farming;
(iv) farming near rivers
(v) using chemical/manure to fertilize soil for maximum yield
(vi) planting of improved varieties and
(vii) planting of improved local varieties.

9.1.2 Factors informing SHF's current agricultural practices for food production in the face of climate change

With respect to (ii) above, the results of this study show that seven factors seem to inform the SHFs' CSA practices, namely:

(i) Flooding – categorised as natural capital
(ii) Unpredictable weather conditions - categorised as natural capital
(iii) Drought - categorised as natural capital
(iv) Lack of infrastructure (pump, and pipes among other) - categorised as physical capital
(v) Lack of funds to maintain irrigation farming infrastructure - categorised as financial capital
(vi) Problem of pests and diseases - categorised as natural capital
(vii) Low crop yields - categorised as natural capital.

What was significant to note was the resultant consequence, which is unintended that arose as a result of the adoption of each of the above CSA practices to mitigate the above challenges:

(i) Using multiple cropping to mitigate flooding – this brought to the fore the lack of technological or scientific know how, which is categorised as a lack of human capital
(ii) Using crop rotation to mitigate unpredictable weather conditions – this brought to the fore the Lack of know how to forecast weather condition of the environment, which is categorised as a lack of human capital.
(iii) Using irrigation farming (local canals) to mitigate drought and lack of infrastructure – this brought to the fore the lack of resources to maintain the irrigation system and lack of funds to maintain irrigation infrastructure, which is categorised as lack of physical and financial capital respectively.
(iv) Farming near rivers to mitigate lack of fund to maintain irrigation infrastructure and the drought – this brought to the fore lack of know how to forecast weather condition of the environment, which is categorised as lack of human capital.
(v) Using chemicals/manure for maximum yield to mitigate low yields, problem of plant pests and diseases – this brought to the fore the lack of financial resources to purchase

the seedlings, and dependence on the government/extension workers to supply, which is categorised as lack of physical and financial capital respectively.

(vi) Planting improved varieties (seedlings/crops) to mitigate low yield, drought, and problem of plant pest and diseases – this brought to the fore the lack of financial resources to purchase the seedlings, and dependence on the government/extension workers to supply, which is categorised as lack of physical and financial capital respectively.

(vii) Planting local improved seedlings to mitigate low yield, drought, and problem of plant pest – this brought to the fore the lack of scientific know-how, which is categorised as lack of human capital.

The above results, show that the adoption of CSA practices alone is "insufficient" to solve the challenges of climate change facing SHFs, thus corroborating Sullivan et al. (2012) results. Furthermore, the discovery of further unintended challenges to the use of CSA practices is significant in that it allows for a broader definition of the term "insufficiency of CSA".

9.2 Discussion of preliminary study research question 2

With respect to preliminary study Research Question 2: *Do SHF in uMsinga regard the integration of ICT and CSA into their existing agricultural practices as crucial for adequate food productivity and livelihood in the face of Climate Change adaptation?*

(i) If so, or if not, what informs their perceptions?

(ii) If not, what informs their perceptions?

With respect to above (2), the result in this study indicates that uMsinga regarded the integration of ICT into their CSA practices.

The integration is necessary to alleviate the SHFs' unintended challenges resulting from their CSA practices. What was significant to note was the resultant consequence, which is unintended that arose as a result of the uMsinga SHFs to interface ICT and CSA:

(i) Regard for ICT interface – this brought to the fore the limited literacy to utilise ICT devices, which is categorised as facilitating conditions and

(ii) Regard for ICT interface - this brought to the fore the lack of indigenous ICT-based agro-weather apps, which is categorised as lack of performance expectancy.

The above results, show that the adoption of ICT alone is "insufficient" to solve the challenges of climate change facing SHFs, thus corroborating Misaki et al. (2016); Yohannis et al. (2019) results. Furthermore, the discovery of further unintended challenges to the regard of SHFs to ICT is significant in that it allows for a broader definition of the term "insufficiency of ICT".

With respect to (2i) above, the results of this study showed that the following seven factors seem to inform uMsinga SHFs' regard for the intersection between ICT and CSA practices, namely:

(i) Enjoyment in use of mobile phone – categorised as a hedonic motivation
(ii) Past experience of using mobile phone – categorised as a habit
(iii) Network service charges – categorised as a price value
(iv) Perceived usefulness of mobile phone – categorised as a performance expectancy
(v) Perceived ease of the use of mobile phones – categorised as effort expectancy
(vi) Perceived association with individuals – categorised as a social influence and
(vii) Perceived availability of supportive resources – categorised as a facilitating condition.

9.3 Discussion of the main study research question 1

With respect to main study Research Question 1:

(i) What level of ICT literacy do SHF in uMsinga have? and
(ii) What level of ICT literacy do SHF in uMsinga need?

This research questions are further broken down into the following three sub-questions:

- What level is ICT literacy of uMsinga SHFs?
- How adequate is the ICT literacy?
- What informs the level of the ICT literacy?

The aim of this first main research question was fivefold:

(i) Level of ICT literacy possessed by the SHFs in uMsinga
(ii) Trends stemming from the analysis of SHFs' ICT literacy level
(iii) Factors affecting the SHFs' ICT literacy levels
(iv) The relation between the identified factors and ICT adoption and
(v) The type of ICT literacy needed by the uMsinga SHFs to incorporate ICT into their CSA practices in the face of climate change for food production.

With respect to (i) above, the results of the study showed five levels of ICT literacy, namely:

- First level of ICT literacy - mobile phone symbol identification literacy
- Second level of ICT literacy - basic ICT literacy
- Third level of ICT literacy - semi-medium-level ICT literacy
- Fourth level of ICT literacy - medium-level ICT literacy and
- Fifth level of ICT literacy - advanced ICT literacy.

What was significant to note was that the uMsinga SHFs lacked ICT literacy from third (semi-medium) to fifth level (advanced). This affirms findings in previous studies (Angello, 2015; Chikaire et al., 2017; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016) that SHFs lacked ICT literacy. However, the authors were unable to point to what level of ICT literacy would need to be developed in the farmers. The finding in this study shows that SHFs' ICT literacy should start from the semi-medium to advance level of ICT literacy before the interface between ICT and CSA. Therefore, this study extended previous research findings by revealing the level of ICT literacy proficiency SHFs have and the level which development should start.

With respect to (ii) above, the results of the study showed that the slope declines gently downward from the first to the second level but sharply from the second to fifth level. The moderate proficiency curve on the other hand undulates, while the low proficiency curve ascends upward at a sharp slope from the second to the fifth level. The graph indicates that, as the SHFs progress from first to fifth level, the low ICT literacy proficiency increases. Thus, the trends indicate that the uMsinga SHFs have inadequate ICT literacy.

With respect to (iii) in page 211 above, the study shows that it was significant to note that only two demographic factors of the SHFs that seem likely to significantly inform their ICT adoption, namely:

(i) Age of the SHFs – categorised as moderating variable which negatively influence adoption and
(ii) Educational level – categorised as moderating variable which positively influence adoption.

With respect to (iv) in page 211 above, the result in this study shows that uMsinga SHFs' age and educational level unlikely affected their ICT literacy proficiency and ICT adoption at both first and second level. However, the SHFs' age and educational level affected their ICT literacy proficiency and ICT adoption at the third to fifth levels.

With respect to (v) in page 211 above, the result of this study shows that the ICT literacy proficiency of uMsinga SHFs might require training from the third to fifth level irrespective of their age group and educational background for effective interface between ICT and CSA practices.

9.4 Discussion of the main study research question 2

With respect to main study Research Question 2: *How can the ICT literacy levels be developed to incorporate the integrated use of ICT devices and CSA using CBPAR?*

(i) To know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool, interfaced with CSA to adapt to the impacts of climate change on food production
(ii) To understand how uMsinga SHFs would use these functionalities and the reasons.

The aim of this second main research question was to use community based participatory action research (CBPAR) and living theory (LT) as frameworks to engage the SHFs' community. CBPAR consists of five (5) stages, namely:

(i) design and implementation of intervention programme with SHFs (1st stage)
(ii) SHFs' engagement (2nd stage)
(iii) data collection (3rd stage)
(iv) data analysis (4th stage) and

(v) reporting the findings (5^{th} stage) (Burns et al., 2011, p. 11).

Whilst living theory (LT) action reflection cycle consists of 10 questions which were used to facilitate the five stages above, namely:

(i) What was my concern?
(ii) Why was I concerned?
(iii) What experiences can I describe to show why I was concerned?
(iv) What did I do about my concern?
(v) What I did about it?
(vi) What kind of data did I gathered to show the situation as it unfolded?
(vii) How did I explain my educational influences in learning?
(viii) How did I show that any conclusions I came to were reasonably fair and accurate?
(ix) How did I evaluate the evidence-based account of my learning?
(x) How did I modify my concerns, ideas and practices in the light of my evaluations? (McNiff & Whitehead, 2006, p. 3; Whitehead & McNiff, 2006, p. 89).

The study shows the relationship between the five stages of CBPAR and the 10 action reflection questions of LT in Table 8.1, Chapter 8.

With respect to 1^{st} stage of CBPAR in page 213, above, the results are twofold:

- Planning of intervention programme, and
- Implementation of intervention programme.

The result of the planning shows four categories of concern about the intervention programme, namely:

(i) Perceived usefulness of the intervention programme - categorised as a performance expectancy
(ii) Anxiety regarding poor eye sight and inability to read due to age – categorised as anxiety
(iii) Duration and Date (Mondays being preferable) – categorised as time and
(iv) Venue for the implementation of the intervention programme – categorised as venue.

It was significant to note that venue or location, duration and date which could be measured in term of time is yet to be given consideration in UTAUT1 and UTAUT2 as observed in Ismail (2009, 2010).

Furthermore, the result shows nine activities carried out to develop the uMsinga SHFs' ICT literacy proficiency and reasons for each action performed (see section 8.2.2, Chapter 8). Furthermore, the result shows that the uMsinga SHFs were grouped into two for the workshop because of limited availability of ICT facilities.

With respect to 3^{rd} stage of CBPAR in page 213 (iii) above, the study shows that the SHFs' interacted with the demo app on the SPs. The actions of the SHFs were audio recorded.

With respect to 4^{th} stage of CBPAR in page 213 (iv) above, this finding shows that the SHFs could deduce the application of the demo app on their CSA to understand when to fumigate their crops to prevent chemical wastage during rain seasons. It is therefore significant to know that when any learner reflect upon learning, it means learning has taken place and knowledge has improved (McNiff & Whitehead, 2006). Thus, this implies that the SHFs might find it easy to implement what they have learnt during the intervention programme and prepared for the intersection between ICT and their CSA practices.

With respect to 5^{th} stage of CBPAR in page 213 (v) above, the finding shows that the uMsinga SHFs' post-intervention programme report revealed four (4) main categories of evaluation, namely:

(i) SHFs' satisfaction of the intervention, which was categorised as performance expectancy,
(ii) improvement in the uMsinga SHFs' ICT literacy, which was categorised as performance expectancy,
(iii) the uMsinga SHFs' ability to use demo weather app, which was categorised as effort expectancy, and
(iv) improvement in CSA practices, which was categorised as performance expectancy.

What was significant to note was the resultant consequence, which is unintended that arose as a result of the application of the demo app to demonstrate the interface between ICT and their CSA practices:

- use of demo app – this brought to the fore the need for design of indigenous mobile weather app, which is categorised as a performance expectancy.

With respect to research question 2(i) above, the findings show five categories of functionality suggested by uMsinga SHFs, namely:

(i) access to agro-stores
(ii) agro-marketing
(iii) pictorial representation of activities
(iv) crop diagnostic and
(v) weather info and hotline.

With respect to research question 2(ii) above, the findings four categories of uMsinga SHFs' use of the functionality, namely:

(i) Using images/pictures on agro-weather app -which can be classified as effort expectancy that the uMsinga SHFs suggested to mitigate challenge of eye impairment due to age and abandoned app through the use of mobile phone
(ii) Using app to access agro-store/market - which can be classified as effort expectancy that the uMsinga SHFs suggested to mitigate the challenges of expensive chemical and lack of market to sell farm produce through the use of mobile phone
(iii) Using crop diagnostic on app – which can be classified as performance expectancy that the uMsinga SHFs suggested to mitigate the challenges of complex crop diseases, pests and insects through the use of mobile phone and
(iv) Accessing agro-info with app – which can be classified as social influence that the uMsinga SHFs suggested to mitigate challenge of limited agro information through the use of mobile phone.

CHAPTER 10

CONCLUSION, IMPLICATIONS OF THE FINDINGS & CONTRIBUTION TO KNOWLEDGE

The major concern of this study is to explore the intersection between ICT and climate smart agriculture (CSA) as an adaption strategy in mitigating impacts of climate change facing uMsinga community for food production. This is because the uMsinga as Municipality is regarded as a hotspot of climate change (Wettasinha & Waters-Bayer, 2010) being negatively impacted by menace of climate variability. On this premise, the objectives of this study were divided into two preliminary and main study phases.

Preliminary study objectives were to:

a) Establish the current agricultural practices among smallholder farmers (SHFs) in uMsinga
b) Get community buy-in into interfacing ICT and CSA and
c) Confirm the need for interfacing ICT and CSA among uMsinga SHFs.

Main study objectives were to:

a)
   i) assess the level of ICT literacy SHFs in uMsinga have
   ii) determine the level of ICT literacy SHFs in uMsinga need to incorporate the use of ICT devices and CSA to adapt to the impacts of climate change on food production

b) Explore the ways ICT literacy levels in a) and b) above will be developed to incorporate the integrated use of ICT devices and CSA using CBPAR

i) know the kind of functionalities uMsinga SHFs would include in the ICT-based agro-weather tool, interfaced with CSA to adapt to the impacts of climate change on food production
ii) understand how uMsinga SHFs would use these functionalities and the reasons.

Thus, this chapter presents the overview of the study, conclusion of the study, implications of the findings, and contribution to the existing body of knowledge. The detail is discussed below.

10.1 Overview of the study

Chapter 1 of this study presented the contextual background to the study. Similarly, Chapter 2 outlined the context of the study, factors influencing SHFs' adaptation to climate change, factors influencing farmers' adaptation of ICT tools and a summary of the studies reviewed. In Chapter 3, the frameworks guiding this study were discussed. These frameworks include CBPAR, living theory and AST. The AST consisted of two theories, namely the unified theory of acceptance and use of technology (two) (UTAUT2) as well as the theory of irrigators' planned behaviour (TIPB). Furthermore, Chapter 4 presented the research design and the methodology employed to respond to the research questions set for this study. The methodology was guided by using two frameworks, namely: CBPAR and living theory. On this premise, the chapter was divided into three major sections, pre-intervention, during intervention and post intervention. In addition, Chapter 5 presented the analysis of findings of the first phase of the preliminary study, which was analysed to answer questions on the CSA practices uMsinga SHFs engaged in. TIPB was used to make sense of the findings. Chapter 6 presented the analysis of the second phase of the preliminary study, which addresses how uMsinga SHFs regard the intersection between ICT and CSA practices. UTAUT2 was used to make sense of these findings. Furthermore, Chapter 7 presented an analysis of the findings of the first phase of the main study which is on what ICT literacy the uMsinga SHFs have and need in order to interface between ICT and CSA practices. UTAUT2 was used to make sense of the findings. Similarly, Chapter 8 presented an analysis of the findings of the second phase of the main study, which is on the ICT literacy development of the uMsinga SHFs. The intervention programme was guided by using two frameworks, CBPAR and living theory. UTAUT2 was used to make sense of the findings. Likewise, Chapter 9 presented the discussion of findings stemming from the analyses of data generated in this study. Lastly, Chapter 10 presents conclusion, implications of the findings and its contribution to body of knowledge.

10.1.1 Reflection on the contextual background

The intersection between ICT and CSA became necessary in an attempt to fill gaps identified in the literature arising from efforts to mitigate and adapt to impacts of climate change amongst SHFs. Scholars around the globe have made concerted efforts to combat the menace of climate change (CC) among SHFs in rural areas of developing countries by introducing CSA as a sure way (FAO, 2010; Sullivan et al., 2012). However, findings revealed that SHFs' adoption of CSA alone is inadequate to mitigate the threat (Sullivan et al., 2012). This limitation to the success of CSA among the SHFs was possibly due to the complexity of the environment in which the SHFs live and farm (Ospina & Heeks, 2010). The nature of this environment became confusing and unpredictable as indigenous SHFs use traditional methods of weather forecasting. Based on this, efforts were made by deploying ICT to understand such environments and findings revealed that ICT played significant roles in adapting, monitoring, mitigating and in developing strategies related to climate change (Aleke & Nhamo, 2016; Ospina & Heeks, 2010; Shabajee et al., 2014). However, Misaki et al. (2016) and Yohannis et al. (2019) claim that using ICT alone is unlikely to combat the menace of climate change among the SHFs. Thus, Sinyolo et al. (2014) suggested the inclusion of other strategies (like the use of CSA, and ICT among others) into existing agricultural practices to address the resultant effects of climate change on uMsinga SHFs. Hence, this study interface between ICT and the uMsinga SHFs' CSA practices.

10.1.2 Reflection on the frameworks

A framework provides the needed structure and support that a researcher requires for the entire study (Osanloo & Grant, 2016; Tamene, 2016). The frameworks in this study made the research credible (Adom et al., 2018) and served as strong bases for the methods and analysis of this study (Osanloo & Grant, 2016). This study was guided by three major frameworks, namely: adoption/adaptation strategic tools (AST), community participatory action research (CBPAR) and living theory (LT). The AST was drawn from an evolution of the unified theory of acceptance and utilisation of technology (UTAUT2) (Venkatesh et al., 2012) and theory of irrigators' planned behaviour (TIPB) (Wheeler et al., 2013). The UTAUT2 evolved by considering TRA, TPB, TAM,

TAM2, TAM3, RuTAM and UTAUT. The UTAUT2 consisted of seven constructs, namely: hedonic motivation, price value, habit, performance expectancy, effort expectance, facilitating conditions and social influence. This study used UTAUT2 to explain and describe the uMsinga SHFs' intentions to interface between ICT and their CSA practices. The UTAUT2 was preferred, based on its robustness and wide range of use among other theories. Likewise, TIPB evolved by considering PMT and TPB. The TIPB consisted of five variables, namely: financial, natural, physical, human and social capital. TIPB was adopted to explain the factors that possibly influence the SHFs' choice of their agricultural practices and the unintented challenges resulting from these practices. Therefore, UTAUT2 and TIPB were employed to explain and describe the findings generated from data collected in this study.

Similarly, CBPAR (Burns et al., 2011) and LT (Whitehead & McNiff, 2006) guided the data collection of this study. The five stages of CBPAR were used to guide our collaboration with the indigenous SHFs in order to generate new knowledge. Likewise, the living theory was used to understand how the uMsinga SHFs were influenced to develop their ICT literacy that could be employed in interfacing between ICT and CSA to improve their agricultural practices in the face of climate change. Additionally, CBPAR and LT were used to compliment each other because of the nature of this study participants and the participatory paradigm used. The two frameworks supported the indigenous worldview (Wilson, 2008) and permitted collaboration with the uMsinga SHFs during our community forum meetings.

10.1.3 Reflection on the review of related literature

The literature review chapter of this study employed Creswell's model (Creswell, 2003), with five main areas that structured the review. This consisted of the introduction, the research independent variables, the research dependent variables, studies conducted on the independent variables and studies conducted on the dependent variables and, summary of findings.

The review showed that concerted efforts had been made to reduce the impact of climate change among SHFs (Taneja et al., 2014) using adaptation strategies. Climate smart agriculture (CSA) was proven and recommended as a sure way to adapt to impacts of climate change studies (FAO, 2010; Sullivan et al., 2012). The review pointed out that 14 countries from Asia, Africa and America practised CSA. Similarly, the review identified 35 CSA practices while 17 were being practised amongst South African farmers. However, there were few studies conducted on the CSA practices being practised amongst uMsinga SHFs. This study therefore planned to fill this gap. In addition, despite the CSA practices all over the world, the review indicated that CSA alone is inadequate to help SHFs solve their agricultural challenges, due to the complexity of environment (Sullivan et al., 2012, p. 1). Therefore, ICT was deployed because of its significant role in (1) providing early warning systems for climate change, (2) sharing knowledge of adaptation among concerned people, (3) raising climate-related risks awareness, (4) coordinating disaster recovery information, (5) supporting consultation and participation in developing adaptation policies, (6) providing training in flood and risks management, (7) providing data to aid adaptation decision-making as well as (8) collecting and analysing information for vulnerability assessments (Aleke & Nhamo, 2016; Ospina & Heeks, 2010; Shabajee et al., 2014) and for “mitigation, monitoring, adaptation and strategy” (ITU, 2008, p. 2; Ospina & Heeks, 2010, p. 4). The review showed that, despite these roles played, the deployment of ICT alone is unlikely to help SHFs mitigate the impacts of climate change for food production (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36). It was evident that the use of CSA and ICT separately have not yielded the desired result. This implies that a gap exists in literature and is yet unfilled. Therefore, this study proposed the intersection between CSA and ICT to understand the possibility of mitigating climate change threats amongst the SHFs.

Nevertheless, it was significant to note in the studies reviewed that the majority of the SHFs in developing countries like, Nigeria, Kenya, Tanzania and South Africa among others lacked ICT literacy (Angello, 2015; Chikaire et al., 2017; Chisango & Lesame, 2014; Hlatshwayo, 2017b; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016). On this note, a study (Xaba & Urban, 2016) in South Africa suggested ICT literacy training for the SHFs. However, this review found that there is a paucity of literature on SHFs’ ICT literacy training. This study therefore, proposed to fill this gap.

In addition, the review found that ICT software was designed for the benefits of agricultural purposes, such as in Kenya, the use of the Kenya Agricultural Commodity Exchange (KACE) (Wawire et al., 2017), in Rwanda, the E-soko (a web based platform that permit SMS) (Vrakas, 2012) and in India, Digital Mandi (Saravanan & Bhattacharjee, 2014) to influence farmers’ access to market where they sell their farm produce. In this review, seven prominent class of factors influencing the adoption of ICT among users were identified, namely: effort expectancy, performance expectancy, facilitating conditions, hedonic motivation, price values and habit (Buchan et al., 2017; Islam & Grönlund, 2011a; Ismail, 2016; Mahmood et al., 2000; Venkatesh et al., 2003b; Venkatesh et al., 2012). This study planned to know which among this class of factors influenced uMsinga SHFs to adopt ICT into their agricultural practices in the face of climate change.

Likewise, the review found that policy strengthens the integration of ICT (Kifle et al., 2007). Thus, some countries like Rwanda (Vrakas, 2012), Tanzania (van Gorp & Maitland, 2009) and Bangladesh (Sarker & Hasan, 2011) have ICT policies influencing the adoption of ICT among rural dwellers. However, countries like Kenya (Wawire et al., 2017) and South Africa (Chisango & Lesame, 2014) are still formulating ICT policies that will drive the adoption of ICT to mitigate climate change in rural areas. This study promised to provide insight for South Africa policymakers that will guide the conduct of ICT literacy development among rural dwellers.

10.1.4 Reflections on the research methodology

This study employed a sequential transformative strategy mixed methods approach to generate data (Creswell & Creswell, 2017). The approach was guided using CBPAR (Burns et al., 2011) and LT (McNiff & Whitehead, 2006; Whitehead & McNiff, 2006) frameworks to engage uMsinga SHFs at a community forum meeting (Duenpen et al., 2016). The community forum method was used because it afforded the SHFs to collaborate with me in the study and express their views about the project (Blyden, 1995). In addition, the method was in agreement with the participatory paradigm adopted, as this study researched into nature-related issues in collaboration with the indigenous people of uMsinga (Wilson, 2008). Therefore, an appropriate approach like a community forum meeting should be used for data collection. The data collection was divided into two phases, preliminary and main study. The first phase produced textual data using the community forum method. The second phase generated both numerical and non-numerical data sequentially generated at our community forum meeting.

The meetings were facilitated with instruments but guided by five stages of CBPAR (Burns et al., 2011) and the action-reflection cycle questions of living theory (Whitehead & McNiff, 2006). Four instruments were used, namely: a preliminary study forum meeting protocol (PSFMP), ICT literacy assessment tool (ILAT), SHFs' ICT literacy development protocol (SHFIDP), and SHFs' ICT tool design protocol (SHFFIDP). PSFMP was used to generate data for the preliminary research questions while ILAT was employed to produce quantitative data for the main study, research question one (1). Furthermore, SHFIDP and SHFFIDP were used to generate data to answer the second main research questions. SHFIDP was used to facilitate the planning for the SHFs' ICT literacy development programme and SHFFIDP was used to facilitate data generation on functionalities that the SHFs wished to be added to existing web based agro-weather applications app (like the demo app). The instruments were validated and found appropriate.

Additionally, the study adopted a purposive sampling of 35 irrigation SHFs with one (1) extension officer. The sample size was small because of the limitations faced in this study. Likewise, the textual data collected was analysed thematically while descriptive and inferential statistics were used for numerical data.

10.1.5 Reflections on responses to the research questions (major findings)

Findings from phase one of the preliminary study revealed that seven CSA were identified as being practised by uMsinga SHFs. These are multiple cropping, crop rotation, irrigation farming, farming near rivers, using chemicals/manure to fertilize the soil for maximum yield, planting of improved varieties, and planting of improved local varieties. It was significant to understand that all the seven categories identified fell within the 17 identified CSA practices prevalent in South Africa.

Despite these practices, this study further identified seven categories of challenge militating against food production in uMsinga. These include flooding, unpredictable weather conditions, drought, lack of infrastructure (pump, pipes among others), lack of funds to maintain irrigation farming infrastructure, the problem of pests and diseases, and low crop yields. The study further pointed out seven unintended challenges as a result of each of the practices as listed above. These include: lack of know how in dealing with flooding; lack of know how in forecasting the weather conditions of the environment; lack of resources to maintain the irrigation system; lack of funds to maintain irrigation farming infrastructure; lack of financial resources to purchase the seedlings; dependence on the government in the form of extension workers for supplies; lack of financial resources to purchase the seedlings; and lack of scientific know how, respectively. These challenges were grouped as: financial, natural, human and physical capital using TIPB (Wheeler et al., 2013). The challenges further affirm the claim of Sullivan et al. (2012) that CSA alone is insufficient to help SHFs solve agricultural related problems in the face of climate change.

With regard to the resulting challenges for CSA practice, this study sought to ascertain uMsinga SHFs' regard for the intersection between ICT and the CSA practices and how this integration will help in alleviating the challenges experienced by the SHFs. The findings reveal that an overwhelming majority of the SHFs regarded the integration of ICT as being very crucial. Seven factors were found to have influenced this consideration of the uMsinga SHFs, namely: enjoyment in the use of mobile phones; past experience of using mobile phones; network service charges; perceived usefulness of mobile phones; perceived ease of the use of mobile phones; perceived association with individuals; and perceived availability of supportive resources. These seven factors were classified as hedonic motivation, habit, price value, performance expectancy, effort expectancy, social influence and facilitating conditions, respectively, using UTAUT2 (Venkatesh et al., 2012). However, the adequate ICT literacy needed to actualise their intention was an unintended challenge for the SHFs.

This study tested the ICT literacy of uMsinga SHFs at five levels, namely: first level of ICT literacy (mobile phone symbol identification literacy); second level of ICT literacy (basic ICT literacy); third level of ICT literacy (semi-medium-level ICT literacy); fourth level of ICT literacy (medium-level ICT literacy); and fifth level of ICT literacy (advanced ICT literacy). All the SHFs were found to be highly proficient at the first and second level of ICT literacy but had a sharp decline in their proficiency from the third to the fifth levels. Based on the ICT literacy proficiency that is considered to be needed for interfacing between ICT and CSA, the uMsinga SHFs were regarded as having low ICT literacy proficiency. This finding confirms previous studies (Angello, 2015; Chikaire et al., 2017; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016) that claim that SHFs in developing countries lack ICT literacy. This study further finding shows that the SHFs' ICT literacy proficiency needs to be developed from the third to the fifth level in order to interface between ICT and their CSA practice. In addition, the findings show that both SHFs' age and educational level affected the uMsinga SHFs' ICT literacy. This means that the SHFs' ICT literacy proficiency might have to be developed in order for the SHFs to adequately adopt ICT tools into their agricultural practices so as to mitigate and adapt to impacts of climate change in uMsinga.

Further, the findings show evidence from conducting an ICT literacy intervention programme being guided by CBPAR and living theory approaches. The result shows nine activities carried out to develop the uMsinga SHFs' ICT literacy proficiency and reasons for each action performed. The SHFs could deduce the application of the intervention to their CSA in that they understood when to spray their crops, to prevent chemical wastage during rain seasons. When any learner reflect upon learning, it means learning has taken place and knowledge has improved (McNiff & Whitehead, 2006). Further findings from this study reveal the uMsinga SHFs' post-intervention programme report showing four (4) main categories of evaluation, namely: SHFs' satisfaction of the intervention, which was categorised as performance expectancy, improvement in the uMsinga SHFs' ICT literacy, which was categorised as performance expectancy, the uMsinga SHFs' ability to use the demo weather app, which was categorised as effort expectancy, and improvement in CSA practices, which was categorised as performance expectancy. Nonetheless, unintended challenge arose as a result of the application of the demo app in the uMsinga SHFs' CSA practices.

Further findings in this study reveal five categories of functionality suggested by uMsinga SHFs to be added to local web based weather app, namely: access to agro-stores; agro-marketing; pictorial representation of activities; crop diagnostics; and weather info and hotline. Similarly, the findings reveal that five categories of use of these functionalities were suggested by the SHFs. These included: using images/pictures on an agro-weather app – which can be classified as effort expectancy that the uMsinga SHFs suggested, to mitigate the challenges of eye impairment due to age and possible abandonments of the app; using the app to access agro-stores and markets – which can be classified as effort expectancy that the uMsinga SHFs suggested to mitigate the challenges of expensive chemicals and lack of markets to sell farm produce; using crop diagnostics on the app – which can be classified as performance expectancy that the uMsinga SHFs suggested to mitigate the challenges of complex crop diseases, pests and insects through the use of mobile phones; and accessing agro-info with the app – which can be classified as social influence that the uMsinga SHFs suggested to mitigate the challenge of limited agro information through using mobile phones.

10.2 Contribution to the body of knowledge

This section presents the contribution this study makes to existing body of knowledge in areas of information systems, climate change education, and agriculture. Three main parts are considered, the theoretical framework, literature reviewed, and the methodological approach. The details are as follow.

10.2.1 The theoretical framework

Two theories guided the analysis of this study, namely UTAUT2 and TIPB. The first theory was employed to investigate the uMsinga SHFs' adoption of ICT, whilst the second was used to explore the SHFs' CSA adoption. The two theories were concatenated in order to make sense of the nature of the relationship that existed in the intersection between ICT and CSA practices. Limited information system theories exist that explain SHFs' interfacing between ICT and CSA. This study therefore indicated that there is a point of intersection in between the five and seven constructs in TIPB and UTAUT2, respectively. The study indicated that four out of the five constructs in TIPB, namely: physical, financial, social, and human capital negatively informed uMsinga SHFs' adoption of CSA while all the seven constructs in UTAUT2 influenced their regard for ICT buy-in. Similarly, using UTAUT, the age factor was classified as a moderating variable that negatively but significantly informed the uMsinga SHFs' ICT literacy need. Furthermore, using UTAUT, educational level can be classified as a moderating variable that positively and significantly informed the uMsinga SHFs' ICT literacy need.

10.2.2 Literature on the intersection between ICT and CSA

The categories of study reviewed in this study were, climate change, farmers' ICT literacy, and software design related studies. The studies reviewed in this research showed that the impact of climate change is real and that concerted efforts from IPCC, UNFCCC, governments of various nations, researchers, educators and indigenous people are being made. The reviewed studies revealed that climate change is a global challenge and scholars in the field of science (FAO, 2010; Sullivan et al., 2012) have made concerted effort to combat the impact of climate change by introducing CSA as an effective approach. In the review, 36 CSA practices were identified around the world, of which 17 are being practised in South Africa. However, this study reviewed shows that CSA alone is inadequate to provide to mitigate the impacts of climate change (Sullivan et al., 2012). The reason for this limitation could be traced to the complexity of the environment in which farmers live and farm, which Ospina and Heeks (2010) report in their study. Thus, ICT was deployed since it plays significant roles in monitoring, adaptation, mitigation, and strategizing, among others (Ospina & Heeks, 2010). However, the deployment of ICT into agriculture alone is inadequate to help SHFs mitigate climate change (Misaki et al., 2016; Yohannis et al., 2019). Although a study reviewed suggested the inclusion of other strategies into CSA (Sinyolo et al., 2014), this study proposed the interfacing between ICT and SHFs' CSA as a way forward to reduce the impacts of climate change on food production.

The majority of findings in the related literature reviewed reveals that farmers lack ICT literacy (Angello, 2015; Asif et al., 2017; Chikaire et al., 2017; Hlatshwayo, 2017b; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016; Xaba & Urban, 2016). Some of the studies suggested that "adequate workshops, training and awareness should be given to the farmers" (Nzonzo & Mogambi, 2016, p. 295) in order to develop their ICT literacy. Other literature suggested "practical computer training for the enhancement" of rural farmers' ICT literacy (Chikaire et al., 2017, p. 104). However, none of the studies covered the ICT literacy development of rural SHFs to enhance the use of ICT in SHFs' CSA practices at international, national and local level. In South Africa, the White Paper stated that, "government will develop a "list" of the basic skills that citizens need to participate in the digital society" (p. 125). However, the guidelines for the development of rural dwellers' ICT literacy was lacking in the document. Therefore, the findings in this study might have provided information needed for the development of these guidelines.

In addition, studies reviewed in this research show that users' involvement in software design positively influences the adoption of the system (Bano & Zowghi, 2013a; Buchan et al., 2017). However, it became clear that there have been limited studies to examine "exactly what activities users are required to carry out" in the development of software (Bano & Zowghi, 2013b, p. 30). More so, from the few studies (Buchan et al., 2017; Islam & Grönlund, 2011a; Ismail, 2016; Mahmood et al., 2000) reviewed on users' involvement in software development, there was a paucity of empirical study on SHFs' involvement or participation in a software development process. It was suggested in the study by Sada and Wadeisa (2016) that research should be conducted to explore users' views on their involvement in system development, to gain insights on how they will contribute to software development. That is exactly the gap this study has bridged, by engaging uMsinga SHFs in a collaborative partnership that has initiated the required information for the development of an indigenous ICT-based agro-weather app.

10.2.3 Methodological findings

From the review of related literature, previous studies were found to have employed quantitative, qualitative or mixed method approaches in exploring farmers' adoption of ICT or CSA. However, there are few studies that have used a sequential transformative strategy as a mixed methods approach, being guided by both living theory and CBPAR to explore SHFs' intention to interface between ICT and CSA. That is exactly what was used in this study. A questionnaire instrument was used to facilitate the collection of numerical data, while textual data were collected at the community forum meeting. The data gathering was guided by CBPAR and living theory frameworks. The procedure for data collection was divided into three sections, namely: pre-intervention, during intervention and post-intervention. However, it was significant to note that eight methodological challenges were recorded in the process of data collection that had implications for this study, namely:

(i) Ethical clearance requirement conflicting with approach
(ii) Assumption and expectation meeting reality
(iii) Misrepresentation of concern due to misinterpretation resulting from language barrier
(iv) Research interfering with making a living
(v) Changing of initial plan to align with infrastructure on the ground
(vi) No visual representation and visual recording, limited evidences recorded
(vii) Inappropriate recording facility approved for indigenous research
(viii) Inappropriate data recording equipment approved vs study adopted approaches.

10.3 The implications of the findings

This study has major insights into the nature of the relationship between ICT and the SHFs' CSA practices in adapting to impacts of climate change identified in this study. From these findings, implications were drawn for policy, practice, research and climate change education.

10.3.1 Implication of the findings for policy

The findings of this study have implications for policy, practice and research. The South African ICT policy document acknowledges the significance of rural dwellers' development (Republic of South Africa, 2016). This study therefore has implication for the formulation of policies regarding ICT literacy development of rural area dwellers and ICT use. This study has attempted to bridge the gap of the "digital divide" that has existed between the poor and rich in South Africa by developing the ICT literacy of the uMsinga SHFs in order to incorporate ICT into their existing CSA practices (Republic of South Africa, 2016, p. 36). In addition, this study has attempted to provide South African policymakers with a "list" of the basic ICT skills development "that citizens need to practice and participate in the digital society", which was found to be lacking in the ICT Policy White Paper (p. 125).

10.3.2 The implications of the findings for practice

The findings revealed that uMsinga SHFs practised seven different CSA practices to mitigate the impacts of climate change facing them. It was significant to note that out of these seven CSA practices, new local improved varieties emerged. The planting of the local improved seedlings in this study has implication for adaptive knowledge and practice. In addition, the analysis of the finding indicates that the SHFs are thinking of applying the demo app used during training to combat the impacts of climate change (McDonagh, 2007). This capacity demonstrated by the uMsinga SHFs to have known where to apply the app in their farm might improve practice to reduce impacts of climate change.

Furthermore, it was significant to note that seven factors informed uMsinga SHFs' practice of CSA, namely: (i) flooding, (ii) unpredictable weather conditions; (iii) drought; (iv) the lack of infrastructure (pumps and pipes, among others); (v) the lack of funds to maintain irrigation farming infrastructure; (vi) the problem of pests and diseases; and (vii) low crop yields. In addition, it was significant to note that, in an attempt to mitigate these climate change challenges through CSA practice, the uMsinga SHFs experienced unintended problems from the practices. This affirms the claim of Sullivan et al. (2012) that CSA alone is inadequate to solve SHFs' problems in the face of climate change. Furthermore, the unintended challenges identified in this study endorse the reference to the "insufficiency of CSA" in Sullivan et al. (2012). Similarly, using TIPB, three capitals[14] were found to be the major classes of climate change challenges facing uMsinga SHFs, namely: natural, physical, and financial capital. However, four unintended capitals resulting from the SHFs' practice of CSA came to the fore; these were natural, physical, financial, and human capital. This study thus, concluded that the unintended capital is greater than the initial capital. This can be said to have accounted for the reason why CSA alone is insufficient to mitigate climate change.

Based on the unintended challenges uMsinga SHFs experienced, they therefore positively regarded the intersection between ICT and their CSA practices. Seven factors informed the SHFs' positive regard for ICT adoption in their practices, namely: (i) enjoyment in the use of mobile phones; (ii) past experience of using mobile phones; (iii) network service charges; (iv) perceived usefulness of mobile phones; (v) perceived ease of the use of mobile phones; (vi) perceived association with individuals; and (vii) perceived availability of supportive resources. These informing factors were classified, using UTAUT2, as hedonic motivation, habit, price value, performance expectancy, effort expectance, social influence and facilitating conditions. It was significant to note that two unintended challenges arose from the regard of the SHFs to adopt ICT, namely: the lack of ICT literacy and the lack of an indigenous agro-weather app needed for the intersection, which were classified as facilitating conditions and performance expectancy respectively. These unintended challenges limiting the intention of the uMsinga SHFs could account for the assertion in the literature reviewed in this study that, despite the significant roles of ICT, the deployment of ICT alone was unlikely to help the SHFs to mitigate the impacts of climate change for food production (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36). In this regard, this study extended the work of these authors by providing evidence for the insufficiency of the deployment of ICT alone to mitigate SHFs' problem of climate change. This means that the challenges of inadequate ICT literacy and lack of indigenous agro weather apps must be solved.

[14] Capital is used in this study to describe different challenges SHFs encounter in the face of climate change. This capital has five forms, natural, physical, financial, social and human capital (Wheeler et al., 2013).

This study confirms the findings in previous studies (Angello, 2015; Asif et al., 2017; Chikaire et al., 2017; Hlatshwayo, 2017b; Lekopanye & Sundaram, 2017; Nzonzo & Mogambi, 2016; Xaba & Urban, 2016) that SHFs lack the literacy needed to integrate ICT into agricultural practice. Specifically, this study shows that SHFs' ICT literacy is deficient from the third (semi-medium) to the fifth level (advanced). It further shows that the ICT literacy of SHFs could be developed from semi-medium level upward in order to interface between ICT and CSA. Likewise, two moderating factors, namely: educational level and age were found influencing the ICT literacy of uMsinga SHFs.

Additionally, the studies (Nzonzo & Mogambi, 2016; Xaba & Urban, 2016) reviewed in this study limited their search to suggestion for developing the ICT literacy of SHFs. This study therefore extended the existing body of knowledge by providing nine actions guided by CBPAR and living which may be needed to develop the ICT literacy of indigenous SHFs. The ICT literacy development of uMsinga SHFs using CBPAR and LT brought the use of a demo ICT-based weather app into their CSA practices. The limitations of the demo app identified by the uMsinga SHFs brought about the need to design an indigenous agro-weather app for the SHFs. The SHFs suggested five functionalities and four ways to use the feature in the app. This is significant because the reviewed studies (Damodaran, 1996; Hope & Amdahl, 2011; Kujala et al., 2005) show that software designers rarely involved users in their designs. The reasons were that the software developers felt they are experts in design while users are novices who could contribute little to software development (Hope & Amdahl, 2011). The uMsinga SHFs' suggestions regarding the functionalities and use prove that they should be involved in the process of developing the proposed indigenous agro-weather app for the uMsinga community and that their contributions made sense. It was significant to understand reasons why many deployed ICT tools are abandoned by users. Therefore, technology transfer to indigenous people may not succeed when they are not fully involved at every stage of the design.

It was evident that the use of CSA and ICT separately have not yielded the desired result as clearly observed by some authors (Sullivan et al., 2012); (Misaki et al., 2016, p. 12; Yohannis et al., 2019, p. 36). However, this study has bridged the gap in the previous research by interfacing between CSA and ICT in order to help SHFs mitigate the threat that climate change poses to food production.

10.3.3 Implications of the findings for research

Further, the findings suggest that extension officers and researchers could learn from the SHFs to understand how to mitigate and adjust to climate change, as observed by Simonelli (2008). This suggests that local knowledge of climate change education from the SHFs could be useful for educational capacity building in Republic of South Africa (RSA). Similarly, the findings showed that the proposed development of an ICT-based agro-weather app for groups like uMsinga SHFs may be useless if the functionalities suggested by the SHFs are not included in the design (also see (Choudhari & Kute, 2014; Mahajan et al., 2016). This finding suggests that further research should be conducted on the design and implementation of an ICT-based agro-weather app for uMsinga SHFs. The findings further reveal that failure to incorporate the suggested functionalities into the design might lead to the app being unused by the SHFs, which might result into crop wastage due to the failure to respond to the impacts of climate change. This finding suggests that the customized ICT-based agro-weather app must incorporate the suggested functionalities. For example, it implies that the symbolic representation of activities on the app may be the best language that the SHFs understand for the effective use and deployment of the ICT-based agro-weather app (Chikaire et al., 2017). In addition, Khadse et al. (2015) explain that conventional or traditional ways of crop diagnosis are fast becoming unpopular in recent time, possibly because of complexity of our environment.

10.3.4 Implications for research methodology

The eight methodological challenges identified in this study have implications for research procedures. **First**, the conflict between the ethical clearance requirements and the research approach spanned all the five stages of CBPAR used in this study. This conflict appeared to hinder the assumed appropriate methods and equipment designed for data collection. The conflict tended to limit this study and caused methodological constraints. **Second**, the challenge of assumptions and expectations meeting reality has strong implications for the process of data collection. This implies that a researcher should be flexible enough to adjust any initial plans when reality is met on the field for data collection. **Third**, misrepresentation of aims due to misinterpretations resulting from language barriers have implication for collection of correct data in this study. Though, misinterpretations should be expected in any research that involves indigenous people with researcher who possibly might not understand the indigenous language of a study participants. Rukema (2014) experienced misconstrued research ideas in his study due to language barrier while negotiating with research participants**. Fourth**, research interfering with study participants' making a living. This methodological challenge might have significant implication on the participation of research participants in a study. When the desired size of participants is not met, this might require modification of the initial methodology of the study. **Fifth**, changing of initial plans to align with the infrastructure on the ground might have significant implications for the procedures planned for the research. It is therefore significant to note that alternative plans should be in place when planning for research involving the use of ICT facilities. **Sixth**, having no visual representation and visual recording in a study might have significant implication for the evidence captured. In this study, the use of an audio recorder to capture data limited the evidence recorded because audio recording could not capture a practical demonstration as a video recorder or photograph would. **Seventh**, the inappropriate recording facility approved for research might have significant implications for the analysis of data. It might be challenging analysing data gathered in a community forum meeting, which permits freedom of participation, if the audio equipment makes it hard to differentiate between speaker A and B. **Eight**, inappropriate data recording equipment approved might conflict with the approaches adopted in the study. The use of data recording gadget in mixed method for data collection might have significant implications for the evidence required by the framework adopted in a study. In this study, it appeared that the use of audio recorder is insufficient to reveal convincing evidence of voiceless action related activities.

10.3.5 Implications for climate change education

It was significant to note that planting of the local improved seedlings amongst the indigenous uMsinga SHFs in this study has implication for climate change education. This is because the agricultural officers who oversee the uMsinga SHFs will learn new reactions of the plants to impacts of climate change, process the lessons learnt and document for information dissemination. The collection of how these indigenous SHFs response to the changing climate could constitute way forward to handling impacts of climate variability which could be used in teaching other farmers, students, and researchers. Therefore, much could be learnt from the indigenous uMsinga SHFs (Simonelli, 2008, p. 18) to mitigate climate change threat in South Africa.

10.4 Limitations of the findings and suggestions for further studies

This study aimed to explore the intersection between ICT and uMsinga SHFs' CSA, in order to understand the nature of the relationship[15] in adapting to the impacts of climate change. The study participants were limited to rural SHFs who practise irrigation farming. Thus, the success of the study was limited by the sample size of 35 SHFs, with one extension officer. The sample size was small due to the limited population of SHFs within the farmers' association to which I had access. Likewise, the irrigator farmers in the municipality, were difficult to bring together in a place for they were busy with farming activities and separated by far distance to a section of their plots. Other limitations confronted in the study were barriers of finance, time, and language. The language barrier was because the participants were non-English speakers. The rural community members only understand and speak a local dialect of IsiZulu. Based on these factors, the study was limited to one association of irrigator SHFs.

Further, the study is a subset of main Council for Scientific and Industrial Research (CSIR) project which was to develop an ICT-based agro-weather app for uMsinga SHFs. The present study therefore considered the ICT literacy with which the SHFs will use the app after designed. It also examined functionalities that the SHFs will wish to be included as part of the design for effective adoption into CSA. However, there is need for further study to be conducted on the design and implement of an indigenous ICT-based agro-weather app for uMsinga SHFs. It is also recommended that this study be replicated in other places with larger sample sizes, for the purpose of generalisation.

[15] This is the relationship that exist between the ICT and climate smart agriculture.

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APPENDIX A. Letter to Co-op Chairman

School of Education, College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus, Durban,
South Africa.

September, 2017.

Coop Chairman,

uMsinga.

Dear Sir / Madam,

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT YOUR COOPATIVE

My name is Olusegun Ojo Bakare I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood Campus. The title of my research is: *The intersection between ICT and Climate Smart Agriculture (CSA) in adapting to the impacts of Climate Change on food production: Implications for Climate Change Education (CCE) in Capacity Building amongst uMsinga's smallholder farmers (SHF).* I am interested in asking you some questions via a community forum interview.

Please note that:

- The information that you provide will be used for scholarly research only.
- Your participation is entirely voluntary. You have a choice to participate, not to participate or stop participating in the research. You will not be penalized for taking such an action.
- Your views in this community forum will be presented anonymously. Neither your name nor identity will be disclosed in any form in the study.
- The community forum will take about 60 minutes.
- The record as well as other items associated with the interview will be held in a password-protected file accessible only to me and my supervisor. After a period of 5 years, in line with the rules of the university, it will be disposed by shredding and burning.

- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the community forum interview to be recorded by the following equipment:

Recording equipment to be used in the stu	**I am willing**	**I am not willing**
Audio equipment		
Photographic equipment		
Video equipment		

- If you agree to participate please sign the declaration attached to this statement (a separate sheet will be provided for signatures).

I can be contacted at: University of KwaZulu-Natal, Edgewood Campus, Pinetown; Cell: number: 0839962623; Email: oluseguns.bakare@gmail.com.

My supervisor is Prof. B. P. Alant who is located at the School of Education, Science and Technology cluster, Edgewood campus of the University of KwaZulu-Natal.

Contact details: Email: alantb@ukzn.ac.za; Tel: 031-260 7606.

You may also contact the Research Office through: Mr. P. Mohun, The Humanities and Social Sciences Research Ethics Committee contact details are as follows: Tel: 031 260 4557/4609; Email addresses: HssrecHumanities@ukzn.ac.za; mohunp@ukzn.ac.za.

Thank you for your contribution to this research.

DECLARATION

I ____ (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

__________________________ _________________

Signature of participant Date

Appendix B. Informed Consent Letter to Participants

School of Education, College of Humanities,
University of KwaZulu-Natal,
Edgewood Campus, Durban,
South Africa.

September, 2017.

Dear Sir / Madam,

RE- REQUEST FOR YOUR CONSENT TO PARTICIPATE IN MY STUDY

My name is Olusegun Ojo Bakare I am a PhD candidate studying at the University of KwaZulu-Natal, Edgewood Campus. The title of my research is: *The intersection between ICT and Climate Smart Agriculture (CSA) in adapting to the impacts of Climate Change on food production: Implications for Climate Change Education (CCE) in Capacity Building amongst uMsinga's smallholder farmers (SHF).* I am interested in asking you some questions via a community forum interview.

Please note that:

- The information that you provide will be used for scholarly research only.
- Your participation is entirely voluntary. You have a choice to participate, not to participate or stop participating in the research. You will not be penalized for taking such an action.
- Your views in this community forum will be presented anonymously. Neither your name nor identity will be disclosed in any form in the study.
- The community forum will take about 60 minutes.
- The record as well as other items associated with the interview will be held in a password-protected file accessible only to me and my supervisor. After a period of 5 years, in line with the rules of the university, it will be disposed by shredding and burning.

- If you are willing to be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the community forum interview to be recorded by the following equipment:

Recording equipment to be used in the stu	**I am willing**	**I am not willing**
Audio equipment		
Photographic equipment		
Video equipment		

- If you agree to participate please sign the declaration attached to this statement (a separate sheet will be provided for signatures).

I can be contacted at: University of KwaZulu-Natal, Edgewood Campus, Pinetown; Cell: number: 0839962623; Email: oluseguns.bakare@gmail.com.

My supervisor is Prof. B. P. Alant who is located at the School of Education, Science and Technology cluster, Edgewood campus of the University of KwaZulu-Natal.

Contact details: Email: alantb@ukzn.ac.za; Tel: 031-260 7606.

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Thank you for your contribution to this research.

DECLARATION

I ____ (full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

Signature of participant

Date

Appendix C. Preliminary Study Forum Meeting Protocol (PSFMP)

Section A: Exploring uMsinga SHFs' existing agricultural practices in relation to CC adaptation?
i. To identify climate smart agriculture practice (a) Types of CSA the farmers practice
(b) How do the farmers apply the practices? If not close to CSA, which practice do not promote CSA?
(c) Has association/relation/extension officers being of help in the practice? If yes, how?
(d) How has access to market, loan, fertilizer and information the practice?
(e) Why/reasons for the practice? What informs their practice (whatever their practices are?)
(f) How can the farmers' knowledge be used in adaptive pedagogical development? (What have you discovered over the years that researchers don't know?) (g) How can the farmers knowledge that promote GHG be engaged with?
(h) Implication of the practices on adaptive capacity building (what have you discovered over the years of farming?). How has the practices help your skills to overcome impacts of climate change?
ii. Are there challenges being faced with the current agricultural practices in the face of climate change for food production?
(a) What are these challenges encountered in the practices?
(b) What are the causes of these challenge?
(c) How have you been solving these problems? (introduce the relevance of ICT here: like asking how do you get water to irrigate your crops, do you make calls to find out issues about water from distance person; how do you know when it will rain next?)
(d) What are the reasons for the solution adopted?
(e) Lessons learnt
Section B: Get the community buy-in into interfacing ICT and CSA project?
i. What are the factors influencing community buy-in into interfacing CSA and ICT?
ii. Are the uMsinga SHFs aware of:
(a) Climate Change adaptation?
(b) ICT adoption?
• Do you use ICT?
• What type of ICT do you have?
• What do you do with the ICT? How useful is it to you? What do you enjoy in using mobile phone? How long have you been using ICT?

	• How do you use the ICT? Do you find it easy to use? Do people influence you to use it? What are your experiences since you have been using mobile phone?
	• Why do you use the ICT? How necessary do you think buy mobile and using mobile phone to you? Why?
	• Why not?
	• Challenges of using ICT (network problem, electricity to charge phones, buying airtime, buying smart phones etc.)
	• Suggest what could be done to solve the identified problems?
Section C: To understand the informing factors of regards for interfacing between ICT and CSA	
i. Do SHF in uMsinga regard the integration of ICT and CSA into existing agricultural practices as crucial for adequate food productivity and livelihood in the face of climate change? Yes/No	
	(a) If so, why?
	(b) If not, why?

Appendix D. SHFs' ICT Literacy Development Protocol (SHFIDP)

SHFs' ICT Literacy Development Protocol (SHFILDP)
Based on the outcome of our test, how would you want the ICT literacy levels developed to use the agro-weather tool? (audio record suggestions)
Kususelwa kwimiphumela yethu, ungafuna kanjani ukuthi amazinga okufunda olwazi nokuxhumana kwezobuchwepheshe ukuba athuthukiswe kusetshenziswa ithuluzi lesimo sezulu kwezolimo? (ividiyo noma imibono ngerekhodi ezwakalayo)
ii. Why? (audio record their reasons)
Ngobani? (noma ukurekhodwa kwezizathu zabo)

Appendix E. Smallholder Farmers Functionalities Inclusion Discussion Protocol (SHFFIDP)

Smallholder Farmers Functionalities Inclusion Discussion Protocol (SHFFIDP)
What kind of functionalities would you like to include in the ICT based agro-weather tool to enable you to use the tool effectively?
Hlobo luni lwezinsebenziso ongathanda ukuzifaka kulwazi nokuxhumana nobuchwepheshe mayelana nethuluzi lesimo sezulu lezolimo ukuze ukwazi ukusebenzisa ithuluzi ngempumelelo?
Why would you like to include such features? (audio record their reasons)
Kungani ungathanda ukufaka lezi zinhlobo? (ividiyo noma ukurekhodwa kweizathu zabo)
Explain how you would be able to use these functionalities? and (audio record suggestions)
Chaza ukuthi uzokwazi kanjani ukuzisebenzisa lezi zinsebenziso? (ividiyo noma ukurekhodwa kweemibono yabo)
why? (audio record their reasons)
Kungani? (ividiyo noma ukurekhodwa kwezizathu zabo)

Appendix F. ICT Literacy Assessment Tool (ILAT)

The study is planned to explore the intersection between information and communication technologies (ICTs) and climate smart agriculture (CSA) among uMsinga smallholder farmers in the face of climate change for food productivity. The purpose of this research questionnaire is to determine the level of ICT literacy with which the smallholder farmers will combined ICT and CSA. We will appreciate if you can carefully study the questions in order to gain insight to the necessities or needless of combining ICT and CSA to adjust to impacts of climate change in uMsinga.

This questionnaire will be brief and that your identity will be provided with pseudonym in this study. It will only be known to the researcher. All information provided will be kept confidential. The names of this communities or yours will not appear in any publication resulting from this study and any identified information will be omitted from the report. Your involvement in this research is purely academic and voluntary, therefore, you are at liberty to withdraw from the study at any given stage and no harm will be fall you.

Therefore, first, we will need some background information from you.

Lolu cwaningo luhlelelwe ukuhlola ukuxhumana phakathi kolwazi nobuchwepheshe bezokuxhumana (ICTs) kanye nesimo sezulu nokukhalipha kwezolimo (CSA), phakathi kwabalimi abasebancane noma abasakhasa eMsinga lapho bebhekana nokushintsha kwesimo sezulu ekukhiqizeni ukudla. Injongo yalolu hla lwemibuzo cwaningo ukuthola izinga lokufundiseka kwezolwazi nobuchwepheshe kwezokuxhumana (ICT) lapho abalimi abasakhasa bezohlanganisa ulwazi nobuchwepheshe kwezokuxhumana kanye nesimo sezulu nokukhalipha kwezolimo. Siyoncoma uma ungakwazi ukufundisisa ngokucophelela imibuzo ukuze sizuze ukuqondisisa izidingo noma okungekhona izidingo ngokuhlanganisa ulwazi nobuchwepheshe bezokuxhumana (ICTs) kanye nesimo sezulu nokukhalipha kwezolimo (CSA) ukulungisa umthelela wokuguquka kwesimo sezulu eMsinga.

Leli phepha lemibuzo lizochaza kabanzi nokuthi ubuwena buzoba mbumbulu noma buzofihlwa kulolu cwaningo. Kuzokwaziwa kuphela umcwaningi. Yonke imininingwane enikeziwe izogcinwa iyimfihlo. Amagama alemiphakathi noma awenu angeke avele kunoma yikuphi ukushicilelwa okuholela kulolucwaningo kanye nanoma yiluphi ulwazi luzokhishwa kulo mbiko. Ukuzibandakanya kwakho kulolucwaningo kwenzelwe nje ezifundweni futhi ngokuzithandela, Ngakho-ke, wena ukhululiwe noma uvumelekile ukuba uhoxe ekungeneleni ucwaningo noma ikusiphi isigaba kanti futhi akukho okubi okuzokulimaza noma okuzokwehlela.

Ngakho-ke okokuqala, sizodinga isizinda solwazi esithile kuwe.

	Demographic Information	
1	Name of Community	

2	Name of Participant	
3	Maximum Education Level Attained	
4	Age	
5	Gender (Male/Female)	
6	Marital Status (married, single, divorce, widow, widower)	
7	Years of Farming Experience	
8	Income	

Level 1 ICT Literacy: Ability to recognise basic mobile phone symbols. *Isigaba sokuqala sokufundiseka ngolwazi lwezokuxhumana nobuchwepheshe: Ukukwazi ukukhombisa izimpawu ezibalulekile kumakhalekhukhwini.*			
s/n	Identify the following Basic Symbols on your mobile phone *Khomba lezi zimpawu ezilandelayo kumakhalekhukhwini wakho.*	Able to Recognize *Uyakwazi ukukhomba izimpawu*	Not Able to Recognize *Akakwazi ukukhomba izimpawu.*
9	 *Uphawu olukhombisa uYebo*		
10	 *Uphawu olukhombisa uQha*		
11	 *Uphawu olukhombisa ukugcwala kwebhethili*		
12	 *Uphawu olukhombisa ukuthi ibhethili isizophela*		

13	 *Uphawu olukhombisa ukuthi ibhethili isemlilweni*		
14	 *uphawu olukhombisa iWiFi*		
15	 *uphawu olukhombisa inethiwekhi*		

Source: Adapted from https://cacm.acm.org/news/160253-a-boost-to-your-mobile-signal/fulltext?mobile=false, https://www.shareicon.net/internet-signal-wi-fi-signs-outline-wifi-slim-icons-outlined-connection-sign-686019,

Level 2 ICT Literacy: This section is to test participants' skills on the use of basic mobile phone to perform common operations. Kindly rate the participant by what he/she can do with mobile phone by ticking (✓) the appropriate box. *Isigaba sesibili sokufundiseka ngolwazi lwezokuxhumana nobuchwepheshe: Lesi sigaba sihlola ikhono labantu lokusebenzisa umakhalekhukhwini ukwenza lokhu okujwayelekile. Sicela uhlose ukuthi lowomuntu ukuthi uyakwazi yini ukusebenzisa umakhalekhukhwini ngoku ngokuthikha ibhokisi elifanele ( )*				
	Demonstrate with a mobile device how to do the following (*Khombisa ngethuluzi ukuthi kwenziwa kanjan lokhu okulandelayo*.)	Satisfactory Demonstrated (*ubonakala enza ngokugculisayo*.)	Partially Demonstrated (*Kubonakalisa ukuthi uyazama*)	Not Able (*Ubonakalisa ukungakwazi*)
16	How can you ON and OFF a mobile phone? *(ungawuvula uwuvale kanjani umakhalekhukhwini?)*			
17	How do you load a mobile phone with airtime without assistance of anyone? (*Uyifaka kanjan i-ethaymu ngaphandle kokusizwa omunye omuntu?)*			
18	How do you use your mobile phone to call someone and terminate the discussion without assistance of anyone?			

	(Uwusebenzisa kanjan umakhalekhukhwini wakho ukuffonela umuntu uqede inkulumo ngaphandle kokuthi usizwe omunye umuntu?)			
19	When someone calls you on your mobile phone, how do you receive and terminate the call? (*Uma kukhona okushayelayo kumakhalekhukhwini wakho, ulwamukela kanjan ulivale kanjani ucingo*)			
20	When someone calls on your mobile phone, how do you identify the caller? *(Uma ngabe umuntu ekushayela kumakhalekhukhwini wakho, ubona kanjan ukuthi ubani okushayelayo*?)			
21	How do you know that you had miss call(s) on call log? *Ubona kanjan ukuthi kukhona okufonelile ngaphambilini kwi call log yakho?*			

Level 3 ICT Literacy: Using basic mobile phone for documentation of caller contacts, typing and ready text messages. Kindly rate the participant by what he/she can do with mobile phone by ticking (✓) the appropriate box. *Isigaba sesithathu sokufundiseka ngolwazi lwezokuxhumana nobuchwepheshe: Ukusebenzisa umakhalekhukhwini ukugcina izinombolo ngokubhala imiyalezo esilungil. Sicela uhlole ukuth umuntu uyakwazi yini ukwenza lokhu ngomakhalekhukhwini, uthikhe ibhokisi elifanele.*				
	Demonstrate with a mobile device how to do the following. *Khombisa ngomakhalekhukhwini ukuthi kwenziwa kanjani lokhu okulandelayo.*	Satisfactory Demonstrated *Ubonakala enza ngokugculisayo*.)	Partially Demonstrated *Kubonakalisa ukuthi uyazama*)	Not Able *(Ubonakalisa ukungakwazi*)
22	How do you save contacts of callers into a phonebook*? Izigcina kanjani izinombolo zabantu*			

	abakushayelayo kumakhalekhukhwini wakho?			
23	How can you retrieve contacts from a phonebook? *Ungazibuyisela kanjani izinombolo zabantu kumakhalekhukhwini?*			
24	Use your mobile phone to demonstrate how to send text messages to contact on a phonebook? *Sebenzisa umakhalekhukhwini wakho ukhombise ukuthi uthunyelwa kanjani umyalezo kumuntu onezinombolo zakhe kumakhalekhukhwini wakho?*			
25	How can you access and read received text message on a mobile phone? *Uyithola uyifunde kanjani imiyalezo ethunyelwe kumakhalekhukhwini wakho?*			
26	How can unwanted text message be deleted from a mobile phone? *Uyisusa kanjani imiyalezo ongayifuni kumakhalekhukhwini wakho?*			

Level 4 ICT Literacy: This section is to test the participants' skills on use of smartphone to perform additional task of sending audio and video messages as well as accessing received audio and video messages. Kindly rate the participant by what he/she can do with mobile phone by ticking (✓) the appropriate box. *Isigaba sesine sokufundiseka ngolwazi lwezokuxhumana nobuchwepheshe: Kulesi sigaba sibheka amakhono abantu okusebenzisa omakhalekhukhwini abasezingeni eliphezulu ukwenza okungaphezulu ukuthumela okulalelwayo nokubukwayo ngemiyalezo. Hlola ukuthi umuntu uwusebenzisa kanjani umakhalekhukhwini osezingeni eliphezulu ngokuthikha ebhokisini elifanele.*				
	Demonstrate with a mobile device how to do the following.	Satisfactory Demonstrated	Partially Demonstrated	Not Able *Ubonakalisa ukungakwazi*

	Khombisa ngomakhalekhukhwini ukuthi kwenziwa kanjani lokhu okulandelayo.	*Ubonakala enza ngokugculisayo.*)	*Kubonakalisa ukuthi uyazama*	
27	How can a smart phone be used to send audio message without any assistance? *Ungawusebenzisa kanjani umakhalekhukhwini osezingeni eliphezulu ukuthumela umyalezo ngaphandle kosizo*			
28	How can a smart phone be used to send video message without any assistance? *Ungawusebenzisa kanjani umakhalekhukhwini osezingeni eliphezulu ukuthumela okubukwayo njenge video?*			
29	How can you access audio messages received on a mobile phone? *Ungayithola kanjani imiyalezo engama video kumakhalekhukhwini wakho?*			
30	How can you access video messages received on a mobile phone? *Ungithola kanjani imiyalezo yamavideo ethunyeliwe kumakhalekhukhwini wakho?*			

LEVEL 5 ICT Literacy: This section is to test participants' ability to use smartphone to access internet facilities. Kindly rate the participant by what he/she can do with smartphone by ticking (✓) the appropriate box. *Isigaba sesihlanu sokufundiseka ngolwazi lwezokuxhumana nobuchwepheshe: Kulesi sigaba sihlola ukuthi abantu bayakwazi yini ukusebenza omakhalekhukhwini abasezingeni eliphezulu ukuthola izinto ezikwi internet. Sicela uhlole ukuthi umuntu uyakwazi yini ukwenza lokho ngohlobo oluphambili lukamakhalekhukhwini.*				
	Demonstrate with a mobile device how to do the following *Yenza lokhu okulandelayo usebenzise umakhalekhukhwini.*	Satisfactory Demonstrated *Ubonakala enza ngokugculisayo.*)	Partially Demonstrated	Not Able *Ubonakalisa ukungakwazi*

			Kubonakalisa ukuthi uyazama	
31	How can you activate mobile device to access the internet? *Ungenza kanjani ukuthi umakhalekhukhwini wakho uxhume kwi internet*?			
32	How can you browse the internet with a mobile device? *Ungayi bheka kanjani i- internet ngomakhalekhukhwini wakho?*			
33	Use a mobile device to set GPS application to navigate a route from Msinga to Durban? *Sebenzisa umakhalekhukhwini wakho usethe iGPS uthole indlela esuka eMsinga uya eThekwini?*			
34	How can you use mobile phone to check weather forecasting information? *Ungawusebenzisa kanjani umakhale khukhwini wakho ukubheka imininingwane yesimo sezulu?*			
35	How can you use a mobile phone to send email? *Ungawusebenzisa kanjani umakhalekhukhwini ukuthumela i-email?*			
36	Use a mobile device to check your mail box? *Sebenzisa umakhalekhukhwini wakho ukubheka ama-emails wakho*.			
37	How can you use google play? *Ungawusebenzisa kanjani uGoogle play?*			

38	How can you download Apps from the internet using mobile phone? *Ungawa download kanjani amaApps kwi internet usebenzisa umakhalekhukhwini*?			

Many thanks for your response.

Siyabonga kakhulu ukuchitha isikhathi senu ukuphendula lolu cwaningo mbuzo

Appendix G. The Identified Global Climate Smart Agriculture Practices

Global CSA Practices			South Africa CSA Practics		
Practices	**Countries**	**Sources**	**Practices**	**Sources**	**uMsinga CSA Practices**
Changing cropping pattern	Indian, Nepal, Bangladesh, Nigeria	(Ayanlade et al., 2017; Kabir et al., 2017; Khanal & Kattel, 2017; Tripathi & Mishra, 2017)	Agro-ecology	(Senyolo et al., 2018)	Multiple Cropping
Changing farming location	Malaysian	(Masud et al., 2017),	Agroforestry	(Senyolo et al., 2018),	Farming Near Rivers
Compost, and farmyard manure	Malaysian, Zambia, Mozambique, and Malawi	(Makate et al., 2017; Masud et al., 2017),	Bio-char	(Senyolo et al., 2018)	Irrigation System of Farming
Contour terraces	Kenya, Bangladesh	(Farouque & Takeya, 2007; Mutuku, 2017b)	Changing planting dates	(Senyolo et al., 2017, 2018; Ubisi et al., 2017),	Manure and Fertilized
Employing new technology	Midwestern US	(Mase et al., 2017),	Conservation agriculture	(Senyolo et al., 2017, 2018; Ubisi et al., 2017),	Planting of Improved Local Varieties
Engaging in off-farm jobs,	Ghana	(Abdoulaye et al., 2017),	Crop diversification	(Senyolo et al., 2017; Ubisi et al., 2017)	Planting of Improved Varieties
Grain legume rotations,	Zambia, Mozambique, and Malawi, Nigeria	(Makate et al., 2017; Wahab & Popoola, 2018),	Crop rotation	(Makeleni et al., 2018)	Crop Rotation
Improved animal husbandry	Bangladesh	(Kabir et al., 2017),	Drought early warning detection	(Senyolo et al., 2018)	
Infield conservation practices	Midwestern US, Ghana	(Mase et al., 2017),	Early maturing	(Senyolo et al., 2017; Ubisi et al., 2017)	
Inorganic fertilizers	Zambia, Mozambique, and Malawi, Ghana	(Denkyirah et al., 2017; Makate et al., 2017).	Farming near water bodies	(Nethavhani, 2013),	
Irrigation system	Indian, Malaysian, Nepal, Ghana, South Africa	(Abdoulaye et al., 2017; Khanal & Kattel, 2017; Masud et al., 2017; Sinyolo et al., 2014; Tripathi & Mishra, 2017),	Increasing pesticide	(Guodaar et al., 2019)	
Open ridges	Kenya, Bangladesh	(Farouque & Takeya, 2007; Mutuku, 2017b)	In-Field Rain Water Harvesting (IRWH)	(Goitsemodimo, 2015; Sullivan et al., 2013)	
Planting of improved varieties	Bangladesh, Ghana	(Abdoulaye et al., 2017; Denkyirah et al., 2017; Kabir et al., 2017; Senyolo et al., 2018),	Inter-cropping	(Senyolo et al., 2018),	
Planting trees for shade and shelter	Ghana	(Abdoulaye et al., 2017; Denkyirah et al., 2017),	Mixed cropping	(Senyolo et al., 2017; Ubisi et al., 2017)	
Purchasing additional crop insurance	Midwestern US	(Mase et al., 2017),	Planting tolerant and drought resistant crops.	(Senyolo et al., 2017; Ubisi et al., 2017)	

Small Reservoirs and Zai Pits	Kenya	(Agesa et al., 2019; Sullivan et al., 2013)	Rainwater harvesting and	(Senyolo et al., 2017; Ubisi et al., 2017),
Terrace improvement and direct seeded rice (DSR) adoption	Nepal	(Khanal & Kattel, 2017),	Site-specific nutrient management	(Senyolo et al., 2018)
Tied ridges	Kenya, Bangladesh	(Farouque & Takeya, 2007; Mutuku, 2017b)		
Agro-ecology	South Africa	(Senyolo et al., 2018)		
Agroforestry	Indian, Ghana, Uganda, South Africa	(Borden et al., 2019; Bukomeko et al., 2019; Mthembu et al., 2019; Tripathi & Mishra, 2017),		
Bio-char	South Africa	(Senyolo et al., 2018)		
Changing planting dates	Indian, South Africa, Malaysian, Bangladesh, Ghana	(Abdoulaye et al., 2017; Kabir et al., 2017; Masud et al., 2017; Tripathi & Mishra, 2017)		
Conservation agriculture	South Africa	(Kassam et al., 2018),		
Crop diversification	South Africa, Bangladesh, Ghana	(Abdoulaye et al., 2017; Denkyirah et al., 2017; Kabir et al., 2017)		
Crop rotation	South Africa	(Makeleni et al., 2018)		
Drought early warning detection	South Africa	(Senyolo et al., 2018)		
Early maturing	Indian, South Africa, Ghana, Kenya	(Abdoulaye et al., 2017; Agesa et al., 2019; Tripathi & Mishra, 2017),		
Farming near water bodies	Malaysian, Ghana, South Africa	(Abdoulaye et al., 2017; Masud et al., 2017),		
Increasing pesticide	Ghana, South Africa and Zimbabuwa	(Denkyirah et al., 2017; Didarali & Gambiza, 2019),		
In-Field Rain Water Harvesting (IRWH)	South Africa	(Goitsemodimo, 2015; Sullivan et al., 2013)		
Inter-cropping	Indian, South Africa	(Tripathi & Mishra, 2017),		
Mixed cropping	South Africa, Ghana	(Abdoulaye et al., 2017),		
Planting tolerant and drought resistant crops	South Africa, Nigeria	(Ayanlade et al., 2017)		
Rainwater harvesting and	South Africa, Ghana, Uganda	(Abdoulaye et al., 2017; Kiggundu et al., 2018),		
Site-specific nutrient management	South Africa	(Senyolo et al., 2018)		