EVALUATION OF COMPETENCIES OF PUBLIC EXTENSION OFFICERS ON THE USE OF CLIMATE-SMART AGRICULTURE STRATEGIES BY SMALLHOLDER FARMERS IN CAPRICORN DISTRICT MUNICIPALITY-LIMPOPO PROVINCE, IN SOUTH AFRICA.

BY

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[redacted]

FULL DISSERTATION

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DEDICATION

This study is dedicated to my mother, Ms. Linah Chaza. Without your unwavering love, guidance, and sacrifices, I would not be the person I am today. Thank you for imparting life's greatest lessons and, above all, for teaching me the invaluable virtues of humility and perseverance.

Your wisdom and encouragement have been the constant source of inspiration, motivating me to reach for the seemingly impossible. Your strength, resilience, and boundless love have shaped my character and instilled in me the determination to overcome challenges.

As I navigate the complexities of this study, I carry with me the lessons you have taught me the importance of hard work, power of kindness, and the belief that every dream is attainable with dedication and humility.

This achievement is as much yours as it is mine. Thank you, Mom, for being my rock and my guiding light.

DECLARATION

I, Nomzamo Pertunia Chaza, declare that the dissertation hereby submitted to University of Limpopo for the degree Masters of Agricultural Management (Agricultural Extension) has not been previously submitted by me for a degree at this or any other institution; that it is my work in design and in execution and that all materials contained herein have been duly acknowledged.

Ms NP Chaza　　　　　　　　　　　　　　Date

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ABSTRACT

Globally, the significance of extension officers in promoting the adoption of Climate Smart Agriculture (CSA) among small-scale farmers is increasing. This study assessed the competencies of public extension officers in implementing CSA strategies in smallholder farming within Limpopo province. This evaluation is vital for ensuring an ongoing professional development of public extension officers, enabling them to effectively navigate evolving CSA strategies and deliver comprehensive advisory services to farmers. The study's objectives were: (i) to describe the socio-economic characteristics of the extension agents, (ii)to determine the Knowledge, Attitude, Perception (KAP) and understanding the level held by extension agents towards the use of CSA, (iii) to identify factors that influence access to information and technology for climate smart agricultural users. To evaluate competencies of extension officers in implementing climate-smart agriculture, a quantitative research design was employed. Data was collected through a structured questionnaire administered to 80 out of the 85 officers in the area using convenience sampling. The analysis of the data was conducted using descriptive statistics, which provided valuable insights the demographic and professional characteristics of the respondents. The study's findings revealed several key demographic and professional characteristics of the respondents. The most prevalent age group was 46 years and older. In terms of gender distribution, most respondents were female (54.9%), followed by males (45.1%). The predominant marital status among respondents was married (50.7%), and a considerable proportion holds a degree as their highest education level (46.5%). The mean indicator score was notably higher for knowledge (0.6928). This implied that extension officers in the study area exhibit a substantial level of knowledge regarding climate-smart strategies. Despite the positive findings, the study identified challenges faced by extension officers in enhancing their knowledge of climate-smart adaptation strategies. These challenges include three recurring factors, which consistently influenced access to information and technology for users engaged in climate-smart agriculture. The influential predictors affecting access to information and technology in Capricorn district were three Coping and Adaptation Strategies, Acquisition of Knowledge, and lastly Computer and ICT Skills. The study proposed recommendations based on its findings, aimed at fostering collaboration among stakeholders for the efficiency and longevity of agricultural extension services in Capricorn district. Recommendations for extension officers include active engagement in continuous learning, participation in community outreach programs, embracing innovation, and acting as mentors to junior colleagues. Researchers are encouraged to collaborate closely with extension officers, support innovation adoption, and contribute to the development of training programs. Educational institutions should update curricula, develop practical training programs, and establish continuous professional development systems. The Department of Agriculture is advised to strategically allocate resources, advocate for policies supporting CSA practices, establish monitoring and evaluation frameworks, and facilitate collaboration among stakeholders.

Keywords: Climate- Smart Agriculture competencies, KAP, climate-smart strategies, public extension agents.

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LIST OF ABBREVIATIONS AND ACRONYMS

CO2	Carbon dioxide
CIA	Central Intelligence Agency
CSA	Climate Smart Agriculture
CSAS	Climate Smart Agriculture Strategies
FAO	Food and Agriculture Organization
GHGs	Greenhouse gases
GDPs	Gross Domestic Products
ICT	Information and Communications Technology
TPB	Theory of Planned Behavior

CHAPTER ONE: BACKGROUND AND INTRODUCTION

1.1 Introduction

South Africa's agriculture is particularly vulnerable to climate change, as productive farming is affected directly by quality of the rainy season, temperature, climate variability, extreme weather events, and carbon dioxide (CO2) concentrations in the atmosphere (Zen *et al*., 2019). Climate change is a worldwide complication, and its consequences are made noticeable more particularly in the agricultural sector where it has outstandingly affected animal and crop production mostly in developing countries (Elum *et al*., 2017). Agriculture lies at the crossroads of climate-change mitigation and adaptation efforts.

Globally, the agricultural sector contributes around 12% of anthropogenic greenhouse gas (GHG) emissions according to some estimates, while in South Africa the sector is responsible for half that percentage (Tongwane *et al*., 2016). These impacts extend beyond food security and can negatively affect the national economy, should the country's ability to export crops and generate foreign revenue be reduced, while food must be imported. It is, above all, poorer farming groups that will be the most adversely affected by climate change since they suffer most from its impacts, by being most directly dependent on the natural environment and ecosystem services for their survival and livelihoods (Dube *et al*., 2016). As a result of poverty, insufficient knowledge, financial constraints, and poor infrastructure, there is little chance of poverty-stricken farmers switching to other sources of income.

The world's climate is changing fast and will continue to do so for the foreseeable future, no matter what measures are now taken. The effects of climate change on agriculture should therefore be seen in terms of both the productivity of farming operations and the risk of disruption of production, with implications for food security and income for millions of households in South Africa (Zougmoré *et al.,* 2016). The agriculture sector must produce more food to meet the needs of the growing population, as it looks set to be negatively impacted by climate change (FAO, 2013).

Agriculture as a sector is most vulnerable to climate change with many threats, including the reduction in agricultural productivity, production instability, and limited means of coping with adverse climate impacts. Most estimates indicate that climate change is likely to threaten income amongst societies already suffering from food insecurity, and high rates of poverty (Behnassi *et al.,* 2014). To successfully address climate change issues, the agricultural sector must become climate smart. This includes promoting and adapting to technologies and practices that address the issue of climate change (Matteoli *et al.,* 2020).

Efforts to combat the impact of climate change on agriculture, livestock production, and community well-being necessitate the development of climate-smart approaches for both mitigation and adaptation (Matteoli et al., 2020). These approaches aim to address challenges related to crop and livestock production, health, and the reduction of greenhouse gas emissions from livestock. Kumar *et al*., (2018) alluded that, extension officers play a pivotal role in implementing these strategies at the grassroots level, facilitating the dissemination of crucial information. According to El Bilali et al. (2020), information and communication technologies (ICTs) have become instrumental in transmitting vital agricultural information to developing countries, fostering global connectivity and knowledge exchange. This interconnectedness allows these nations to access the latest advancements in weather forecasting, natural resource management, and related technologies, as highlighted by the insights of Rao (2007). In essence, the synergy of climate-smart practices, the engagement of extension officers, and the integration of ICTs form a comprehensive approach to address the multifaceted impacts of climate change on agriculture and livestock in developing nations.

Suvedi and McNamara (2012) emphasized the need for communication and collaboration between extension and research in agricultural services. They further stated that extension personnel should be aware of active research, research findings, and lastly researchers should be aware of field-researchable issues. According to Aker (2011), the demand for information and communication technologies (ICTs) in agricultural extension services is always increasing. The use of ICTs accelerates, simplifies, and reduces the cost of information dissemination. extension professionals should be aware of emerging ICTs and apply them in their work (Aker,2011).

Information and communication technologies are paving new approaches to communicating and sharing information. Using such kind of technologies improves the knowledge and skills of individuals (Warren, 2002). Technologies such as information communication technologies are types of technologies that allow users to access different types of data and information through telecommunications (Latzer, 2009). These communication technologies include the internet, mobile phones, wireless networks, and other communication tools (Meibos,2017).

Through these ICT tools, farmers can interact with each other in real time even when they are in different countries. Instant messaging, video or voice conferencing, and social networking allow farmers to interact with each other from all over the world without having to travel. ICT is therefore one of the most beneficial ways of spreading knowledge and information through science and technology (Olaniyi *et al.,*2013). It has created new ways of communication and information sharing globally, despite geographical limitations. In South Africa, the Information and Communication Technology industry continues to show dynamic growth (Maumbe and Okello 2013). Agricultural extension officers need to be well-trained in these technologies to help small-scale farmers with the adoption of climate-smart technologies and the use of ICT tools (Antwi-Agyei and Stringer, 2021).

Agricultural extension officers, as stated by Singh and Grover (2013) is the bridge between research and farmers as they play key roles in agriculture by providing farmers with information, new technologies, and education on how to mitigate GHGs and cope with climate change to increase production and ameliorate living standards. Extension's major activities over time have been the dissemination of useful information from research to farmers and taking farmer's problems to researchers and this is even more important considering climate change and its impact on agriculture (Obiora, 2013). The delivery of extension services to smallholder farmers depends mostly on the competencies of extension workers about the diffusion of advanced technologies and information in agriculture (Mgbenka, Mbah and Ezeano,2016).

According to Issahaku (2014), competency is a skill, a personal characteristic, or a motive demonstrated by various behaviours which contribute to outstanding performance in a job. It is the quality of being adequately or well qualified and having the ability to perform a specified job.

Suvedi and Ghimire (2015) further stated that a competent extension professional is an asset of agricultural extension services. According to Suvedi and Ghimire (2015), a diverse and dynamic agricultural system, advancing science and technologies, changing sociodemographic, increasing globalization, and increasing competition for resources necessitate that agricultural extension professionals be proficient in technical aspects of their areas of expertise as well as processes and service delivery. In other words, there is an increasing need and desire for extension experts to display a better level of professionalism in their services. As a result, extension staff should have the requisite abilities to anticipate and provide quality educational programs that are relevant and important to our public (Maddy *et al.,* 2002).

Stevens (2012) suggested that extension officers act as facilitators and assist farmers in their decision-making and technology adaptation. With the changing climate-threatening production, extension agents need to encourage farmers to adopt relevant applicable practices which are reconcilable with CSA principles, but they can only do this if they are competent in the CSA practices. Amongst many, CSA practices include precision farming, tillage, mulching, organic fertilization, cultivar selection, etc. Exposure to extension services influences the capacity of farmers to adapt to climate change (Maponya and Mpandeli, 2013) because they educate farmers for example on how to develop and disseminate local cultivars of drought-resistant crop varieties with information about the crops' advantages and disadvantages. According to Maponya and Mpandeli, (2013), climate change and its associated uncertainties imply that agricultural extension services need to regularly access new knowledge and disseminate it in an adequate and timely manner to the farmers.

1.2 Problem statement

In a developing country like South Africa, the rural people solely depend on extension officers for technical advice and information. The success of any extension program will be determined largely by the ability of her extension personnel to display competence since the whole extension delivery process is dependent on them to transfer new ideas and technical advice to the rural people (Owen, 2004).

According to Seevers *et al.,* (2007), future extension experts need to be more capable and innovative to suit the demands of various audiences. Extension employees must develop new information and skills, as it is only knowledgeable and skilled people can play a crucial part in the success of an organization in today's technology world. Swanson and Mancini (1996) stated that great value should be put on core competencies in business and industry, particularly referring to their knowledge and skill in these domains. Graham (2009) stated that, to be a successful extension officer nowadays, one must be knowledgeable not just on technical subjects, but also in areas such as management, programming communication, human relations, and leadership.

South Africa like other developing countries lack access to updated and advanced technologies to fight against the effects of climate change. Climate change is a major contributor to low agricultural productivity in South Africa. By virtue, farmers face low agricultural productivity and food shortages (Abor and Quartey, 2010). Small-scale agriculture in the Capricorn region, like in other parts of the Limpopo province, is mostly rain-fed and sensitive to climate change, notably changes in temperature regimes and precipitation patterns, as well as extreme weather events (Ubisi, 2016). According to Bossio *et al.,* (2010), the consequences of climate change led to unsustainable land and agricultural water management in the district. Maponya (2021) indicated that the Department of Agriculture, Land Reform, and Rural Development could play a vital role to train extension staff in climate change strategies and adaptation measures for smallholder farmers. Both agricultural extension officers and farmers in the Capricorn district in Limpopo province have benefited from the use of Information Communication Technology (ICT) tools for agricultural information exchange and easy communication with farmers (Ramavhale, 2020).

According to the International Telecommunication Union (ITU, 2022), there is a connection between ICT and climate change. ICT opens new avenues for alleviating and adjusting to climate change. ICTs help with short- and long-term climate change monitoring and analysis, as well as increasing awareness, safeguarding the environment, and lowering carbon emissions (ITU, 2022).

Although much is known about the relationship and benefits of using ICT tools in mitigating climate change, little is known about the competencies of public extension officers in the Capricorn district in the use of climate-smart agriculture because extension workers are capacitated and benefit from ICT. Davis and Verma (1993) asserted that there is a strong necessity to determine and to further develop the relationships between the qualities of agricultural extension staff competencies in human development learning, leadership development, communication methods, extension program planning, and extension program implementation, extension program evaluation, as well as organizational commitment and extension workers' performance.

ICT can play a key role in providing extension officers and farmers with the information needed for their crop production, input supply, pest and disease control, post-harvest logistics, marketplace solutions among others. The availability of such timely information can enhance quality decisions made by farmers on what crops to grow given the preceding weather conditions, resources available, and marketplace supply chain (Rahman, 2009). A study conducted by Antwi-Agyei and Stringer (2021), on climate-smart agriculture and effective extension services showed that majority (84%) of the sampled participants indicated that the use of ICT by extension officers as climate-smart agriculture helps in climate change adaptations as it allows prediction of weather forecasts and others were not sure. The importance of climatic smart agriculture has got various opinions. This may be because of the different socio-economic factors and availability of infrastructures to support the implementation of climate-smart agriculture strategies.

Several studies in the Limpopo province in the agricultural extension contexts focus on the relationship between extension officers and smallholder farmers, with the belief that extension officers can solve the climate change challenges faced by farmers. For example, Zikhali (2016) focused on "meeting the extension needs of smallholder farmers: the climate information gap in the public agricultural extension and advisory services in Limpopo, South Africa". “Hence, this project attempts to assess the competencies of public extension officers in the use of climate-smart agriculture strategies in smallholder farming of Limpopo province, South Africa".

1.3 Rationale of the study

The agricultural industry must produce more food to fulfil the requirements of a rising population, as it looks like it is currently set to be negatively impacted by climate change (De Silva and Soto, 2009). Agriculture is the most sensitive industry to climate change, with several challenges such as reduced agricultural output, unstable production, and inadequate ways of dealing with severe climatic effects. According to most projections, climate change is projected to undermine income in cultures already suffering from food insecurity and high rates of poverty (Behnassi, Boussaid and Gopichandran, 2014).

The Limpopo province is particularly vulnerable to climate change and volatility since the agricultural output is strongly dependent on climatic conditions, notably the quality of the rainy season. Furthermore, as stated by Letsatsi - Duba (2009), climate change is happening in Limpopo province with other developmental issues like poverty, unemployment, and food insecurity. It is therefore, feared that it may outstrip the province's adaptability limits in other areas. Smallholder farmers bear the brunt of climate change's consequences. As a result, climate-smart initiatives that strengthen the ongoing development efforts and improve farmers' adaptive ability are required (Lipper *et al*., 2014). Climate-smart practices rely on agricultural extension officers; therefore, farmers see extension officers as their final option for credible and helpful information on climate-smart agriculture (Okoth, 2019).

Agricultural extension officers worldwide are tasked with disseminating technology and initiatives to farmers. Agricultural extension services include all elements of timely information, connecting farmers with sources of agricultural supplies and financing facilities, and, most critically, transferring technology and providing education services to farmers in all parts of agriculture (Anaeto *et a*l., 2012). The primary purpose of the extension is to disseminate innovations to specific clients such as farmers, pastoralists, foresters, and other rural inhabitants who rely on agriculture in some manner. It is the responsibility of extension officers to disseminate best practices and innovations currently developed by numerous research efforts around the world on ways to improve the adaptive capacity and resilience of vulnerable people to the effects of climate change, thereby increasing productivity and reducing poverty (Singh and Grover, 2013).

A good extension service should be able to disseminate knowledge about new and improved technologies that address specific restrictions from research institutions to farmers, and then back to researchers and policymakers (Kyomo, 1992). Bridging the gap between research, extension, and farmers is widely acknowledged as one of the most severe institutional issues confronting agricultural development. It is also acknowledged that an effective communication system is a critical component for boosting technical information transferability (Tollefson, 1995).

This study deploys qualitative content analysis to assess public extension officers' abilities to implement climate-smart agricultural methods in rural smallholders. FAO (2018) alluded that farmers would continue to miss out on benefits unless extension officers embrace climate-smart agriculture measures to boost the resilience of smallholder farmers to climate change. The study aims to evaluate the knowledge level of extension officers regarding the implementation of climate-smart agriculture in smallholder farming and its associated advantages.

The anticipated outcomes of the project are expected to have a significant impact on key stakeholders in the agricultural sector. The findings of this research will be valuable for the Department of Agriculture in the study region and for extension staff involved in initiatives for the development of smallholder farmers. Furthermore, the research will assist agricultural extension workers in their efforts to acquire these competencies. It will also function as a guiding tool for extension managers and trainers, providing support and direction to extension officers in their knowledge acquisition endeavours. Identifying the necessary competencies for public extension officers not only promotes individual growth but also contributes to organizational development, equipping the organization to address future challenges effectively. Understanding the competencies of extension officers is crucial for improving organizational productivity, demonstrating the organization's ability to utilize existing resources efficiently in achieving its goals .

1.4 The aim of the study

The aim of this study is to evaluate the competencies of public extension officers in the use of climate-smart agriculture strategies in smallholder farming in Limpopo province, South Africa.

1.5 The specific objectives of the research study include:

I. To describe the socio-economic characteristics of the extension officers in Limpopo Province.

II. To determine the Knowledge, Attitude, Perception (KAP), and understanding level held by extension officers towards the use of climate-smart agriculture in study.

III. To identify factors that influence access to information and technology for the climate- smart agricultural users.

1.6 Research questions

I. What is the socioeconomic profile of the extension officers in Limpopo Province, South Africa?

II. What is the Knowledge, Attitude, Perception (KAP), and understanding level held by extension officers towards the use of climate-smart agriculture in the study?

III. What are the factors that influence access to information and technology for climate- smart agricultural users?

1.7 Scientific contribution

This study assessed public extension officials' competence in the implementation of climate-smart agricultural techniques in Capricorn district of South Africa, Limpopo Province. The study's findings identified areas where extension officers require further training to provide better and more comprehensive services to smallholder farmers regarding CSA. The study's findings described the level of competency of extension officers in Capricorn district. The findings of this study revealed a wealth of insight for various and relevant stakeholders on the best media or source to convey information to smallholder farmers to ensure successful conveyance and capacity office block for extension officers.

The findings of the study will also highlight the disparities and outline problems that extension officers may face while disseminating climate-smart practices. This will assist governments and other sector players in planning for the gaps that must be addressed in addressing difficulties impeding officer skill upgrading and operational propagation of climate-smart solutions in the research region.

1.8 A report of the study is structured and presented in five chapters.

- Chapter 1 introduces the study by providing context and background information on the significance of CSA in Limpopo and other parts of the world, outlining the challenges faced by extension officers in promoting CSA practices. It also outlines research questions, rationale, study aim and objectives, and overall structure of the research report.
- Chapter 2 conducts a thorough literature review of existing research on CSA and extension officers in both global and South African contexts. It examines the role of extension officers in promoting CSA practices, their socioeconomic profiles, knowledge, attitudes, perceptions, and understanding of CSA, their knowledge and skills regarding climate change and CSA strategies, and the factors that influence their access to information and technology related to CSA.
- Chapter 3 outlines methodological approach used to conduct the study, including research design, population, study site, sampling procedures, data collection tools and processes, data analysis processes, ethical considerations, and attempts made to reduce bias.
- Chapter 4 presents findings of the study in detail, providing clear and organized presentation of the data, interpretation of the findings, and analysis of data in relation to the research questions.
- Chapter 5 summarizes the study, providing a concise overview of the key findings and conclusions. It also reiterates the main findings and their implications, and provides recommendations for policy, practice, or further research based on the study's findings.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This section outlines previous studies on the competencies of extension officers on climate-smart strategies in agriculture and the role it has in smallholder farmer development. The section will resume with a (2.2), short history of agricultural extension and the use of improved technologies (2.3), followed by theoretical explanation of extension officers' Knowledge, Attitudes and Perceptions (2.4). This section will further highlight the core competencies of extension officers and how they are used to adapt to Climate Smart Agriculture and the ever increasing and changing Information and Communication technologies (2.5). This section also looks into the knowledge of extension officers about climate change (2.6) as well as the level of knowledge of extension officers about climate smart agriculture (2.7) the section documented the sources of information used by extension officers for climate smart agriculture practices (2.8) the section will outline the barrier of extension officers in using climate-smart agriculture practices (2.9) and finally, the section will conclude with a summary of literature review.

2.2 History, concept, and origins of agricultural extension

For thousands of years, improved agricultural technology and management techniques have been transmitted and applied in numerous regions of the globe, counting China, Mesopotamia, Egypt, and America. The origins of public or government-funded extension and advisory networks may be traced back to Ireland and the United Kingdom in the mid-nineteenth century as stated by Swanson and Rajalahti (2010).

Every definition of Agricultural Extension reflects the time and interests of extension officers. Maunder (1973) defined agricultural extension as a service or system that assists farmers in improving their farming techniques and methods through educational processes to increase their production efficiency and income, while improving their standard of living, and upgrading their social and educational standards. On the other hand, Adams (1982) defined agricultural extension as the assistances provided to farmers in identifying and analysing productivity limits and becoming aware of opportunities to improve.

According to Agricultural Services Innovation and Reform Project (2003:1), agricultural extension is an educational process in which knowledge or advice is created, communicated, and utilized to make decisions for farm and farm household livelihood development.

At the beginning of 1867, the word "extension" was then used to describe adult education programs conducted by the universities of Oxford and Cambridge in England. These educational initiatives helped universities extend their operations outside the campus and into the local community (Swanson and Rajalahti, 2010:1). This description of extension suggest that extension workers must always be ready to educate and extend CSA knowledge and skills to small scale farmers in rural communities. According to Akinnagbe and Ajayi, (2010:1), these educational initiatives have consequences which included aspects of technology transfer, larger rural development goals, managerial skills, and non-formal education.

The goal of extension and advisory services was then to help producers use their land and other agrarian resources more efficiently, productively, and sustainably by providing information, advice, education, and training (DAFF, 2014:9). Although agricultural extension may be defined in different ways by different authors in time, its main goal remains the same throughout the years. The goal of agricultural extension is still focused on educating farmers on how best they can use their land to maximize production. In my view, small scale farmers are challenged with climate change in their communities hence, it is high time that advisory services collaborate with small scale farmers in learning about CSA to use their agrarian resources in a sustainable manner.

Oladele (2005), stated that the concept of agricultural extension has evolved over the years and is becoming increasingly important in countries which depend heavily on agriculture for their livelihood. Additionally, Oladele (2005) stipulated that, agricultural extension is still used to assist farmers in making better and more sustainable use of their land and other resources. Evenson and Mwabu (2001) alluded that, the correct and vital purpose of modern agricultural extension services should be to provide critical information to farmers on each visit, with the complexity of these messages rising with subsequent visits.

According to Worth (2006), the objective of agricultural extension must be focused on enhancing farmer sustainability. This implies that agricultural extension services should not only provide immediate solutions but also empower farmers with the knowledge and practices necessary for long-term success in agriculture. The fundamental communications of agricultural extension services as stipulated by Evenson and Mwabu (2001) should be focused on enhancing core production techniques, with a particular emphasis on land preparation, operation timeliness, crop spacing, plant population numbers, adoption of better seed varieties, and weeding as early communications furthermore, after the fundamental communications.

The emphasis may then shift to more nuanced messages concerning fertilizer use and pest control approaches, as well as the environment-productivity relationship. While the concept of agricultural extension has been changing throughout the years the core fundamental of its goal is still focused on improving the use of resources and production. In my view, the evolution concept of agricultural extension over the years highlights the enduring commitment of agricultural extension services to empower farmers with knowledge and practices that contribute to long-term sustainability and productivity in agriculture. The collaboration of fundamental principles with evolving insights will ensure that agricultural extension remains a relevant and impactful tool in supporting the agricultural community. Before, the agricultural extension was implemented in a linear method, with farmers or other extension receivers were "forced" to absorb or consume technology that was delivered to them. There were no defined strategies for packaging and assessing the result or effect of extension in terms of human capacity development as stated by Evenson and Mwabu (2001).

Amanuel (2007:1) further stated that these were typical instances of top-down supply-driven methods. These supply-driven top-down approaches are still practiced in most parts of less developed nations, where farmer-extension worker interactions are skewed in favour of the latter. However, agricultural extension workers disseminate improved information and technologies to fulfil their primary goals that influences their work.

The top-down approach was not an effective way of implementing agricultural services to farmers, for farmers are faced with different problems and require different solutions. Farmers have different goals hence as a result, the linear method was then implemented. This top-down approach would be effective only if extension workers are capacitated in CSA knowledge, skills, and technologies to share with small scale farmers in a bottom-up approach taking into consideration the farmers knowledge of adapting to climate change.

According to Swanson and Rajalahti (2010), agricultural extension has three primary goals that influence their work (visibility). Their goals include achieving food security, enhancing rural livelihoods, and better managing natural resources (Umali and Schwartz, 1994). Swanson and Rahalahit (2010) further stated that, the lack of visible results in agricultural extension performance has created a heated debate both globally and in Africa, especially among poor countries. The lack of genuine farmer interaction not only result in creation and spread of wrong technology but also represents a missed opportunity for farmer empowerment. According to Katz, Plüss, and Schidegger (2007:18), farmers who learn to experiment and produce innovations alongside extension professionals are better able to adapt to changing situations, and this will result in agricultural extension being more visible. The need of competent extension officers is of great need to farmers, as farmers are dependent on them to help assist on adoption of sustainable agricultural practices amid to reduce the ongoing effect of climate change. This implies that, the role of competent extension officers is underscored, as farmers heavily depend on their guidance to adopt sustainable agricultural practices, especially in the face of ongoing climate change .

2.3 Knowledge, Attitude, Perception (KAP) of extension officers in the use of technologies

The KAP of agricultural extension officers can be studied and understood using Ajzen' 1985 "theory of planned behaviour". The Theory of Planned Behaviour (TPB) predicts an individual's intention to engage in a behaviour at a specific time and place. It posits that individual behaviour is driven by behaviour intentions, where behaviour intentions are a function of three determinants: an individual's attitude toward behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991). Behaviour is contained in a person's behavioural, normative, and control beliefs.

The theory does not specify where these beliefs originated; it merely points to a host of possible background factors that may influence the beliefs people hold – factors of a personal nature such as personality and broad life values; demographic variables such as education, age, gender, and income; and exposure to media and other sources of information (Ajzen, 2011). The factors of theory of planned behaviour: Reactions and reflections are expected to influence intentions and behaviour indirectly by their effects on the theory's more proximal determinants. This theory has been successfully applied to a wide range of behaviours. Interestingly, it is complex behaviour such as managerial decision making which saw only a few attempts to use TPB. This is true for company internationalization. While the main elements of the theory are generally accepted, it has been suggested on many occasions that the model would benefit from the inclusion of more constructs in terms of explanatory quality.

The TPB may have the potential for developing behaviour change interventions (Han and Kim, 2010). The theory of planned behaviour points out that individual behavioural intention is determined by attitude and subjective norms. The theory applies to the study in the sense that the behavioural intention of extension agents in getting involved in building their knowledge and in disseminating climate-smart agricultural initiatives to farmers is greatly determined by their perception of its usefulness, attitude, beliefs, and knowledge of those initiatives. Previous analyses by various authors have shown that increased awareness, knowledge, participation, and capacity among farmers are keys to sustainable development of agriculture (Blackmore,2010). Farmers play a crucial role in making strategic and operational decisions that bridge theoretical concepts with practical applications. Striking a balance between envisioning a desirable future and what is realistically feasible, farmers require guidance and support from extension officers. It is emphasized that extension officers should not only focus on addressing specific issues but also strive to understand the farmers themselves, moving beyond the role of mere experts to building meaningful relationships (Mills et al., 2017).

The reliability, competence, credibility, impartiality, and trustworthiness of advisors are crucial factors acknowledged in the agricultural context (Ingram, 2008), with trust being particularly significant for the credibility of advisors, especially those with a farming background or a trusted network (Blackstock et al., 2010).In Limpopo Province's rural community, adverse climatic conditions are posing challenges to agricultural production (Mpandeli et al., 2005). A study on the "Perceptions of Iranian Agricultural Extension Professionals towards sustainable agricultural concepts" (Allahyari *et al*., 2008) highlighted that age, level of education, years of experience, and organizational position significantly influence extension professionals' perceptions. The theory of planned behaviour (TPB) plays a role in shaping the attitudes, subjective norms, perceived behavioural control, and intentions of extension officers towards adopting climate-smart strategies, with factors such as age, education, income, and gender coming into play.

Notably, a study by Ndoro (2011) found that a significant proportion of extension officers in South Africa are in their middle ages, suggesting that they are in their economically active years. This demographic characteristic is expected to positively impact their knowledge of climate-smart strategies, aligning with the findings of Fredericks and Yu (2018). The age of extension officers can influence their openness to embracing new agricultural practices and technologies (Wheeler, 2008). In my view, these studies collectively underscore the importance of considering various demographic and contextual factors that influence extension officers in their endeavours to promote climate-smart strategies in agriculture.

The age of extension officers can significantly influence their willingness to embrace new methods and technology, with younger officers, who are more familiar with current technology and methodologies, being more open to adopting climate-smart solutions (Wheeler, 2008). Morris and James (2017) support this idea by affirming that age is a determining factor in the acceptance of novel communication methods, such as mobile applications or social media platforms, particularly among younger extension officers. Additionally, younger officers may be more influenced by societal norms surrounding sustainability, increasing their likelihood of adopting climate-smart strategies.

Conversely, older extension officers, with years of experience, bring valuable traditional knowledge and well-established relationships with farmers, which can be leveraged to promote climate-smart practices (Mashi, Inkani, and Obaro, 2022). This gives the implication that, the age factor introduces a nuanced dynamic where younger officers may embrace technological innovations and sustainability norms, while older officers contribute traditional knowledge and strong farmer relationships. According to Terdoo and Adekola (2014), the educational background of extension officers also plays a pivotal role in their understanding and adoption of climate-smart strategies. This finding is corroborated by Victory, Oyewole, and Olaitan (2022), who suggest that extension officers with higher levels of education in agriculture are more likely to comprehend climate change, sustainable agriculture, and innovative farming techniques.

The significance of education is further emphasized by Olorunfemi, Olorunfemi, and Oladele (2020), who argue that education positively influences the attitudes and intentions of extension officers towards adopting and promoting these practices. Well-educated extension officers may possess stronger analytical skills, enabling them to critically evaluate research findings and effectively communicate climate-smart approaches to farmers (Olorunfemi, Olorunfemi, and Oladele, 2020). However, education alone is not sufficient; it is crucial for extension officers to have a certain level of income to effectively promote new technologies to farmers. In my view, the combination of education and financial resources is essential for extension officers to proactively advance climate-smart strategies in agriculture.

According to Raj and Garlapati (2020), the income level of extension officers can significantly affect their ability to embrace and advocate for climate-smart practices. They argue that extension officers with higher incomes may enjoy better access to resources and technology, enabling them to develop and demonstrate climate-smart practices more readily. Additionally, higher-income extension officers may benefit from increased opportunities for professional growth and training (Kare, Gujo, and Yote, 2021). Conversely, those with lower incomes might face financial constraints that limit their capacity to adopt or promote climate-smart activities (Raj and Garlapati, 2020).

It is crucial to provide adequate financial support and incentives for all extension officers, irrespective of their income levels, to effectively implement and promote climate-smart strategies. In my view, higher incomes for extension officers contribute to a more motivated, knowledgeable, and stable workforce, ultimately enhancing their capacity to effectively advocate for and facilitate the adoption of Climate-Smart Agriculture practices among farmers. The successful implementation and adoption of climate-smart strategies hinge on how extension officers communicate new information to farmers, rather than being constrained by the gender norms held by farmers. Srite and Karahanna (2006) suggest that gender norms and roles can influence subjective norms, which are individual views of social expectations and acceptance associated with an action.

In many societies, gender norms may assign different responsibilities to men and women in agriculture. Extension officers must be mindful of these gender dynamics and ensure that their interventions consider the specific needs and constraints of both male and female farmers (Chowa, Garforth, and Cardey, 2013). This is particularly important as women often have limited access to resources, information, and decision-making power, hindering their ability to adopt climate-smart practices. In Limpopo Province, gender inequality is evident, as reported by Zwane (2009), indicating that extension officers are predominantly male, holding diplomas as their educational qualification. This underscores the importance of effective communication by extension officers and the necessity to address gender dynamics in agriculture. It emphasizes that gender norms can influence the adoption of climate-smart practices, especially for women who may encounter unique challenges .

2.3.1 Knowledge of extension officers about climate change

According to Gomez-Zavaglia *et al*., (2020) climate change has significant implications for agriculture, including changes in weather patterns, increased frequency of extreme weather events, shifts in crop suitability, altered pest and disease dynamics, and water availability challenges.

Antwi-Agyei and Stringer (2021) and Nyarko and Kozári (2021) indicated that, extension officers play a crucial role in disseminating information, providing technical assistance, and promoting sustainable farming practices to farmers and rural communities. Their knowledge of climate change is vital for helping farmers adapt to the evolving conditions and adopt climate-resilient agricultural practices. In addition, Davis (2008) and Davis *et al.,* (2018) stated that, the field of extension has been evolving and will continue to do so. Davis *et al.,* (2018), further elaborated that, this evolution results in extension workers' roles and attitudes changing with changing global realities. In my view, climate change poses multifaceted challenges to agriculture, and the expertise of extension officers becomes instrumental in ensuring that farmers receive the necessary information and guidance to adapt to these changing conditions and adopt sustainable farming practices.

On the other hand, Davis and Sulaiman (2014) revealed that the changing global realities such as climate change and technological advancement causes extension to broaden and become more holistic and the broadening of extension has affected development paradigms to change over the decades. For instance, the extension was first influenced by the linear transfer of technology or diffusions approach (Koutsouris, 2018). This approach assumed that researchers and technical experts had the responsibility to generate new technologies, extension workers to transfer them, and farmers to adopt them. In this context, farmers' empirical knowledge tended to be neglected. However, the diffusion of innovations theory has heavily influenced extension thinking and practice (Rogers, 1995). The theory, developed by Everett Rogers in 1962, has indeed had a significant impact on extension thinking and practice. Rogers' work explores how new ideas, products, and technologies spread and are adopted within a social system. Rogers (1995) diffusion research emerged from the difficulties extension workers had in getting farmers to use new farming practices and information. Diffusion research has proved that extension workers have the task of influencing farmers to adopt new and improved technology and farm management practices, rather than a direct transfer of technologies. This gives the implication that the field of extension services has undergone a transformation from a linear transfer of technology approach to a more holistic and nuanced strategy influenced by the diffusion of innovations theory.

This shift in my view emphasizes the importance of understanding social dynamics, considering farmers' perspectives, and adopting a more participatory and context-specific approach to agricultural extension. Even though extension officers are used to the top-down approach of transferring knowledge, they still require capacity building on climate change and on climate smart agriculture to be able to influence farmers to adopt new and improved technology and farm practices (Masere and Worth, 2021). This implies that extension services should emphasize the re-training of extension staff to acquire new professional skills and competencies in climate risk management, setting up emergency management units in extension agencies, and building resilience capacities of vulnerable people (Ozor and Nnaji (2011).

Wojcik *et al*., (2014), highlight the importance of engaging extension staff in long-term professional development aimed at improving their training in climate education, as well as preparing them to effectively communicate climate change information to farmers who may be extremely vulnerable to climate change. Nevertheless, little is known about agricultural extension agents' capacity needs, the barriers they face, and the solutions that can help them to become more effective in supporting smallholders. According to Antwi-Agyei (2021), efficient delivery of extension services to farming communities requires that extension officers have good knowledge and understanding of the drivers of climate change, that could inform some of the adaptation interventions and technologies which are delivered to smallholder farmers. Antwi-Agyei (2021) study first looked at what were the main causes of climate change, and the respondents reported that deforestation was a major cause of climate change.

A large majority of participants mentioned charcoal harvesting, poor farming practices, increased release of greenhouse gases, high population growth rate, and overexploitation of natural resources as major causes of climate change. Nearly three-quarters of the respondents indicated that the use of nitrogen-containing fertilizers and the conversion of forests into agricultural lands greatly to influence the occurrence of climate change.

Furthermore, as indicated by Antwi-Agyei (2021), this suggests that extension officers in the study attributed climate change to anthropogenic causes and that they have a good understanding of both distal and proximal drivers presented in the wider literature. Minimaxing the above-mentioned causes was seen as a possible solution so far. In my view, it is important for extension officers to have comprehensive understanding of the drivers of climate change, as it enables them to tailor extension services and interventions effectively to address the specific challenges faced by smallholder farmers in the context of a changing climate .

2.3.2 Knowledge level of the extension officers on climate-smart strategies

Climate-smart strategies aim to enhance agricultural productivity, increase resilience to climate change, and reduce greenhouse gas emissions. According to Leeuwis, (2013), these strategies are critical for sustainable agriculture in the face of changing climate patterns hence to know the knowledge level of extension officers on these strategies is of importance.

The knowledge level of the extension offices on climate-smart strategies plays vital importance towards the smooth transition or dissemination of information through information and communication technologies on conservational agriculture, planting of drought-resilient crop varieties, water management, use of integrated pest management, mulching, information communication technologies, and practice green revolution (Vincent and Balasubramani, 2021). In my perspective, extension officers play pivotal role in promoting climate-smart strategies among farmers as their knowledge level is essential for the successful implementation and dissemination of information on conservation agriculture, drought-resilient crop varieties, water management, integrated pest management, mulching, and the use of information and communication technologies in agriculture.

Extension officers also play an important role in promoting and facilitating climate-smart agriculture strategies, technologies, and innovations.

In case of poor farming productivity change by climate change, extension officers' level of knowledge on climate-smart strategies can help build and improve natural resource vulnerability by helping farmers innovate their farms (Drexler, 2021). This is achieved using technologies that will allow small-scale farmers to carefully match their crops and required climatic conditions, which will result in less use of pesticides and other farm chemicals. Instead, in terms of drought, extension officers' knowledge can facilitate the introduction of drought-tolerant cultivars in the smallholder farming sectors.

Extension officers currently experience weak technical knowledge of climate change due to lack of resources hence, there is a need for stronger communication, networking, facilitation, and partner engagement capacities (Afful, 2016). According to Afful (2016), this would help officers to work more efficiently when supporting farmers in implementing climate-smart strategies. Furthermore, Maka *et al.,* (2019) indicated that extension officers need to provide research results from researchers about climate change. Additionally, Maka *et al.,* (2019) suggested that training and equipping through extension can assist farmers to better cope with and find appropriate solutions to counter the effects of climate change and variability on crop production through, for example, the adoption of new agricultural practices and technology.

This gives practices and that, extension officers are key facilitators in the adoption of climate-smart agriculture practices as their knowledge and capacities are crucial in helping farmers adapt to the challenges posed by climate change, promoting sustainable practices, and fostering resilience in agricultural systems. In my view, addressing the limitations faced by extension officers, such as weak technical knowledge and resource constraints, is essential for more effective support to farmers in the face of climate change. On the other hand, Babu *et al.,* (2013) suggested that where appropriate, agricultural extension may also help to build up local farmers' groups and organizations so that they can benefit from extension programs and aptly provide social support to individual member farmers.

Agricultural extension provides the indispensable elements of knowledge that farmers need to improve their agricultural productivity. According to Antwi-Agyei and Stringer (2021), extension education as a capacity-building strategy is key as it contains information on the character of variability and climate change in agricultural production as well as measures to enhance people's capability to better cope with associated negative effects on their livelihoods. Van Niekerk *et al.,* (2011) stated that, the South African agricultural extension service is challenged to improve food security, develop rural areas through agricultural activity, and create sustainable jobs in farming. Top of the extension officers' tasks include disseminating useful information to farmers and helping them to gain knowledge so that they may improve their standard of living (Röling, 2019).

However, with regards to the broader concept of capacity development, extension officers also need more training before they can train those that they are sent to assist, and this could be achieved through continuous or short-course training to be on the right track with newly developed climate-smart. In my opinion, capacity-building through extension education and continuous training is essential for extension officers to effectively support farmers and keep abreast of the latest developments in climate-smart strategies . According to Abegaz and Wims (2015) there were statistically significant differences in extension officers and exposure to climate change between their education levels.

Agricultural extension officers with a diploma qualification were less prone to receive climate change education, whereas those with either a postgraduate or a BTech/degree qualification were more likely to receive climate education. The finding shows a significant difference in education level and knowledge about climate change. More extension officers with diploma qualifications were more likely to indicate that climate change education was a topic in their curricula. Zikhali *et al.,* (2020), state that participants with postgraduate qualifications and BTech/degrees were more likely to have been taught climate change as either “full modules” or “as a section” within the module. This gives the implication that there is a strong association between the education levels of agricultural extension officers and their exposure to climate change education.

In my view, this emphasizes the importance of ongoing education and professional development for extension officers to effectively address the challenges posed by climate change in agriculture. Hence, agricultural extension officers holding a diploma qualification exhibit a comparatively lower theoretical understanding of the concept of climate change, indicating a need for additional training. Furthermore, those with a postgraduate qualification were found to be less likely to undergo capacity-building training, such as in-service training, in contrast to their counterparts with a BTech/degree or a diploma qualification, who displayed a higher inclination towards receiving in-service training (Sebeho and Stevens, 2019). Notably, variations in competency levels among extension officers are evident across different education levels. As reported by Zikhali *et al*., (2020), extension officers with a postgraduate qualification were more likely to express a high level of competence in disseminating climate education. The study also highlighted that those with an undergraduate qualification were more prone to perceive their competency levels as either average or below average. This finding aligns with the notion that work experience can serve as a determinant of an extension officer's knowledge and expertise, as suggested by some respondents (Zikhali *et al.,* 2020). This gives the implication that higher education levels, such as postgraduate qualifications, may contribute to a higher perceived level of competence, while work experience is considered a determining factor in an extension officer's overall knowledge and expertise.

In my view, recognizing these variations is essential for designing targeted capacity-building programs that address the specific needs of extension officers with different educational backgrounds. Lastly, to excel as effective facilitators, extension officers should consistently engage in the following practices. Firstly, as highlighted by Maka *et al.,* (2019), extension agents, who serve as key information conduits to farmers, must regularly conduct training sessions aimed at enhancing farmers' awareness of climate change and variability. Secondly, maintaining regular visits to farmers is crucial. During these visits, extension agents should share information on contemporary farming issues, advancements in agricultural technology, climate change and variability, and provide training on innovative agricultural techniques designed to mitigate the impacts of climate change.

There are various climate change adaptation and mitigation strategies, these mitigation strategies aim to address the impacts of climate change and reduce greenhouse gas emissions. According to the Food and Agricultural Organization (2013), the concept of Climate-Smart Agriculture (CSA), has been developed to address the following three critical pillars: food security, adaptation, and mitigation. In my view, regular training sessions enhance farmers' awareness, while consistent visits allow for the sharing of up-to-date information and the provision of training on innovative agricultural techniques. In addition, the direct partnership between the government and extension officers shows that five types of practice climate-smart agriculture are being promoted. These are the promotion of water management and the use of sustainable farming approaches, animal traction in place of tractors, environmentally friendly pest control techniques, mulching, and information communication technology. The direct partnership between the end-user and the government elicited two types of climate-smart agriculture promoted, namely, changing planting dates and the use of fertilizer. Below is the list of types of climate-smart agriculture .

2.3.2.1 Conservation agriculture

According to FOA (2016), conservation agriculture is a farming system that can prevent losses of arable land while regenerating degraded lands. Conservation agriculture is premised on the following principles: permanent soil cover; minimum soil disturbance, and variation of plant/crop species (Ibid.). The promotion of climate-smart agriculture practices through conservation agriculture is significant, especially because of the need to embrace and promote climate-smart agriculture in Limpopo, where vulnerability is high (Joseph and Simelane, 2013). Furthermore, the notion of treating conservation agriculture as a philosophy implies that conservation agriculture should be seen as a culture that should guide Limpopo smallholder farmers' agricultural practices. In other words, the principles of conservation agriculture should engender and permeate their agricultural practices. These places the farmers in a better position to adapt to the effects of climate change by adopting the philosophy and principles of conservation agriculture.

2.3.2.2 Planting of drought-resilient crop varieties

According to Senyolo et al., (2018), drought is a huge challenge to agricultural production and food security in South Africa. In the Capricorn district a study by Mpandeli et al., (2019), confirms that drought is a major challenge to smallholder agricultural activities. Therefore, there is a need to find means of adapting to drought conditions across the country, especially in smallholder farming contexts such as Limpopo. Climate-smart agriculture practices, such as reduced tillage, improved fertilizer use, manure management, and the adoption of diverse and drought-resilient crop varieties, are essential for adaptation, according to Lipper et al. (2014).

In the Sekhukhune municipality, Mpandeli, Nesamvuni, and Maponya (2015) noted that smallholder farmers grow drought-resilient crops like sorghum to mitigate the effects of drought. Senyolo et al. (2018) also found that diversifying to drought-tolerant and early maturing crop varieties is an effective climate-smart agricultural practice in South Africa. In the Limpopo province, common crops farmed by small scale farmers include maize, tomatoes, cabbage, spinach, pumpkins, squash, green beans, and sweet potatoes, which are deemed crucial for local food supply and the economy (FAO, 2022).

However, with increasing drought conditions, adopting more drought-resilient crops is of need. Recommended crops for the region include sorghum (varieties M35-1 and Macia), millet (pearl millet varieties Okashana 1 and Kangara), cowpeas (varieties IT18, Glenda, and Bechuana white), Bambara groundnuts, pigeon peas, cassava (varieties TME 419 and TMS 30572), pearl millet (HHB 67 and Pennisetum glaucum), sweet potatoes, groundnuts (varieties ICGV-SM 08502 and ICGV 91114), and Tepary beans, all known for their high drought tolerance and minimal water requirements (Maponya,2021;CGIAR, 2019; IITA, 2018; Satyavathi *et al*.,2021; Wolf,2018). Adopting these varieties can help farmers in Limpopo manage water scarcity, ensuring sustainable agricultural production and improved food security (World Bank, 2019). In my view Implementing these recommendations can help smallholder farmers in Limpopo better manage drought conditions, ensuring sustainable agricultural production and improved food security.

2.3.2.3 End-user direct partnership

The government (agricultural extension practitioners) and end-users (smallholder farmers) are in a direct partnership and this partnership is anchored on the services offered by the extension practitioners. Below is the list of some end-user direct partnership approaches.

2.3.2.4 Water management

Research by the South African Weather Services Indicator (2008) as well as Mthembu and Zwane (2017) found that the dry weather conditions in Msinga are a major concern for the prevalent rain-fed and commercial agricultural practices in the area. It is therefore notable that the extension practitioners promoted a climate-smart practice of water management in their interactions with end-users. climate-smart agricultural practices such as water harvesting are promoted in the direct partnership that exists between the government and the end-user. The participants emphasized that farmers are encouraged to reuse water and harvest and store water using water tanks.

Promoting this CSA (water management) practice is particularly important, given that Msinga is very prone to drought (Joseph and Hamilton, 2013). Beyond Msinga, the scarcity of water for agricultural activities remains a major threat to food security, poverty, and sustainable development in South Africa (Kahinda and Taigbenu, 2011). Therefore, promoting water management strategies such as water harvesting and recycling could help smallholder farmers during drought events.

2.3.2.4 The use of sustainable farming approaches

Lipper *et al*., (2014) point out that, climate-smart agriculture support efforts at all levels for sustainably using agricultural systems to always achieve food and nutrition security for all people, while integrating necessary adaptation and capturing potential mitigation. The analysis shows that sustainable farming approaches, such as the conversion of weeds or grasses to animal feed are promoted in place of bush burning. The extension practitioners advised the end-user against bush burning because fires bring out too much smoke. So, instead of burning the weeds, they were advised to use them to feed animals. Though this practicing climate-smart agriculture ice may sound simple, however, it is a commendable sustainable agricultural practice.

Carbon dioxide (smoke) as a greenhouse gas contributes enormously to climate change (United Nations Framework Convention on Climate Change, 2007). According to the United States Environmental Protection Agency (2018), carbon dioxide accounted for 81 percent of the greenhouse gases emitted in 2016. As explicitly stated, farmers are discouraged from "burning fires, because sometimes the fire brings out too much smoke". By advising farmers against bush burning, the extension practitioners are encouraging them to adopt sustainable or climate-smart approaches to farming that is not harmful to the environment.

2.3.2.5 The use of animal traction in place of tractors

Animal traction is the use of animals such as bulls, oxen, cows, donkeys, mules, horses, goats, camels, water buffaloes, etc. to assist farmers in carrying out the tasks such as planting, ridging, mowing, ploughing, and transportation of loads. Simalenga and Jongisa (2000), stated that the use of animal traction is an environmentally friendly and appropriate option for smallholder farming communities who cannot afford farming machines like tractors. The participants encourage the use of animal traction in place of tractors or in the case that they do not have tractors.

One can infer that animal traction is promoted in line with climate-smart agriculture. As highlighted in the excerpt above, they are also promoting that climate-smart thing. Perhaps the participants considered the use of animal traction to be more environmentally sustainable and friendly given that animals do not emit the quantity of carbon dioxide tractors emit. In addition, the use of animal traction can be more economically viable and accessible to smallholder farmers than tractors, even though it maybe be more labour-intensive, particularly in South Africa. As highlighted by Simalenga and Jongisa (2000), access to tractors has remained unaffordable and uneconomical for smallholder farming systems in South Africa.

2.3.2.6 The use of environmentally friendly pest control techniques

Sivakumar (2006), outlined agricultural adaptation to include practices such as adjusting the efficacy in applying inputs such as fertilizers, insecticides, and pesticides. Innovative approaches to pest control are promoted in the partnership between the extension practitioners and the end-users. Evidently, “Farmers are encouraged to use innovative pest control techniques such as mixing ash with water and spraying it to control pests”.

Furthermore, the analysis reveals that farmers are encouraged to use “animal stools" to control pests. The use of stools for pest control serves a double purpose. First, it is used for pest control, and thereafter, the stool is converted to farm manure. Furthermore, these practices are popular homemade pest control solutions amongst smallholder farmers that help them to grow their plants organically. These approaches are more environmentally friendly and hence climate-smart because the approach addresses the problems of pests without harming the environment, unlike chemicals/pesticides which are considered problematic by the participants.

2.3.2.7 The use of mulching

Research by Speranza (2010), found that the practice of mulching improves soil resilience to climate change. In addition, mulching increases soil humus content, improves soil structure and soil organic carbon content, and in turn improves its resilience to climate change (Speranza, 2010). These practices protect the seedlings from the sun from penetrating and drying them, as indicated in the above excerpt. This shows that the practice of mulching is beneficial to farming in several ways.

This approach to climate-smart agriculture approaches has been identified as one of the important sustainable land management practices for adaptation to climate change in countries like the Democratic Republic of Congo (Nwajiuba *et al*., 2015). Mulching can reduce soil temperature and enhance carbon sequestration while increasing the length of the growing season.

2.3.2.8 The use of information communication technology.

Lipper *et al*., (2014), suggested that tools such as radio programs and other forms of information and communication technologies (ICTs) can be used to strengthen the capacities of extension systems to disseminate agricultural context-specific information. Lipper *et al.,* (2014), maintained that, though these systems (ICT) are already in place in most countries and contexts, they should be expanded to include information relevant to climate-smart agriculture practices. In this regard, the extension practitioners encouraged farmers to listen to the radio to listen, to learn about things happening that day regarding weather and farming.

It is significant to note that farmers are encouraged to listen to the radio to get information about the weather and temperature as indicated in the above excerpts. This will enable the farmers to decide if it will be appropriate for planting certain crops for that period. In other words, listening to the radio and getting information on weather conditions will enable the farmers to make informed decisions. Still, on promoting/disseminating ICT, the analysis shows that technologies such as "extension switch online" are promoted in the partnership.

2.3.2.9 Use of fertilizers

According to the report by the International Fertilizer Association (2016), fertilizer usage is estimated to contribute to about 50% of today's food production, hence cannot climate-smart agriculture happen without fertilizers. According to the report, fertilizer help achieves all the triple climate-smart agriculture wins, increasing agricultural productivity; adapting and mitigating agriculture to climate change realities; and achieving global food security (Report of International Fertilizer Association, 2016). The analysis reveals that climate-smart agriculture technology in the form of fertilizers was promoted in the existing partnership between the end-users and the government stakeholder group.

2.3.2.10 Changing planting dates.

Changing planting dates is one of the common climate-smart adaptation practices adopted by farmers in Nigeria, according to a study conducted by Onoja *et al.,* (2019) in Nigeria and Ethiopia. A study, which engaged about 240 farmers from Ethiopia and Nigeria, found that in Nigerian farms, changing planting dates was adopted by 76%, diversification of crops was used by 71%, and planting of high-resistant varieties was adopted by most (82%). This shows that the practice of climate-smart agriculture of changing planting dates is widely adopted by smallholder farmers in sub-Saharan Africa. These finding on practices of climate-smart agriculture being promoted in the direct partnership between government and end-users resonates with the findings of the study conducted by (Nwajiuba *et al.,* 2015).

According to Nwajiuba *et al*., (2015), farmers in Nigeria, Cameroon, and the Democratic Republic of Congo are already implementing climate-smart agriculture practices, even though they do not have a conceptual or theoretical understanding of what means. For example, climate-smart practices such as mulching, change of planting dates, manure fertilization and application, soil conservation, livestock integration, etc. were practiced by the smallholder farmer engaged in the study (Ibid.)

2.4 Factors influencing access to information and technology for climate smart agricultural users.

The effective access of Climate-Smart Strategies by Extension Services encounters numerous barriers that can hinder the successful implementation and adoption of these strategies by farmers. The Tertiary Agricultural Education curricula employed in Africa have historical origins from the colonial era, with the current curricula being rooted in an agricultural philosophy geared towards producing cash crops for consumption by the colonizing countries (Zikhali *et al.,* 2020). This implies that the curricula and training provided to extension officers may not be well-suited to the present environment and socio-economic conditions of African farmers. Consequently, indigenous knowledge systems, rural livelihood practices, and the experiences of the most vulnerable farmers regarding climate change and variability are often disregarded.

Extension officers have reported that their tertiary qualifications provided them with outdated textbook knowledge but failed to equip them with essential skills such as technology proficiency, advisory capabilities, and service delivery expertise needed for effective interaction with farmers (Zikhali, 2016).This situation aligns with the findings of Orusha *et al.,* (2012), who noted lack of interaction between local farming communities and undergraduate students in agricultural education in Nigeria. This deficiency impedes the development of crucial skills like communication, teamwork, management, and transferable skills, negatively impacting the information dissemination process in the field. Many extension officers enter the field directly after completing their undergraduate qualifications without acquiring the mentioned capacities, thus compromising the effectiveness of agricultural extension advisory services to farmers.

Additionally, Grist (2014) has highlighted lack of long-term institutional plans for addressing climate change in South Africa. Most government-led adoption approaches are focused on short-term outcomes like agricultural production rather than addressing the broader and enduring institutional, economic, and political challenges that hinder holistic and long-term climate adaptation.

In terms of extension services, Ngcoya (2017) emphasizes the prioritization of an agro-ecological approach in the eThekwini Municipality, combining indigenous knowledge and technical expertise to address climate change issues. However, the municipality faces challenges in having an adequate number of agricultural extension advisors knowledgeable in both scientific and indigenous knowledge. Similarly, a study by Fosu-Mensah *et al.,* (2012) revealed that access to agricultural extension services, among other factors, significantly influences adaptation to climate change. In my perspective, addressing these challenges requires reforms in agricultural education curricula, the development of long-term institutional plans for climate change, and improvements in the quality and quantity of extension advisors with expertise in both scientific and indigenous knowledge .

2.5 Summary of literature review

This chapter reviewed previous studies on the knowledge level of extension officers on climate-smart agriculture in the smallholder farming sector. The review included studies conducted worldwide inclusive of Africa and South Africa.

The study further explored the theoretical model of the Theory of Planned Behaviour (TPB) theory and the conceptual framework. The TPB was adopted in this study because it predicts an individual's intention to engage in a behaviour at a specific time and place. It posits that individual behaviour is driven by behaviour intentions, where behaviour intentions are a function of three determinants: an individual's attitude towards behaviour, subjective norms, and perceived behavioural control. Moreover, the study explored the variables of TPB in relation to extension officers ' personal characteristics such as age, education, income, and gender.

These personal characteristics can influence competence of extension officers towards adopting to climate-smart strategies and the rate of which they will deliver extension service to small scale farmers.

The competencies of public extension officers were also clearly outlined, and this gave a clear indication for the need of competent agricultural extension professionals in Limpopo Province and other developing countries. Competency assessment is needed because contexts of climate change have changed since previous studies were conducted. Technologies have advanced, farmers have new needs and problems and workers need new skills to address them. The literature above indicates that, knowledge level of extension officers on climate-smart strategies plays vital towards the smooth transition or dissemination of information through information and communication technologies on conservational agriculture, planting of drought-resilient crop varieties, water management, use of integrated pest management, mulching, information communication technologies, and practice green revolution.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter aims to describe the study area and the process followed in collecting data to evaluate competencies of public extension officers on the use of climate-smart agriculture strategies in smallholder farming in Capricorn District Municipality, Limpopo Province in South Africa. Methods and tools of data collection and analysis used in this study are explained. The chapter is divided into six sub-topics, which are outlined as follows: (3.2) It begins with the discussion of the study's research design; (3.3) Description of the study area; (3.4) Discussion of the sampling procedure and population; (3.5) Method of data collection; (3.6) Analyses of datal; (3.7) Limitation of the study and lastly (3.8) discussion of the ethical consideration of research participants and lastly.

3.2 Study design

A research design plays a crucial role as a structured framework for arranging data collection and analysis, with the objective of consolidating pertinent outcomes in a study (Mathebula, 2015). In this study, a quantitative research method was incorporated. Quantitative research involves the systematic collection of structured and measurable data to achieve statistical analyses and numerical findings related to phenomena. According to Kothari *et al.*, (2016), quantitative research is defined as a systematic inquiry focused on the measurement of quantity. The adoption of a quantitative research design for this study was based on its advantages in enabling a researcher to comprehend "what is" in a phenomenon related to a conceptualized problem.

The purpose of this study was to address the following questions: "What is the socioeconomic profile of extension officers in Limpopo Province, South Africa?", "What is the Knowledge, Attitude, Perception (KAP), and understanding level held by extension agents regarding the use of climate-smart agriculture in the study area?", and "What factors influence access to information and technology for users of climate-smart agriculture?"

To accomplish these objectives, a structured interview technique utilizing a well-structured questionnaire was employed among the selected sample population of crop extension officers in the Capricorn district. Given the size of participant pool and nature of their roles at work, this method of data collection was considered the most appropriate when compared to alternative approaches.

3.3 Study Area

Capricorn District is the provincial cost-effective enlargement hub since it is found in Polokwane, the provincial capital. It covers an area of around 21 700 km^2 and has a population of roughly 1 330 436 people (Stats-SA, 2015). The district is classified as a category C municipality, and it serves as a stopover between Gauteng and the northern portions of Limpopo, as well as between the north-western districts and the Kruger National Park. It serves as a gateway to Botswana, Zimbabwe, and Mozambique and is made up of the four local municipalities listed below: Blouberg, Lepelle-Nkumpi, Molemole and Polokwane are the municipalities of interest in the district (Stats-SA, 2015), as illustrated in Figure 3.1. The area has an internal airport and is connected to Gauteng via one of South Africa's greatest segments of the N1. It is the province's third-largest district economy and is primarily rural. It has a semi-arid climate with rainy and hot summer periods and chilly and dry winter seasons (Cai *et al.,* 2017).

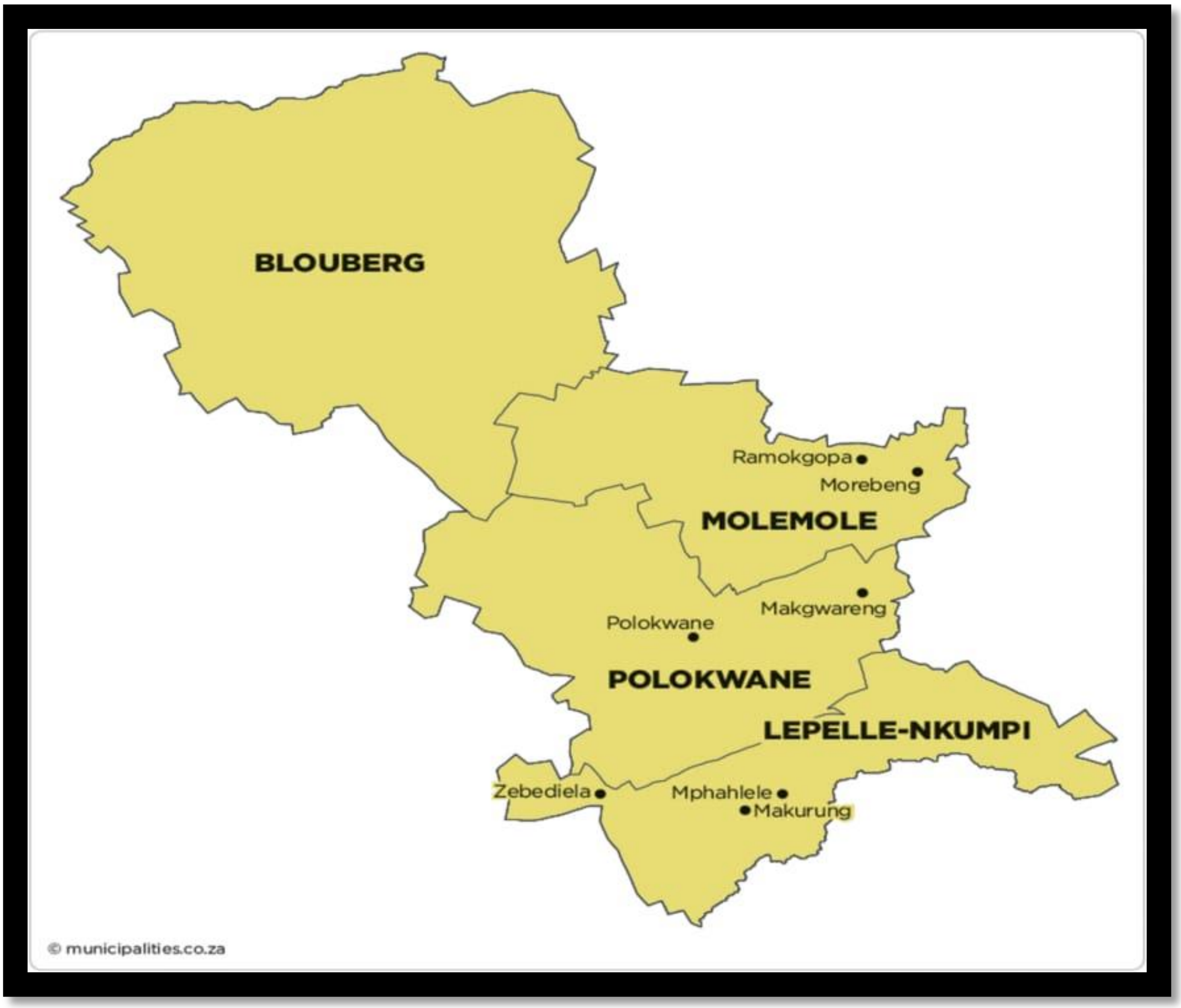

Figure 3.1: Map of study area Source: https://www.municipalities.co.za

3.4 Sampling procedure and population

In the sampling procedure and population selection for this study, the researcher opted for a convenience sampling approach to identify study participants. Convenience sampling is a nonprobability method where participants are chosen based on their availability, accessibility, and willingness to participate (Etikan *et al.,* 2016). This method was deemed appropriate due to specific nature of the extension officers' roles. The entire population of potential participants, consisting of only crop public extension officers in Capricorn District Municipality, was identified through a list obtained from Department of Agriculture, Capricorn district at the outset of data collection.

The collected information revealed the presence of 88 agricultural extension officials in Capricorn district. Despite recommended sample size being 60 extension officers by the Raosoft sample size calculator, practical considerations necessitated a sample size of 71 officers, ultimately leading to the inclusion of 80 extension officers in study.

3.4.1 Sampling size

According to Delice (2010), sample size is defined as the number of representatives chosen or obtained from the study population to partake in research. Capricorn district's Department of Agriculture provided a list of employed extension officers, from which all crop extension officers were selected to participate in the study. The Raosoft sample size calculator, as presented in Table 3.1, was employed to determine sample size. The formulae for calculating Raosoft sample size is displayed below, where the sample size (n) and margin of error (E) are denoted by:

$$X = Z(^{c}/_{100})^{2} r(100-r)$$

$$N = {}^{N\,x}/_{((N-1)\,E^{2}\,+\,x)}$$

$$E = \text{Sqrt}\,[^{(N\,-\,n)x}/_{n(N-1)}]$$

Therefore, based on a population of 80 extension officers, the recommended sample size was 60 extension officers and deemed necessary sample size of 71 officers.

Table 3.1 presents the distribution of crop production extension agents employed in each municipality within the Capricorn district.

Table 3.1: Sample frame

Municipality	**Population size distributed by municipalities**	**Number of extension agents sampled for the study**
Blouberg	15	11
Lepelle-Nkumpi	16	16
Molemole	20	18
Polokwane	29	26
Total	80	71

Source: Survey,2023

3.5 Data Collection

Data collection is the systematic process of gathering, measuring, and analysing accurate information for research purposes using established and validated methods (Marino et al., 2013). In this study, a self-administered questionnaire was employed to gather data from the selected participants. Details of the tool and the process are outlined below. The data collection spanned 15 days and took place in various municipalities.

3.5.1 Data collection tools

Data collection was carried out through the utilization of a self-administered structured questionnaire, which was segmented into three sections corresponding to the study's objectives. According to Roopa and Rani (2012), a structured questionnaire is a document that is made of structured or pre-set questions that enable a researcher to capture respondents' information. Among its merits is the fact that it allows researchers or enumerators to successfully collect large amounts of information in less time without compromising the validity and reliability of information collected. However, this instrument does not point out whether participants are telling the truth about the problem studied, and more labour is required during data caption.

The questionnaire was designed to measure competencies of public extension officers in the use of climate-smart agriculture strategies in smallholder farming for Limpopo Province. Section A of the questionnaire accommodated the socio-economic profile of extension workers in the study area. Section B consisted of questions measuring the extension workers' level of knowledge of climate-smart strategies. This section was developed based on literature reviews and extension workers were asked questions on their level of knowledge and skills acquired on climatic smart strategies using a 5-point Likert type scale. Section C was created to examine factors that influence access to information and technology for climate smart agriculture.

3.5.2 Data collection process

Initial step in data collection process involved the researcher seeking permission from head office of the Department of Agriculture and Rural Development of Limpopo province. This approval process spanned a period of 10 days.

Following approval, the researcher obtained information about sub-zone managers and coordinated data collection dates in alignment with pre-scheduled meetings. The study's intentions were communicated to crop extension officers through their respective coordinators during these meetings. To avoid interference with scheduled meetings, the researcher coordinated data collection times with the respective zones. This further assisted in ensuring availability of selected potential participants. As a result, participants at various zones were available at the set time of data collection expect for those who were on leave. On the day of data collection, available extension officers were briefed about the study, its objectives, and were formally invited to participate. They were provided with information regarding the autonomy to give consent, the right to voluntarily withdraw consent, and other ethical considerations as stipulated by the Turfloop Research Ethics Committee. Participants who agreed to take part in the study signed consent forms and were then included. Questionnaires were distributed by the researcher to the respondents, who were instructed to complete and return them.

3.5.3 Measuring the variables.

Section A: Socio-economic characteristics: Questions based on the socio-economic characteristics of the respondents were asked in this section and the respondents were required to indicate the group they fall into. The variables measured were as follows:

Age: The actual age of the respondents in years as at the last birthday was obtained.
Gender: respondents were asked to indicate whether they were (1) female or (2) male.
Marital status: Respondents were asked to indicate their status out of the following scales (1) Married or (2) Widowed or (3) Never married.

Level of education: Respondents literacy level was measured on the scale of (1) Certificate, (2) Diploma, (3) Degree, (4) Honours, (5) Masters, (6) Doctoral.

Years of experience in extension service: Respondents were asked to indicate how long in years they have been in the extension service.

Section B: Knowledge Level of Extension Agents on climate Smart Agricultural Strategies:

Knowledge, Attitude and Perception (KAP) understanding level held by extension agents towards the use of climate-smart agriculture was tested through a questionnaire with questions relating to the concept of climate smart strategies. Their responses were rated as (1) Fully aware, (2) Aware, (3) Partially aware, (4) Not aware, (5) Fully not aware.

Section C: Factors that influence access to information and technology for climate smart agricultural users.

Respondents were asked to select from the list of significant limitations preventing them from effectively delivering climate-smart agriculture programs to small –scale farmers rated on a 5-point Likert scale of (1) Always, (2) Often, (3) Sometimes, (4) Rarely and (5) Never.

3.5.3 Content validity

Content validity of the questionnaire was ensured through a comprehensive process. The process involved multiple steps to ensure that the questionnaire accurately measured the constructs of interest and was aligned with the study's objectives. The first step was conducting a thorough literature review which was crucial to identify relevant and appropriate questions that covered the breadth of the study's content domain. This step helped establish a solid foundation for the questionnaire's content. The second step was collecting data from 10 extension officers who didn't form part of the actual sample. This step was done so that the questionnaire could be pretested before data collection could resume. The third step was analysing data collected. This was done to check if the questionnaire captured what it was intended for and how much time it took. The fourth step was seeking feedback from experienced supervisors in the field for critical evaluation of the questionnaire's content and alignment with the study's objectives. Their insights helped identify potential gaps for improvement, ensuring that the questionnaire effectively measures what it is intended to. The fifth step was engaging colleagues in a peer review process, this act added another layer of assessment, focusing on the questionnaire's face validity.

The step helped to ensure that the questions were clear, understandable, and easy to follow for the crop extension officers. Lastly, the sixth step involved making corrections and incorporating feedback received throughout the process demonstrating a commitment to refining the questionnaire and enhancing its overall quality of the questionnaire. The number of questions in the questionnaire were reduced and objective three was restructured for better understanding. This iterative approach ensured that the final questionnaire was well-developed and suitable for the study's purpose.

3.6 Data Analysis

The researcher evaluated 85 questionnaires for completeness and assigned identification numbers for subsequent data analysis. Of these, 5 incomplete questionnaires were excluded, leaving 80 fully completed and consent-signed questionnaires for the study. The third objective was rephrased during data analysis to better suit the analysis from “To examine the challenges that extension officers encounter in using climate smart agriculture practices in the study area to identify factors that influence access to information and technology for the climate- smart agricultural users”. Data entry was performed using Statistical Package for Social Sciences (SPSS) version 26.0, and descriptive analysis employed bar graphs, line graphs, and tables based on frequency distribution. Various statistical measures, including variability and relationships between variables, were computed. The socio-economic characteristics of extension officers were analysed using ranking, and factor analysis examined knowledge, attitude, perception, and understanding levels regarding climate-smart agriculture. Additionally, an ordinal regression model was utilized to analyse the factors influencing access to information and technology for climate-smart agricultural users. The collected data was comprehensively summarized through diverse methods of presentation, contributing to a thorough exploration of the research objectives.

3.7 Limitations of the study

Some of the limitations of the study were identified and are indicated below: -

- The study was conducted in Limpopo Province focusing only on Capricorn district. Therefore, findings of the study cannot be inferred to other districts within the province. Capricorn district crop production extension officers cannot be compared to Mopani district crop extension officers or any other extension officers from the other districts as officers may be exposed to different challenges.
- The study only took into consideration crop production extension officers, leaving out animal and soil specialists therefore, this study is only applicable to crop specialists.
- The language barrier posed a challenge, particularly given that the Limpopo Province predominantly speaks Sepedi, while the researcher's native language is SiSwati. Fortunately, most extension officers could respond to the questionnaire without the need for translation. Only a small percentage, specifically 4% of the study population, consisting of individuals aged around 60 and nearing retirement, found certain terms challenging and required translation assistance.
- The questionnaire underwent expert validation without a specific piloting phase. Piloting, which generally involves testing the questionnaire with a small sample, was omitted in this instance due to time constraints.

3.8. Ethical clearance

In adopting a quantitative methodology for data collection, this study involved interactions with a considerable number of individuals, necessitating a strict adherence to ethical practices. To obtain ethical clearance, a research proposal was submitted to the Turfloop Research Ethics Committee (TREC), which was granted given the involvement of human subjects in the study. Additionally, to prevent some issues with the Department of Agriculture and Rural Development during data collection, a letter requesting permission to collect data within Capricorn district was submitted to the Department of Agriculture and Rural Development. Permission to collect data was subsequently granted by the Department. Throughout the evaluation process, the researcher diligently upheld ethical considerations, steering clear of bias or discrimination.

Adhering to ethical research regulations was considered crucial to prevent any harm to the participants. The study conscientiously addressed key ethical principles, including maintaining confidentiality, obtaining informed consent, and ensuring non-maleficence.

3.8.1 Confidentiality

Professionalism was consistently practiced and maintained throughout the study. The confidentiality of all answers was rigorously upheld, ensuring that any responses derived from the collected data remained strictly confidential. This measure was implemented to safeguard the well-being of the study's participants and to prevent any potential harm.

3.8.2 Informed consent

The study took measures to ensure that participants were willing and well-informed about the research being conducted. Throughout the data collection process, the researcher read the consent form to participants. To affirm their involvement, all participants were provided with a consent form to sign. This protocol was implemented to guarantee that every participant in this research willingly and knowingly chose to participate for specific purpose of the research.

3.8.3 Non-maleficence

Given the scholarly nature of the study, no embarrassing questions were posed to the participants. To emphasize this, participants were reminded to refrain from answering any questions would them uncomfortable. This approach aimed to maintain a respectful and considerate environment during data collection process.

CHAPTER 4: RESULTS AND DISCUSSIONS OF THE STUDY

4.1 Introduction

This chapter presents and discusses results of the study emanating from analysis of the data collected. It includes the descriptive statistics and empirical results. It shows how the set objectives were analysed for better understanding of the expected outcomes as weighed against the results.

4.2 The socio – economic characteristics of extension agents in Capricorn District, Limpopo province.

Table 4.1. Socio-economic characteristics

Variables	Categories	Frequencies (N)	Percentages (%)
Age			
	25-30yrs	12	16.9
	31-35yrs	8	11.3
	36-40yrs	12	16.9
	41-45yrs	14	19.7
	46yrs>	25	35.2
Gender			
	Female	39	54.9
	Male	32	45.1
Marital status			
	Married	36	50.7
	Widowed	5	7,0
	Never married	30	42.3
Education level			
	Diploma	5	7.0
	Degree	33	46.5
	Honours	20	28.2
	Masters	11	15.5
	Doctoral	2	2.8

Source: Survey,2023

Table 4.1 above shows an overview of the socio-economic characteristics of extension officers in the Capricorn district. The above table encompasses key details regarding variables such as age, gender, marital status, and educational level among the officers. Analysis of these identified variables was conducted using a ranking methodology.

This approach facilitated a structured examination, allowing for a comparative assessment of the socio-economic characteristics of crop extension officers within Capricorn district.

4.2.1 Age of the extension officers/agents

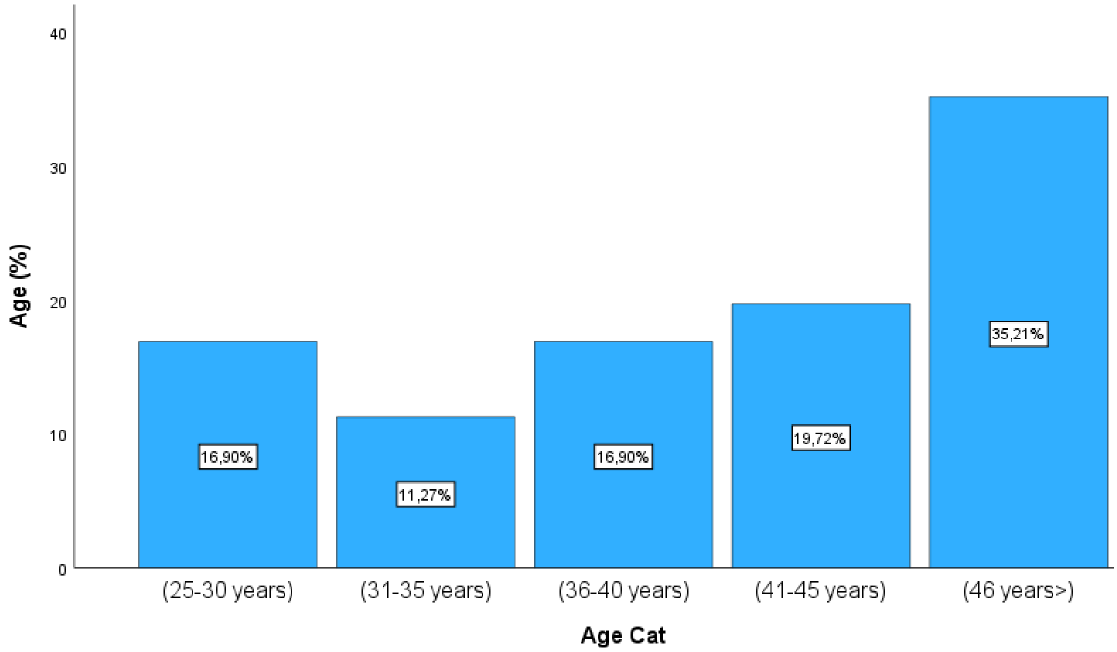

Figure 4.1: Age categories of extension officers/agents

The data from Figure 4.1 illustrates a predominant trend among extension officers in Capricorn district, with a significant proportion being in their late 30s or older. Notably, the largest cohort falls within the (46 and older) years age range, constituting 35.2% of the total. Younger age groups are present but less prevalent, with 16.9% in the (25-30) age bracket and 11.3% in the (31-35) age range. These findings highlight the aging demographic among extension officers, signalling a pressing need for a comprehensive retirement plan within the extension officer workforce. The observed concentration of extension officers nearing retirement age suggests the importance of developing strategies to address succession planning. The data resonances previous studies, such as those conducted by Ngaka and Zwane (2011) and Ndoro (2011), which also highlighted the prevalence of middle-aged extension officers.

Importantly, the current findings emphasize a critical gap in the absence of a structured retirement plan, particularly one that facilitates recruitment of younger extension officers. Introducing a plan to bring in younger professionals is essential for injecting fresh perspectives and ensuring integration of new agricultural technologies. This strategic move aligns with the broader shift toward embracing technological advancements in the agricultural sector.

4.2.2 Gender of the extension officers/agents.

Table 4.1 indicates a positive shift towards a near-equal gender balance within the extension service of Capricorn District. The data shows that slightly more female officers (54.9%) are now present compared to male officers (45.1%). This balance is seen as a positive development for inclusivity and representation within the service. The change from previous findings, as highlighted by Zwane *et al*. (2018), is noteworthy. The earlier study suggested a different scenario, indicating a higher presence of male extension officers in Capricorn District and other districts in Limpopo Province. The current near-equal gender distribution represents a significant improvement and suggests a positive trend towards gender inclusivity in the extension service. This diversity can lead to a more nuanced understanding of the complexities of agricultural practices and challenges faced by farmers, ultimately contributing to more effective and comprehensive extension services.

4.2.3 Martial status of the extension officers/agents.

The data from Table 4.1 reveals that most extension officers in the study are married (50.7%), this showcases the importance of considering marital status in their work and well-being. Marriage, as Al-Islam.org (2019) suggests, promotes mental and physical health, which is vital for extension work. Additionally, a noteworthy proportion of respondents have never been married (42.3%), while a smaller percentage are widowed (7.0%). This underscores the significance of acknowledging the diverse marital statuses among extension officers. Culturally and traditional show importance of marriage in the studied population, suggesting that being married may contribute to garnering respect and acceptance among extension workers in the communities. Drawing from a study in Southwestern Nigeria by Olorunfemi (2019), the notion is supported that married extension officers are viewed as responsible due to their familial responsibilities.

This aligns with the findings of Kolawole and Oladele (2013), who asserted that married extension agents tend to be more committed and trustworthy in assuming positions of responsibility. The marital status of extension officers appears to be a crucial factor influencing their health, cultural acceptance, and perceived dedication to their roles.

4.2.4 Education level of the extension officers/agents.

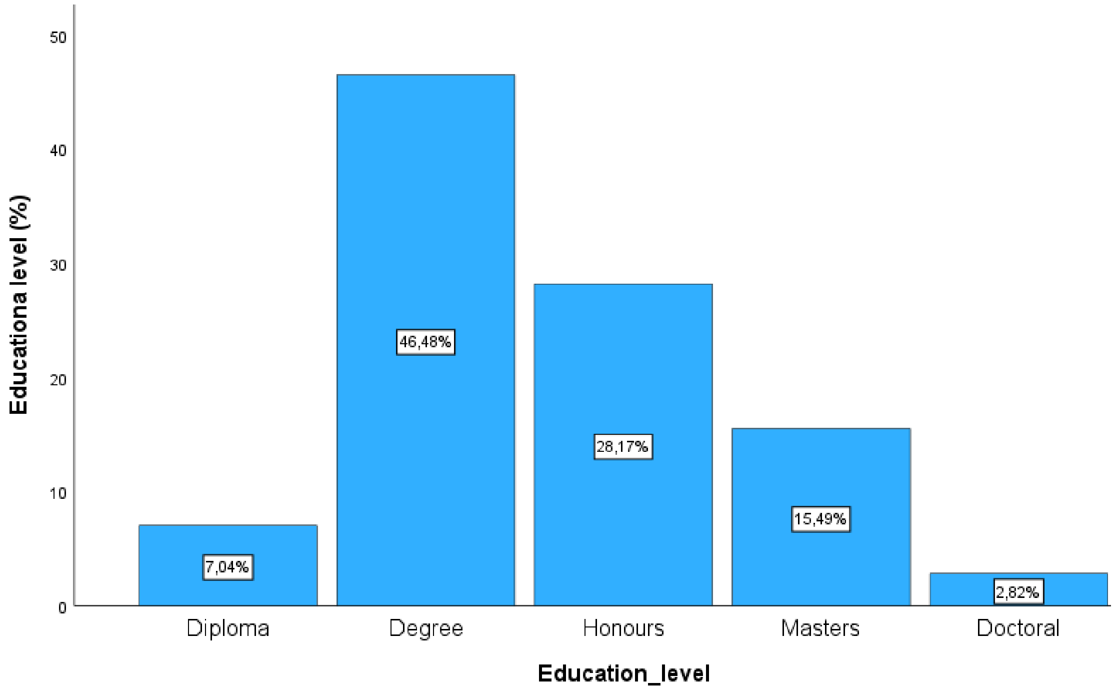

Figure 4.2: Education level of extension officers/agents

The bar graph depicted in Figure 4.2 illustrates a varied spectrum of educational levels among the extension officers. The largest group comprises individuals with degrees (46.5%), followed by those with honours degrees (28.2%) and diplomas (7.0%). Additionally, some officers hold master's degrees (15.5%), and a smaller percentage possess doctoral degrees (2.8%). When combined, 80.2% of the officers have at least a degree, indicating perceived importance of education for effective extension work. The inclusion of diplomas, degrees, honours degrees, master's, and doctoral qualifications also signifies a diverse range of expertise and specialization within Capricorn district. These findings are positive, particularly considering that most extension officers are degree holders, as emphasized by Rana *et al.,* (2018) the minimum educational qualification for agricultural extension officers is a degree.

The results suggests that most respondents are likely well-versed in climate-smart strategies and possess a solid understanding of the fundamental concepts of professionalization.

Table 4.2. Economic characteristics

Variables	Categories	Frequencies (N)	Percentages (%)
Working experience			
	1-5	17	23.9
	6-10	12	16.9
	11-15	20	28.2
	16-20	9	12.7
	21>	13	18.3
Specialization			
	Animal		
	Plant	71	100
	Training		
	Other		
Rank			
	Junior	50	70.4
	Senior	21	29.6
Number of wards			
	1-4	52	73.2
	5-9	11	15.5
	10>	18	11.3
Farming			
	YES	24	33.8
	NO	47	66.2

Source: Survey,2023

Table 4.2 presents a comprehensive snapshot of the economic characteristics of crop extension officers within Capricorn District. The table encompasses a range of factors such as working experience, specialization, rank, the number of wards assigned, and the involvement of extension officers in farming activities. Analysis of economic variables was conducted using a ranking methodology. This approach provided a structured assessment, allowing for a comparative evaluation of the identified economic aspects among crop extension officers in the district.

4.2.5 Economic characteristics of the extension officers/agents.

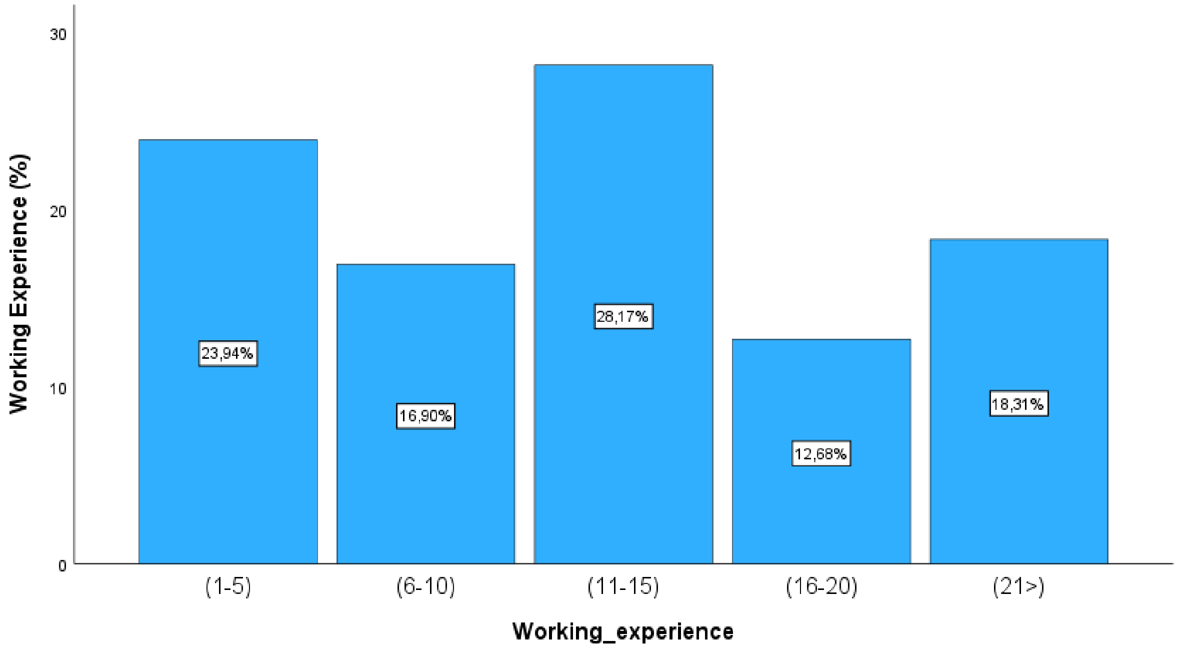

Figure 4.3: Working experience of the extension officers in years

4.2.5 Working experience of the extension officers/agents.

Figure 4.3 illustrates the diverse experience levels of extension officers in Capricorn District. The data underscores a substantial presence of individuals with 11-15 years of working experience (28.2%), indicating a considerable number of professionals with a moderate level of expertise. Additionally, the 1-5 years category constitutes 23.9%, indicating a noteworthy representation of individuals in the early stages of their careers. The distribution is relatively balanced among those with 6-10 years (16.9%) and those with 21 or more years (18.3%) of experience, with the smallest group being individuals with 16-20 years of experience (12.7%). This diversity suggests a workforce that encompasses both junior professionals and seasoned individuals. The presence of varying experience levels within the team creates opportunities for knowledge sharing and mentorship. More experienced officers have the potential to impart their expertise to those with less experience, facilitating skills development and knowledge continuity. This collaborative environment is beneficial for professional growth, aligning with the notion that exposure to diverse perspectives enhances learning and contributes to overall development.

The study's findings align with the perspective presented by Mtega *et al*. (2014), who proposed that individuals engaged in the creation of new agricultural knowledge and innovations or the communication of such knowledge for an extended period tend to be more informed than those with fewer years in service. This correlation suggests that individuals with more years of experience are likely to have accumulated valuable insights and developed networks that contribute to their proficiency in generating and disseminating knowledge over time. The study's results reinforce the idea that prolonged professional engagement can enhance one's expertise and effectiveness in the creation and communication of agricultural knowledge.

4.2.6 Specialization and ranking of the extension officers/agents.

Table 4.2 presents data indicating that all 71 officers (100%) specialize in plant extension. This is a positive aspect for the study, which aimed to evaluate the competencies of crop/plant public extension officers. The results give the implication that officers can cultivate in-depth knowledge and skills in plant-related extension work, potentially leading to more effective interventions and increased yields. Furthermore, the table reveals that majority (70.4%) of extension officers are at the Junior level, with 29.6% holding Senior positions. The distribution implies a substantial presence of Junior officers in the district, possibly due to a significant influx of new personnel or recent promotions, indicating a healthy career progression trajectory. The study's observation of a considerable number of junior officials aligns with Zikhali's (2016) perspective, emphasizing that while senior extension officers possess experience, but junior officers exhibit greater familiarity with new innovations. This suggests a positive trend towards a dynamic and innovative extension service in Capricorn district.

4.2.7 Number of wards covered by the extension officers/agents.

The data from Table 4.2 indicates that a significant majority of respondents (73.2%) are responsible for managing 1-4 wards, suggesting a well-distributed workload across the extension service. A smaller portion (15.5%) oversees 5-9 wards, while a few extension officers (11.3%) manage 10 or more wards. This implies that most extension officers have a manageable workload, and responsibilities are evenly spread within the extension service.

The presence of officers managing 5-9 and 10 or more wards may signify variations in complexity, possibly due to larger areas with more resources needed or regions with greater challenges. This highlights a potential challenge in covering communities efficiently, indicating a wide gap between the number of communities and available extension agents. This situation may hinder the effective dissemination of climate-smart agricultural initiatives and other rural advisory services, aligning with Lukhalo and Zwane's (2022) observation of a high extension-farmer ratio in South Africa, emphasizing the need for the employment of more junior and senior extension officers.

4.2.8 Farming extension officers/agents.

Table 4.2 reveals that approximately one-third of extension officers are actively involved in farming (33.8%), while the remaining two-thirds are not (66.2%). According to Kresna and Hanifa (2023), extension officers engaged in farming are likely to possess a deeper understanding of the challenges faced by farmers in their region. This firsthand experience can enhance the practicality and relevance of their advice and guidance. Furthermore, this suggests that sharing a common ground with farmers through personal farming experience can foster trust and rapport between extension officers and the communities they serve. This improved relationship can, in turn, facilitate better communication and knowledge exchange.

4.3 The Knowledge, Attitude, Perception (KAP) and understanding towards the use of Climate-Smart Agriculture.

Table 4.3: Knowledge, Attitude, Perception (KAP) and understanding level held by extension agents towards the use of climate-smart agriculture.

Items	Indicators	Component				
		Understanding	Knowledge	Attitude	Perception	Uniqueness
1	Introduction of other cultivars	0.792				0.323
2	Cover crops	0.780				0.342
3	Crop rotation strategies	0.779				0.365
4	Blanketing initiatives	0.730				0.423
5	Drought resistant crops	0.703				0.429

6	Genetically modified crops	0.641				0.425
7	Land preparation practices	0.585				0.430
8	Conservation of Agricultural Resources Act,1983	0.520				0.648
9	Artificial lakes and water storage	0.478				0.533
10	Irrigation strategies		0.799			0.355
11	Crop diversification		0.756			0.366
12	Forest conservation and protection		0.750			0.259
15	Conducts him/herself			0.744		0.391
16	Fossil burning and crop wastes			0.720		0.440
17	Plant Improvement Act,1976			0.473		0.537
18	Usage of drainage systems			0.467		0.576
19	Carbon sequestration				0.683	0.354
20	Adoption of afforestation				0.622	0.482

Indicators and components

Table 4.3 above shows the four components used to evaluate the competency level of public extension officers regarding the implementation of climate-smart agriculture strategies in smallholder farming within the Capricorn District Municipality, Limpopo Province, South Africa. Twenty competence indicators were selected and subsequently categorized into four components through Principal Component Analysis (PCA). Factor analysis was then applied to assess the strength of the relationships within these components to determine the level of competence of the extension officers. This analytical approach revealed the 20 indicators were grouped based on shared variability in data. The component values represent the strength and direction of the relationship between the observed variables (indicators) and the underlying latent components of the competencies. A factor loading above 0.5 indicates a moderate to strong relationship between the variable and the underlying factor, suggesting that the variable significantly contributes to the factor or component being measured. Factor loadings below 0.5 indicate a weaker relationship, suggesting that while these values are still considered, they contribute less to the factor or component.

The results from the four components serve as a comprehensive framework for understanding the competency levels held by the extension officers. These components are identified as Knowledge, Attitude, Perception (KAP), and Understanding. Each component encapsulates specific aspects related to the extension officers' capabilities in navigating climate-smart agriculture strategies. The division into these components not only simplifies the complex dataset but also provides a nuanced perspective on the officers' competencies, allowing for targeted interventions or enhancements in areas such as factual knowledge, attitudes, perceptions, and overall understanding of climate smart strategies.

4.3.1 Understanding component

Table 4.3 above delineates understanding component, comprising nine (9) out of the total twenty (20) indicators utilized to gauge the comprehensive understanding of extension officers concerning climate-smart agriculture strategies. Table 4.3 reveals important insights into the competence of extension officers regarding climate-smart agriculture strategies. The scores, which range from 0.478 to 0.792, indicate varying levels of proficiency, with higher scores reflecting a more robust understanding. This suggests that many officers in the district possess a strong grasp of climate-smart strategies, which is essential according to Widayati et al., (2021) for effectively promoting and implementing these climate smart agriculture strategies. The uniqueness scores, ranging from 0.323 to 0.648, highlight the diversity in understanding among the officers. Higher uniqueness scores indicate greater variability, suggesting that while some officers have a comprehensive understanding, others may have gaps in their knowledge. This variability can be seen as both a challenge as Antwi-Agyei and Stringer (2021) indicated that, extension officers play a crucial role in disseminating information, providing technical assistance, and promoting sustainable farming practices to farmers and rural communities. On the other hand, it may be seen as opportunity as it points to the need for targeted training and professional development to ensure a more uniform level of understanding across all officers.

4.3.2 Knowledge component

Table 4.3 also offers insights into the knowledge level held by extension agents concerning implementation of climate-smart agriculture in the study. The knowledge component comprises three (3) indicators selected from the original twenty (20) indicators, indicating a high level of expertise among extension officers regarding climate change and climate-smart strategies. The knowledge component in Table 4.3 indicates the extension officers' expertise and competence regarding climate-smart agriculture, with scores ranging from 0.478 to 0.792, reflecting a high level of proficiency in climate change and climate-smart strategies among the officers. According to Suvedi et al. (2018), a high proficiency is crucial for effective communication, training, and support for farmers. The uniqueness scores within the knowledge component, ranging from 0.323 to 0.533, show a moderate degree of variability in the officers' knowledge levels. This variability suggests that while most officers have a solid understanding, while some may lack depth in their knowledge. According to Glewwe and Muralidharan (2016), targeted training and professional development can address these knowledge gaps, ensuring all officers achieve uniformly high expertise. Olorunfemi et al. (2020) indicated that, officers' competence is characterized by both high expertise and a consistent understanding of climate-smart strategies, making them well-equipped to foster resilient agricultural systems. The consistently high knowledge scores, alongside the understanding component's uniqueness scores, emphasize that extension officers have a robust and consistent high-level knowledge base regarding climate change and climate-smart agriculture, which is vital for their competence in promoting and implementing climate-smart practices.

4.3.3 Attitude component

Table 4.3 presents a comprehensive overview of the attitude component assessed among extension officers, utilizing a total of twenty (20) indicators. Among these indicators, four (4) were identified as particularly influential in determining the attitude competency of extension officers in adopting climate-smart agriculture strategies. The analysis of the attitude component in Table 4.3 indicates a generally positive attitude among extension officers towards climate-smart agriculture strategies, with scores ranging from 0.467 to 0.744. According to Nwaogu et al., (2018), a positive attitude among extension officers is crucial for the successful implementation and advocacy of climate smart strategies. However, the uniqueness scores, ranging from 0.391 to 0.576, reflect variability in attitudes, suggesting that while many officers are favourable, there are differences in the strength and nature of their attitudes. Addressing these differences through tailored training and motivational strategies is essential to foster a uniformly positive attitude (Glewwe & Muralidharan, 2016). The findings suggest that extension officers are generally supportive and prepared to promote climate-smart agriculture, but ongoing support and targeted initiatives are needed to ensure all officers develop a strong continuous and positive attitude. According to Kangogo et al., (2021), the readiness and acceptance of extension officers is vital for the successful adoption of climate-smart strategies, contributing to more resilient and sustainable agricultural systems.

4.3.4 Perception component

Table 4.3 culminates by presenting the perception component, comprising two (2) indicators selected from the total of twenty (20) indicators used to gauge extension officers' perceptions of climate-smart agriculture. The analysis of the perception component in Table 3.1 highlights several key aspects of the competence of extension officers. The generally high perception scores, ranging from 0.622 to 0.683, indicate a favourable view of climate-smart agriculture concepts among the officers, which is crucial for their competence as it suggests strong support for these practices. The variability in uniqueness scores, ranging from 0.354 to 0.482, reflects diverse levels of perception, implying a range of perspectives that can contribute to more adaptable and comprehensive strategies. This diversity, coupled with the generally positive perception, indicates both consistency and variability among the officers, enriching the implementation process. The positive perception signifies a favourable mindset towards adopting and promoting climate-smart agricultural practices, enhancing the officers' effectiveness in their roles. Therefore, the perception component underscores that extension officers are not only knowledgeable but also positively inclined towards innovative agricultural practices, bolstering their overall competence.

Table 4.4 presents the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy, evaluating the appropriateness of the dataset concerning the knowledge, attitude, perception, and understanding levels held by extension agents regarding adoption of climate-smart agriculture.

Factors	**MSA**
Overall	0.696
Adoption of afforestation	0.646
Land preparation practices	0.671
Drought resistant crops	0.795
Conservation of Agricultural Resources Act,1983	0.751
Plant Improvement Act,1976	0.757
Usage of drainage systems	0.696
Forest conservation and protection	0.613
Religious belief and norms	0.522
Artificial lakes and water storage	0.750
Introduction of other cultivars	0.865
Crop rotation strategies	0.747
Blanketing initiatives	0.600
Irrigation strategies	0.623
Early crop processing	0.733
Carbon sequestration.	0.475
Genetically modified crops	0.772
Cover crops	0.772
Crop diversification	0.652
Conducts him/herself	0.508
Fossil burning and crop wastes	0.476

Source: Survey,2023

Table 4.4 employs the Kaiser-Meyer-Olkin (KMO) measure, employing varimax rotation, to assess the sampling adequacy for conducting factor analysis. This analysis is conducted in the context of examining the competency of the extension officers regarding climate-smart agriculture through the four components (knowledge, attitude, perception, and understanding levels). The KMO measure gauges how well the data aligns with the requirements for factor analysis, where higher values signify greater suitability. The overall KMO measure reported in Table 4.4 is 0.696, which is considered good, indicating that the dataset is well-suited for factor analysis. To further evaluate individual variables within the dataset, KMO values ranging from 0.475 to 0.865 were obtained. According to Shrestha (2021), a KMO measure of 0.5 or higher is deemed acceptable, while a measure below 0.5 is considered unacceptable. Collectively, the assessment of KMO values confirms the dataset's suitability for factor analysis, indicating an adequate level of correlation among the competency variables. This robust sampling adequacy enhances the dataset's reliability, supporting its use in exploring extension officers' knowledge, attitude, perception, and understanding towards climate-smart strategies.

4.4 Factors that influence access to information and technology for the climate- smart agricultural users.

Table 4.5 Model fit measures for information and technology for the climate smart agricultural users.

Model Fit Measures

						Overall Model Test		
Model	**Deviance**	**AIC**	R^2_{McF}	R^2_{CS}	R^2_N	χ^2	**df**	**P**
1	142	164	0.197	0.0933	0.238	34.8	7	< .001

Note. The dependent variable 'Information and technology' has the following order: 1 | 2 | 3 | 4 | 5

Extension officers were tasked with identifying factors influencing access to information and technology for users of climate-smart agriculture. An ordinal regression model was employed to analyse the identified determinants of climate-smart strategies users The model fit measures, as presented in Table 4.5, were utilized to evaluate the extent to which statistical model aligns with the observed data. These measures were employed to assess the suitability and effectiveness of the model in explaining the variability present in the dependent variable. The findings reported in Table 4.5 suggest a favourable fit for the model, supported by several key indicators. The relatively low deviance value of 142 indicates a robust fit, signifying a close match between the model's predictions and the actual data. Additionally, the comparatively low AIC value of 164 reflects the model's goodness of fit, achieving a balance between accuracy and complexity.

McFadden's R-squared is a pseudo-R-squared that indicates the proportion of the total variance explained by the model. Higher values (closer or above 0.1) suggest a better fit, the R^2_{McF}, measuring at (0.197), falls within the moderate range, indicating a satisfactory fit in explaining the variability in the dependent variable. Similarly, to McFadden's R-squared the Cox and Snell R-squared (R^2_{CS}), it is another pseudo-R-squared measure. Higher values (closer or above 0.1) indicate a better fit, the R^2_{CS}, is at (0.0933) and in the moderate range, signifying a reasonable fit of the model. Nagelkerke R-squared (R^2_N) is another modification of McFadden's R-squared, aiming to improve its behaviour in the presence of small sample sizes. Higher values (closer to 0.1 or above) suggest better fit, the R^2_N, is reaching (0.238) and falling within the moderate to high range, providing additional support for the model's effectiveness in elucidating variability. A significant chi-square test (p-value < 0.05) suggests that the model significantly improves the fit compared to a null model. The χ^2 test, examining the null hypothesis of no relationship between independent and dependent variables, yielded an exceptionally low p-value ($< .001$). This outcome indicates a robust and significant relationship between these variables. In summary, the collective evidence from Table 4.8 suggests that the model demonstrates a commendable fit for the data. The moderate to high values of deviance, AIC, R^2_{McF}, R^2_{CS}, and R^2_N, along with the very low p-value for the χ^2 test, collectively suggest that the model adeptly captures a substantial portion of the variance in the dependent variable.

Table 4.6: Model coefficients of the factors influencing access to information and technology for climate smart agricultural users.

Model Coefficients – Information and technology

		95% Confidence Interval					
Predictor	**Estimate**	**Lower**	**Upper**	**SE**	**Z**	**P**	**Odds ratio**
Poor linkages	-0.185	-0.713	0.331	0.265	-0.700	0.484	0.831
Modern technologies.	0.281	-0.312	0.885	0.303	0.928	0.353	1.324
Coping and adaptation strategies.	0.875	0.216	1.579	0.345	2.536	0.011	2.398
Acquisition of knowledge	0.450	-0.069	0.992	0.268	1.676	0.094	1.568
Inadequate network coverage	0.205	-0.277	0.701	0.247	0.827	0.408	1.227
Computer and ICT skills.	0.567	0.121	1.051	0.235	2.411	0.016	1.763
Organizational support	-0.065	-0.629	0.495	0.285	-0.227	0.820	0.937

The coefficients presented in Table 4.6 provide valuable insights into how different predictors influence the dependent variable concerning information and technology in the realm of climate-smart agriculture. These coefficients, stemming from an ordinal regression model, signify the weights assigned to each predictor variable. In the context of ordinal regression, these coefficients reveal the strength and direction of the relationship between each predictor variable and the ordered categorical dependent variable. They illuminate the impact and directionality of these predictors in shaping the outcomes associated with information and technology use in the domain of climate-smart agriculture. The results in figure 4.6 highlighted influential predictors affecting access to information and technology, with coping and adaptation strategies and computer/ICT skills demonstrating significant positive impacts. The varying significance levels of other predictors emphasize the nuanced nature of their influence. An estimate closer to (0.5 or above) with a 95% confidence is considered significant. The following are influential predators and their outcomes.

4.6.1 Poor Linkages:

The estimate of -0.185, with a 95% Confidence Interval (CI) of [-0.7134, 0.331], suggests that extension officers perceiving poor linkages may have a negative impact on information and technology access. However, the wide confidence interval, including zero, indicates potential non-significance.

4.6.2 Modern Technologies:

With an estimate of 0.281 and a 95% CI of [-0.3121, 0.885], extension officers with access to modern technologies exhibit a positive impact on information and technology access. The wide confidence interval introduces uncertainty about the significance of this effect.

4.6.3 Coping and Adaptation Strategies:

An estimate of 0.875, along with a 95% CI of [0.2159, 1.579], indicates that extension officers utilizing coping and adaptation strategies significantly positively influence information and technology access. The low p-value (0.011) confirms statistical significance.

4.6.4 Acquisition of Knowledge:

With an estimate of 0.450 and a 95% CI of [-0.0685, 0.992], extension officers focusing on knowledge acquisition tend to positively influence information and technology access. However, the effect's statistical significance is unclear as the confidence interval includes zero.

4.6.5 Inadequate Network Coverage:

An estimate of 0.205, with a 95% CI of [-0.2766, 0.701], suggests that extension officers facing inadequate network coverage may have a positive but statistically non-significant impact on information and technology access.

4.6.6 Computer and ICT Skills:

The estimate of 0.567, along with a 95% CI of [0.1213, 1.051], indicates that extension officers possessing computer and ICT skills have a positive and statistically significant impact on information and technology access.

4.6.7 Organizational Support:

An estimate of -0.065, with a 95% CI of [-0.6292, 0.495], suggests that extension officers perceiving organizational support do not significantly influence information and technology access, as the confidence interval includes zero.

Table 4.7: Reliability Analysis of the factors influencing access to information and technology for climate smart agricultural users

Scale Reliability Statistics

	Mean	Cronbach's α
Scale	2.67	0.828

Table 4.10 displays Scale Reliability Statistics, presenting both the mean and Cronbach's α (alpha) coefficient for a specific scale. The Scale reliability statistics was used to assess the consistency and reliability of a scale. The scale had a range of 1 to 5, hence a mean of (2.5 and above) suggests that, on average, respondents provided responses closer to the higher end of the scale. The mean value for the scale is 2.67, representing the average score across all items. This mean suggests that, on average, respondents tended to score slightly towards the higher end of the scale. The centrality of the mean indicates a tendency for respondents' perceptions or attitudes, as measured by the scale, to cluster around this average score. The Cronbach's α coefficient is calculated as 0.828. Cronbach's alpha serves as a metric for internal consistency or reliability within a scale. In this case, the alpha coefficient of 0.828 is considered indicative of a good level of internal consistency. This implies that the items within the scale are closely interrelated and effectively measure the same underlying construct. Generally, a Cronbach's alpha of 0.7 or higher is deemed acceptable, with 0.8 or higher considered particularly good.

The reliability statistics in Table 4.10 suggest that the scale is a dependable measure of the intended construct. The high Cronbach's alpha underscores the consistency among the items, and the mean score indicates a prevailing trend towards higher values among respondents. However, it's important to note that Cronbach's alpha could not be calculated for this scale. Several factors might contribute to this limitation, such as having too few items on the scale or the items not effectively measuring the same underlying construct. Consequently, further research is warranted to ascertain the reliability of the scale in measuring the intended construct.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives the summary, conclusion, and recommendations of the study. The recommendations discussed are suitable to enhance competencies of public extension officers in the use of climate-smart agriculture strategies in smallholder farming of Limpopo Province, South Africa.

5.2 Summary

In summary, this study employed a quantitative research method to systematically collect structured and measurable data, aiming for statistical analyses and numerical findings. The aim of this study was to evaluate competencies of public extension officers in the use of climate-smart agriculture strategies by smallholder farmers of Limpopo Province, South Africa. Key questions that guided the research design, focused on the socio-economic profile of extension officers, their knowledge, attitude, perception, and understanding of climate-smart agriculture as well as factors influencing access to information and technology. The study area, Capricorn District, was described, emphasizing its economic significance, population, and geographic features. Sampling procedure utilized a convenience sampling approach, chosen due to the specific nature of extension officers' roles. The entire population of crop public extension officers in Capricorn District was identified, and Raosoft sample size calculator was employed to determine an appropriate sample size. While the list showed 88 agricultural extension officials in the district, the study included 80 extension officers, surpassing initially recommended sample size of 60 due to practical considerations, ensuring a comprehensive representation of the target population.

Analysis of the socio-economic characteristics of crop extension officers in Capricorn District, Limpopo province, has provided valuable insights into various factors that shape their roles and contributions. The study covered aspects such as age, gender, marital status, educational level, working experience, specialization, rank, the number of wards covered, and farming involvement. The findings highlight aging demographic among extension officers, positive shift towards gender inclusivity, and the importance of considering marital status in their well-being and community acceptance.

The study further focused on assessing the knowledge, attitude, perception (KAP), and understanding levels among extension agents regarding climate-smart agriculture. The use of factor analysis and Principal Component Analysis (PCA) categorized indicators into four components: Knowledge, Attitude, Perception (KAP), and Understanding. Extension officers demonstrated notable proficiency and a generally positive attitude towards climate-smart agriculture, with high KMO measures supporting the reliability of dataset. Lastly the study investigated factors influencing access to information and technology for users of climate-smart agriculture. The ordinal regression model exhibited a commendable fit, capturing a substantial portion of the variance in the dependent variable. Key findings include the positive impact of coping and adaptation strategies and computer/ICT skills on information and technology access. The reliability analysis indicated good internal consistency in measuring these factors, though certain limitations were acknowledged. Collectively, these findings contribute to a holistic understanding of extension officers' characteristics, their readiness for climate-smart agriculture, and the determinants of access to information and technology. The study's insights lay the groundwork for targeted interventions and policy recommendations aimed at enhancing effectiveness of agricultural extension services in the Capricorn District.

5.3 Conclusion

Extension and advisory services are key to sustainable agriculture, resilient livelihoods, and inclusive growth. In Limpopo and other parts of South Africa as well as other parts of the world, there is need for new training, skills, and attitudes by extension staff to meet demands of the changing sector. The purpose of this research was to answer the following questions: What is the socioeconomic profile of the extension officers in in the Limpopo Province, South Africa? What is the Knowledge, Attitude, Perception (KAP) and understanding level held by extension agents towards the use of climate-smart agriculture in the study? Finally, what are the factors that influence access to information and technology for climate-smart agricultural users?

The study's conclusion concerning the first objective, aimed at identifying the socioeconomic profile of extension officers in Limpopo Province, South Africa, indicated that analysis of the socio-economic characteristics of crop extension officers in the Capricorn district, Limpopo province, which provided valuable insights into the diverse factors influencing their roles and contributions. The detailed examination of age, gender, marital status, and educational level sheds light on the diverse composition of the extension workforce. Additionally, the exploration of economic characteristics such as working experience, specialization, rank, the number of wards assigned, and involvement in farming activities further enriches the understanding of extension officers' professional context.

The data indicates a predominant trend of extension officers in their late 30s or older, emphasizing the need for comprehensive retirement planning within the workforce. The concentration of officers nearing retirement age underscores the importance of addressing succession planning to ensure a smooth transition and infusion of fresh perspectives. The near-equal gender distribution, with slightly more female officers, signifies a positive shift towards gender inclusivity within the extension service. This balance is considered an improvement compared to previous findings, promoting diversity and representation within the agricultural extension sector. Most extension officers are married, emphasizing the potential influence of marital status on their well-being and community acceptance. The inclusion of never married and widowed officers highlights the importance of acknowledging diverse marital statuses and their potential impact on the officers' roles. Most extension officers hold at least a degree, showcasing the perceived importance of education for effective extension work. The diversity in educational qualifications, including diplomas, degrees, honours, master's, and doctoral degrees, indicates a range of expertise and specialization within the extension service. The diverse experience levels among extension officers create opportunities for knowledge sharing and mentorship within the workforce. The presence of individuals with various experience levels contributes to a collaborative environment, fostering professional growth and knowledge continuity. All extension officers specialize in plant extension, highlighting a positive aspect for evaluating the competencies of crop/plant public extension officers. The substantial presence of junior officers indicates a healthy career progression trajectory, aligning with the potential for dynamic and innovative extension services.

A significant majority of extension officers are responsible for managing 1-4 wards, indicating a well-distributed workload. The challenges in covering communities efficiently, especially in regions with more wards, underscore the need for addressing the high extension-farmer ratio and employing more extension officers. The active involvement of approximately one-third of extension officers in farming suggests potential benefits in understanding the challenges faced by farmers and fostering trust and rapport within the communities they serve.

The conclusion regarding the second objective of this study is the Knowledge, Attitude, Perception (KAP) and understanding level held by extension agents towards the use of climate-smart agriculture in the study. The analysis presented in Tables 4.3 and 4.5 provides a comprehensive understanding of knowledge, attitude, perception (KAP), and understanding levels among extension agents regarding climate-smart agriculture in the context of smallholder farming within Capricorn District Municipality, Limpopo Province, South Africa. The use of factor analysis and Principal Component Analysis (PCA) resulted in categorization of 20 indicators into four components: Knowledge, Attitude, Perception (KAP), and Understanding. The understanding component, represented by nine indicators, demonstrated notable proficiency among extension officers, with scores ranging from 0.478 to 0.792. The uniqueness scores indicated variability in understanding levels, contributing to a nuanced evaluation of their preparedness and knowledge base. The knowledge component, consisting of three indicators, reflected a high level of expertise among extension officers, with scores ranging from 0.478 to 0.792. The alignment with the understanding component underscored coherence and consistency in understanding climate-smart strategies. The attitude component, assessed through 20 indicators, indicated a generally positive attitude among extension officers toward adoption of climate-smart agriculture strategies. Scores ranged from 0.467 to 0.744, emphasizing the diversity in attitudes observed. The perception component, comprising two indicators, revealed varying levels of positive perception among extension officers, with scores ranging from 0.622 to 0.683.

Table 4.5 presented the KMO measure of sampling adequacy, evaluating the dataset's suitability for factor analysis. The overall KMO measure of 0.696 was considered good, indicating that dataset is well-suited for factor analysis. Individual variable assessments, with KMO values ranging from 0.475 to 0.865, further supported dataset's appropriateness for factor analysis. The findings collectively suggest that extension officers in Capricorn District possess robust understanding, high-level knowledge, positive attitudes, and generally favourable perceptions towards climate-smart agriculture. The high KMO measure in Table 4.5 reinforces reliability of the dataset, affirming its suitability for exploring extension agents' knowledge, attitude, perception, and understanding regarding climate-smart agriculture.

The conclusion regarding third objective, focused on identifying factors influencing access to information and technology for users of climate-smart agriculture, are derived from insights shared by public extension officers. Ordinal regression model was employed to analyse these determinants demonstrated a commendable fit, as evidenced by various model fit measures presented in Table 4.8. The low deviance and AIC values, along with moderate to high R^2 values and a significant χ^2 test, collectively suggest the model effectively captures a substantial portion of the variance in the dependent variable. Table 4.9 further provided insights into the specific coefficients of predictors influencing information and technology access. Notable findings include the positive and significant impact of coping and adaptation strategies and computer/ICT skills, while other predictors such as poor linkages and organizational support exhibited fewer clear-cut influences. The reliability analysis in Table 4.10 revealed that the scale used to measure factors influencing access to information and technology demonstrated good internal consistency, as indicated by a high Cronbach’s of 0.828. The mean score suggested that, on average, respondents tended to lean towards higher values on the scale. However, it is crucial to acknowledge potential limitations, such as the wide confidence intervals in certain coefficient estimates and the inability to calculate Cronbach's alpha for some scales. These limitations highlight areas for further research and refinement of the study methodology.

5.4 Recommendations

The provided recommendations below are geared towards cultivating a collaborative and supportive atmosphere among extension officers, researchers, educational institutions, and the Department of Agriculture. The overarching goal is to amplify efficiency and longevity of agricultural extension services in Capricorn District. This is particularly relevant in the context of evaluation of competencies of public extension officers concerning the utilization of climate-smart agriculture strategies in smallholder farming within Capricorn District Municipality, Limpopo Province, South Africa.

5.4.1 Recommendations for Extension Officers:

- Extension officers should actively engage in continuous learning opportunities to stay updated on new agricultural technologies and practices, considering pursuing advanced degrees or certifications for professional growth.
- Extension officers are encouraged to actively participate in community outreach programs, integrating personal farming experiences into their services to enhance practical advice and credibility.
- Embracing a culture of innovation is vital; extension officers should actively seek and adopt new technologies and practices, collaborating with researchers and institutions to pilot innovative agricultural projects.
- Extension officers should act as mentors to junior colleagues, actively participating in succession planning programs and advocating for opportunities for younger professionals' professional growth and leadership development.

5.4.2 Recommendations for Researchers:

- Researchers should collaborate closely with extension officers to conduct applied research addressing real-world challenges and ensure findings are shared through accessible platforms.
- Support innovation adoption by providing evidence-based research on the effectiveness of new technologies, working closely with extension officers to bridge the gap between research outcomes and practical implementation.
- Contribute to the development of training programs that enhance capacity of extension officers, providing research-based insights into climate-smart agriculture practices.

5.4.3 Recommendations for Education and Training:

- Educational institutions should update agricultural education curricula to include the latest advancements in climate-smart agriculture, introducing modules that address the needs of extension officers.
- Develop practical training programs that expose students to hands-on experiences in climate-smart agriculture, collaborating with extension services for internships and fieldwork.
- Establish a system for continuous professional development of agricultural graduates entering extension services, ensuring ongoing training and support for staying updated on field developments.

5.4.4 Recommendations for the Department of Agriculture:

- The Department of Agriculture should assess the distribution of extension officers, strategically allocating resources to address high-demand areas and considering recruitment to ensure effective coverage.
- Advocate for policies supporting the integration of climate-smart agriculture practices at local and national levels, collaborating with policymakers to emphasize the importance of sustainable farming methods.
- Establish a robust monitoring and evaluation framework to assess the impact of extension programs, regularly evaluating performance of extension officers based on key indicators and utilizing feedback for continuous improvement.
- The department should facilitate collaboration between extension officers, researchers, educational institutions, and stakeholders, encouraging partnerships that enhance sharing of knowledge, best practices, and innovations in agriculture.

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APPENDIX A: CONSENT FORM AND QUESTIONNAIRE

EVALUATION OF COMPETENCIES OF PUBLIC EXTENSION OFFICERS ON THE USE OF CLIMATE-SMART AG
STRATEGIES BY SMALLHOLDER FARMERS IN CAPRICORN DISTRICT- MUNICIPALITY, LIMPOPO PROVINCE
AFRICA.

QUESTIONNAIRE OF THE STUDY

APPENDIX B: ETHICAL CLEARANCE

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 4713, Fax: (015) 268 2306, Email: moore.hutamo@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE

ETHICS CLEARANCE CERTIFICATE

MEETING: 20 June 2023

PROJECT NUMBER: TREC/346/2023: PG

PROJECT:

Title:	The evaluation of competencies of public extension officers on the use of climate-smart agriculture strategies in smallholder farming in Capricorn District Municipality, Limpopo Province, South Africa.
Researcher:	N Chaza
Supervisor:	Prof. EM Zwane
Co-Supervisor/s:	Mr. EM Letsoalo
School:	Agricultural and Environmental Sciences
Degree:	Master of Agricultural Management (Extension)

PROF D MAPOSA
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **This Ethics Clearance Certificate will be valid for one (1) year, as from the abovementioned date. Application for annual renewal (or annual review) need to be received by TREC one month before lapse of this period.**

ii) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee, together with the Application for Amendment form.**

iii) **PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.**

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APPENDIX C: REQUEST FOR PERMISSION TO CONDUCT A RESEARCH STUDY WITH EXTENSION OFFICERS IN CAPRICORN DISTRICT, LIMPOPO PROVINCE.

University of Limpopo
Centre for Rural Community Empowerment (CRCE)
School of Agriculture and Environmental Studies
Private Bag X1106, Sovenga, 0727, South Africa

TO: Director Agricultural Extension and Advisory Services
Department of Agriculture, Land Reform and Rural Development
Capricorn District.

FROM: Ms. NP Chaza.

Subject: Request for permission to conduct a research study with extension officers at the Capricorn District, Limpopo Province.

Dear Sir/Madam

I am **Nomzamo Pertunia Chaza,** a student at the University of Limpopo presently studying towards a master's degree in Agricultural Extension. I wish to request for your permission to conduct a study within your district. My study is titled **"The Evaluation of Competencies of Public Extension Officers on the use of Climate-Smart Agriculture Strategies in Smallholder Farming in Capricorn District Municipality, Limpopo Province, South Africa"**.

The purpose of the study is to: ....

The research aims to achieve the following objectives.

I. To describe the socio-economic characteristics of the extension agents in the Limpopo Province.

II. To determine the Knowledge, Attitude, Perception (KAP) and understanding level held by extension agents towards the use of climate-smart agriculture in the study.

APPENDIX D: PERMISSION TO CODUCT RESERCH

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
AGRICULTURE AND RURAL DEVELOPMENT

Ref: 12R
Enquiries: Dr T. Raphulu

04 July 2023

Chaza Nomzamo (202105412)
University of Limpopo

RE: APPLICATION TO CARRY OUT RESEARCH UNDER THE DEPARTMENT OF AGRICULTURE & RURAL DEVELOPMENT

1. Kindly take note that your request to conduct research titled "THE EVALUATION OF COMPETENCIES OF PUBLIC EXTENSION OFFICERS ON THE USE OF CLIMATE-SMART AGRICULTURE STRATEGIES IN SMALLHOLDER FARMING IN CAPRICORN DISTRICT MUNICIPALITY, LIMPOPO PROVINCE, SOUTH AFRICA" has been granted. The permission to conduct research in the department is valid from 10th July 2023 to 30th November 2023.

2. The permission entails interviewing Extension Officers in the Capricorn district using a questionnaire.

3. You are required to contact the office of the Director: Agricultural Advisory Services, Capricorn District to brief them on the study, to request up-to-date Extension Officers database, their participation and assistance.

4. Kindly take note that you will be expected to hand over a copy of your final report to the Department for record purposes. You may also be invited to share your findings in the Departmental Research Forum.

5. Hoping that you will find this in order.

Kind regards

Dr. T. Raphulu
Chairperson: Research Committee

04/07/2023
Date

67/69 Biccard Street, POLOKWANE, 0700. Private Bag X9487, Polokwane, 0700

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