SMALLHOLDER CATTLE FARMERS' WILLINGNESS TO ADOPT INDEX-BASED LIVESTOCK INSURANCE IN THE FACE OF CLIMATE CHANGE: EVIDENCE FROM POLOKWANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE

BY

KOENA FRANS MAEKELA

MINI-DISSERTATION

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE

IN

AGRICULTURE

(AGRICULTURAL ECONOMICS)

In the

FACULTY OF SCIENCE AND AGRICULTURE

(School of Agricultural and Environmental Sciences)

at the

UNIVERSITY OF LIMPOPO

Supervisor: Dr MA Nkoana

Co-supervisor: Prof JJ Hlongwane

June, 2022

DECLARATION 1

I Maekela Koena Frans, declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Science in Agriculture (Agricultural Economics) has not previously been submitted by me for a degree at this or any other university; thus, it is my own work in design and execution, and finally all material contained herein has been duly acknowledged.

Signature …… Date 10 June 2022

DECLARATION 2 - PUBLICATIONS

The following publications will form part of the research presented in this mini-thesis.

Publication 1 – Chapter five of this mini-thesis

Koena F Maekela, Mmaphuti A Nkoana and Jan J Hlongwane. Smallholder cattle farmers' willingness to adopt index-based livestock insurance in the face of climate change: Evidence from Polokwane Local Municipality, Limpopo Province. Tropical Animal Health and Production journal is identified for this paper to be published

DEDICATION

This study is dedicated to my family, more especially my parents; Mr MJ Maekela and Mrs MP Maekela in appreciation of all their love, guidance and support.

ACKNOWLEDGEMENTS

First and foremost, I wish to acknowledge the protection, guidance, and wisdom I received from God. I am grateful to have had the opportunity of working under the supervision of Dr MA Nkoana and Prof JJ Hlongwane. I would like to express my sincere gratitude for their valuable suggestions, supervision, and time, words of advice, support and constructive criticisms. I thank you more for your constant patience and guidance throughout the course of this research. No words can measure how thankful I am for your confidence in my capabilities. To the Department of Agriculture, Land Reform and Rural Development (Mankweng service centre), extending my sincere gratitude to the animal health technician Mr PT Motimele for making it possible to access and connect with farmers. I am also thankful to all the farmers who participated in this study, your willingness to cooperate and contribution made it possible for me to do this work.

A special appreciation to Mrs TM Matlala for the immeasurable support and guidance.
The financial assistance from Prof TP Mafeo through the AgriSETA grant money towards this research is hereby acknowledged with gratitude. I would like to take this opportunity to acknowledge Prof MP Senyolo for the advice, and motivational words. Finally, I further convey my sincere thanks and acknowledgements to my classmates, thank you for your company and support.

ABSTRACT

Climate change and variability on a global level is one of the most serious environmental challenges which exacerbates the well-known vulnerability of smallholder farmers. To cushion the shock of climate change, risk management plays a crucial role in farming, and in the same context, insurance positions itself as one of the main risk management instruments available to farmers. However, one of the key reasons to the struggles of smallholder farmers in South Africa is the inability to obtain effective insurance.

To this end, the study identified and profiled the socio-economic features of smallholder cattle farmers, identified smallholder cattle farmers' perceptions on components of climate change as sources of risk to cattle production and finally, analysed the determinants of willingness to adopt IBLI among smallholder cattle farmers. A purposive multistage sampling procedure was used to identify 110 smallholder cattle farmers in the Polokwane local Municipality. IBM SPSS version 26 and STATA version 15 was used to analyse the primary cross-sectional data collected through structured questionnaire interviews.

Farmers' perceptions on components of climate change as sources of risk were identified using the Principal Component Analysis (PCA). The PCA revealed three principal components (PCs) explaining almost 61% of the variance of the original variables (climate change components). Furthermore, about 89% of the sampled farmers were willing to adopt IBLI, while about 11% weren't willing to adopt and the Probit regression model results revealed that marital status, farming experience, access to extension services, off-farm income and land ownership, farmers' educational level, household size, experience of livestock loss and farm size significantly influenced willingness to adopt IBLI.

Based on the findings of this study, the recommended interventions include workshops for raising IBLI awareness, government subsidy on insurance premiums and finally, increased extension service reach to smallholder cattle farmers.

Keywords: Climate change, Smallholder farmers, Index-based insurance

TABLE OF CONTENTS

CHAPTER TWO

LITERATURE REVIEW

CHAPTER THREE

RESEARCH METHODOLOGY

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ARID	Agency for Rangeland Information and Development in Kenya
DAFF	Department of Agriculture, Forestry and Fisheries
CSA	Climate Smart Agriculture
CVM	Contingent Valuation Method
FAO	Food and Agricultural Organization
GAIP	Ghana Agricultural Insurance Pool
IBI	Index-Based Insurance
IBLI	Index-Based Livestock Insurance
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
PCs	Principal Components
PCA	Principal Component Analysis
PLM	Polokwane Local Municipality
UNFCCC	United Nations Framework Convention on Climate Change
WFP	United Nations World Food Programme

CHAPTER ONE

INTRODUCTION

1.1. Background

The livestock farming sector of South Africa is dualistic in nature; this follows the co-existence of a highly commercialised system together with the subsistence-based production system on the other end (Oduniyi *et al*., 2020b). For this country, this sub-sector is by far the largest, contributing about 25% to 30% towards the yearly agricultural output (Maltou & Bahta, 2019). In addition to this, cattle production ranks a major activity within both the smallholder and commercial farming systems (Oduniyi *et al*., 2020b). In rural areas this activity of cattle production is of topmost importance as rural households significantly depend upon agriculture for sustenance of livelihoods. (Fakade, 2016). Similarly, research has evidently indicated that livestock production can be part of the solution to addressing food insecurity and enhance livelihoods in Africa's rural areas (Gwaka & Dubihlela, 2020).

Agricultural production directly depends upon weather patterns and climate change, and following the global change in climate, agriculture is expected to be one of the most affected activities (Gupta *et al*., 2020). Moreover, impressions brought up by climate change upon agriculture are still surrounded by uncertainty. However, notwithstanding the present uncertainty, climate change has become a broadly accepted phenomenon (Karimi *et al*., 2018). Conversely, agricultural production within the sub-Saharan Africa is dominated by the smallholder sector whose farming systems are rain fed and geared towards food security. But then again, climate variability affects these practices adding to other dimensions of crisis in the region such as extreme poverty hence causing uncertainty to climate change resilience of smallholders (Jellason *et al*., 2020).

Climate change and variability on a global level is one of the most serious environmental challenges which exacerbates the well-known vulnerability of smallholder farmers to a wide-range of production constraints. Additionally, this global phenomenon; climate

change, has been noted to have led to the deterioration of agricultural productivity across developing countries with South African production activities being no exception (Mdoda *et al*., 2020). Existing literature notably expresses climate change to be one of the major present challenges in the world (Malhi *et al*., 2021; Linn & Maenhout, 2019). This in turn creates a concern of disruption to agriculturally based livelihoods and prevents the achievement of sustainable development (Karimi *et al*., 2018).

According to Ellis (2017), there are projections of increased global temperatures to the already existing frequent and extreme weather events as an outcome of the changes in climate. Thus, giving rise to the need for development of risk management tools that will allow for poor and vulnerable farmers' adaptation to these changes in climate. Evidence of close correlation between droughts induced by climate change, livelihood and poverty brings forth an increased necessity for rural herd management to be accompanied by financial mechanisms which can yield immediate liquidity to farming households in the event of a disaster (Agency for Rangeland Information and development in Kenya (ARID), 2018).

In the same vein with this backdrop, agricultural insurance serves as one of the many different risk management mechanisms available to farmers across the world's developing countries. Furthermore, this insurance can be delivered to such farmers in different forms, one of which is the weather insurance (Fonta *et al.,* 2018). However, rural households and small-scale systems within low-income countries rarely have access to formal insurance contracts. Additionally, the 'traditional' insurance model has long been viewed as unfeasible in this context owing to challenges associated with high transactions costs, adverse selection and moral hazard (ARID , 2018).

1.2. Key concepts in the study

1.2.1. Climate change

Climate change according to the Intergovernmental Panel on Climate Change (IPCC) refers to the change in the state of the climate that can be identified (e.g., through

statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period, typically decades or longer (Convention on Climate Change (UNFCCC), 2011). This definition is further extended to any change in climate over time, either following natural variability or as a result of human activity. However, the United Nations Framework Convention on Climate Change (UNFCCC) has a different usage of Climate Change to the IPCC, wherein Climate change is referred to as the change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (UNFCCC, 2011).

1.2.2. Smallholder farmers

Smallholder farmers are regarded as the drivers of Africa's numerous economies and are variously defined depending on context and the country one would be looking at (Department of Agriculture, Forestry and Fisheries (DAFF), 2019; Moyo, 2010). Hence in the context of South Africa, Moyo (2010) defines a smallholder farmers as black farmers residing in former homelands, however notes that not all black farmers are smallholders. Generally, the term smallholder is only used to reference their limited resource endowments in relation to other farmers within the sector. Moreover, the term "smallholder" and "small scale" are often used interchangeably (DAFF, 2019). The definition is further corroborated by the Food and Agricultural Organization (FAO) (2012) defining smallholder farmers as small-scale farmers who manage areas that range from less than one hectare to 10 hectares. Finally, Isaga (2018) defines smallholder farmers as farmers producing on relatively small plots of land and are mainly based in rural provinces.

1.2.3. Index-based insurance

Ellis (2017) outlines an index insurance as financial protection against unfavourable conditions linked to weather variability. Tlholoe (2016) defines index-based insurance as a micro-insurance initiative designed to cover potential losses experienced by smallholder farmers as a result of climate variability. For the purpose of this study index-based

insurance will be adopted in the case of cattle as livestock, thus taking on the definition of a micro-insurance initiative whose policy design is intended at protecting smallholder cattle farmers from cattle loss in the face of unfavourable conditions linked to climate change.

1.3. Problem Statement

Climate change is currently one of the environmental challenges in today's world (Linn & Maenhout, 2019). In the same light, Limpopo is a semi-arid province that experiences low and variable rainfall lead to the emergence of drought conditions whose scope of negative effects are to the extent of livestock losses (Maponya & Mpandeli, 2012). Index-Based Livestock Insurance (IBLI) serves as a micro-insurance product which responds to a specific location's forage availability over a set time using satellite tracking to determine a potential indemnity pay-out to policyholders (Ikegami & Sheahan, 2014). Gulseven (2014) outlines that an effective insurance scheme can transfer production risk from farms to financial markets. However, one of the key reasons to the struggles of smallholder farmers in South Africa is the inability to obtain effective insurance as a risk management option against weather extremes which threaten their production (Partridge & Wagner, 2016; Tlholoe, 2016).

A pre-study conducted by the researcher in the Polokwane Local Municipality indicated that smallholder cattle farmers were unable to participate in formal livestock markets owing to poor quality and low numbers of cattle as a result of losses experienced due to lack of forage resulting from rainfall deficits. Hence, insurance proves relevant seeing how climate change's increased frequency and severity of weather extremes imply a threat to the sustainability of cattle farming and livelihoods. However, Oduniyi *et al*. (2020a) confirms the scarcity of literature on willingness to pay for IBLI, particularly in South Africa. Similarly, there is no literature available in the study municipality on IBLI as a means of assisting smallholder cattle farmers in transitioning to climate-resilient agriculture. Therefore, the study intended to provide an analysis of the determinants of smallholder cattle farmers' willingness to adopt index-based livestock insurance as a climate risk adaptation strategy in the Polokwane Local Municipality.

1.4. Rationale

Livestock farming is important in the creation of wealth and improvement in the livelihoods of poor households in rural areas (Ngarava *et al*., 2019; Mafukata, 2015; Ndoro *et al*., 2014).However, climate change risks socioeconomic stability and creates a setback upon efforts of development. As such, adaptation in which insurance can be a key tool is vital to building societal resilience to the impacts of climate change by reducing vulnerability and building both physical and financial resilience (Jarzabkowski *et al*., 2019)**.** However, the challenge in low-income countries is the non-existence or underdevelopment of insurance markets and also, moral hazard and/or adverse selection as problems to farm level insurance products (Tlholoe, 2016). Index-based insurance products' indemnities are based on an index, meaning neither the policyholder nor insurer has better information on potential indemnity value making the product to not be vulnerable to moral hazard and/or adverse selection (Barnett, 2004). In addition to that, a desktop study by Mapfumo (2007) found the Index-based insurance as being potentially feasible to smallholder farmers in South Africa provided there are willing stakeholders of which the smallholder farmers in question form part.

Given the aforementioned, a field survey in the Polokwane Local Municipality which aims to analyse the determinants of smallholder cattle farmers' willingness to adopt Index-Based Livestock Insurance (IBLI) as a climate risk adaptation strategy on their farms proved relevant. This is because the sustainability of the insurance product (IBLI) is rooted in the uptake by the local farmers should it be introduced to the local economy. Additionally, its uptake would thus introduce potential improvements to the existing climate risk strategies available to farmers. In the same vein, the findings and recommendations of the study may contribute to policy around the development of sustainable and climate-resilient smallholder cattle farming systems in the study area.

1.4.1. Aim

The aim of this study was to analyse the determinants of smallholder cattle farmers' willingness to adopt index-based livestock insurance as a climate risk adaptation strategy.

1.4.2. The objectives of this study were to:

i) Profile the socio-economic characteristics of smallholder cattle farmers in the Polokwane Local Municipality
ii) Explore smallholder cattle farmers' perceptions on components of climate change as sources of risk to cattle production
iii) Analyse the determinants of willingness to adopt IBLI among smallholder cattle farmers in the Polokwane Local Municipality

1.4.3. Hypotheses

i) Smallholder cattle farmers do not perceive the components of climate change as sources of risk to cattle production.
ii) Determinant factors do not have a significant influence upon the smallholder cattle farmers' willingness to adopt IBLI in the PLM.

1.5. Organization of the mini-thesis

The organisation of the remaining part of this mini-dissertation follows this order; chapter 2 which follows next, presents a review of the body of existing literature related to the study subject. Chapter 3 provides a presentation of the methodology which is made up of the area where the study was conducted, the sampling and data collection procedures and concludes with the analytical techniques used and tables of hypothesized variables. A description of the surveyed sampled together with the results from the empirical analysis is detailed in discussion under Chapter 4. Finally, the last chapter (Chapter 5) draws conclusions with policy recommendations in line with the findings of the study.

1.6. Summary

This first chapter of the study introduced the research problem, the rationale as well as the main concepts from which the study gains its foundation. The chapter further outlines the aim, specific objectives and finally the hypotheses of the study. The literature and framework supporting this study is presented in the second chapter that follows.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter is keen to providing an in-depth review of local and international literature body that exists on the study subject. The chapter starts by outlining an overview of the state of smallholder agriculture in the context of developing countries amid the challenges imposed by climate change. Followed by an overview of smallholder cattle production in South Africa as a developing country. The chapter goes on to give a review of agricultural insurance and more specifically the index-based livestock insurance product. A review on the relationship of socio-economic characteristics and willingness to pay for agricultural insurance, and drivers or determinants of willingness to adopt/pay for index-based insurance is detailed together with the framework of index-based agricultural insurance as the chapter concludes.

2.2. Cattle production in South Africa

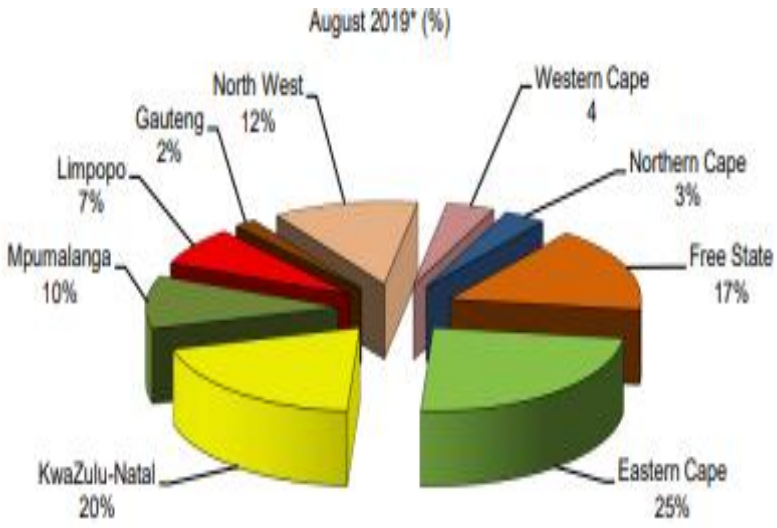

Figure 2.1 Distribution of cattle production by province in South Africa

Source: DAFF, (2019)

Cattle is fairly produced in all provinces of South Africa with the Eastern Cape and KwaZulu-Natal dominating in terms of production level. Additionally, Free State, Northwest and Mpumalanga also have fairly good proportions from 10% in production levels. However, Smallholder farmers in the country (i.e., South Africa) and the sub-Saharan region face cattle production constraints at subsistence and market-oriented levels following a variety of factors, one of which is the risks driven by drought conditions (Mapiye *et al*., 2018).

2.3. Smallholder agriculture amid the changes in climate

According to Ramoroka (2012), it is notable that smallholder farmers fulfill many functions within the agricultural economy, with highlights being around income and employment creation in rural areas. Furthermore, these contributions by the sector towards potentially creating food security have been recognized and reflected within the South African agricultural policy. The agricultural sector is at the core of the majority of livelihood support through its essential role of income generation together with safeguarding the world's food security. However, the sector is considered risky following the many risk issues (i.e., socio-economic and environmental factors that producers have to cope with among which climate change comes out topmost with the potential to cause disturbance to production activities (Ali *et al*., 2020).

The small-scale agricultural sector within most developing countries more especially the Sub-Saharan Africa region is predominantly vulnerable to shocks resulting from climate change. Furthermore, such low-income countries are unfortunately disadvantaged in terms of access to agricultural insurance seeing as formal insurance contracts are rarely available to rural and resource-poor farmers (Okpukpara *et al*., 2021). Climate change brings forth a threat to food security, and thus adapting agriculture to the variable climate could be essential towards ensuring food security and nourishment of a country's rural families (Ali *et al*., 2020).

Literature of recent years has provided substantial evidence of the role of livestock as part of the solution to Africa's household food insecurity while having the potential to enhance rural livelihoods (Gwaka & Dubihlela, 2020). Ali *et al*. (2020) adds to this by outlining how the severe consequences of climate change are not just localized to a certain area or region, but rather observed on a global scale. Moreover, smallholder farmers are likely to be the most hard-hit by the projected elevation in the intensity of climate change looking at their low adaptive capacity which is coupled with livelihoods that are entirely built around climate-sensitive systems (Chingala, 2017). Along with other challenges faced by these farmers, climate change has been observed to be one of the sources from which the fragility of Africa's livestock systems emanates from (Gwaka & Dubihlela, 2020).

2.4. Climate Risk management through agricultural insurance

Many developing countries experience climate-related disasters annually leading to significant loss of lives and infrastructure, making the implementation of risk management strategies vital. This implies approaches aimed at reducing the risk linked to agriculture and enhance food security (Jabbar *et al*., 2020).

2.4.1. Agricultural Insurance: an overview

Agricultural insurance can widely be defined as the stabilization of income, employment, price, and supply of agricultural production through regular and deliberate contribution (i.e., savings and accumulation) of funds in small installments thereby serving as security in bad periods (Kolapo *et al*., 2020). Farmers within developing countries are obliged to adopt traditional measures to handle risk as modern risk-avoidance measures are not readily available in such regions (Khan *et al*., 2013).

Agricultural insurance is aimed at providing cover for financial losses experienced in the event of an unforeseen decline in agricultural production mainly following natural disasters. These policies of agricultural insurance further act as collateral essential for farmers to acquire agricultural loans in the formal finance market (Okpukpara *et al*., 2021).

However, agricultural insurance faces less popularity and has low uptake by a majority of the farmers within countries of low and middle income (Nshakira-Rukundo *et al*., 2021).

Risk management plays a crucial role in farming, and in the same context, insurance positions itself as one of the main risk management instruments farmers can use to cushion themselves against shocks in the face of climate change (Porrini, 2019). Insurance as a risk management method is used to protect against contingent loss and takes upon the definition of being a fair risk transfer mechanism from one entity to another in exchange of a premium to avoid possibly large losses (Okpukpara *et al*., 2021).

2.4.2. An overview of index-based livestock insurance

Index-based insurance as an alternative form of insurance has over the past decade seen interest growth in the research community, governments as well as development organizations. This was in efforts to explore its potential to serve as a form of micro insurance tailored for the needs of poor smallholder farmers and cover potential losses in the event of weather shocks (Amare *et al*., 2019). To this end, this attention being received by IBLI has been linked to its potential to allow farmers adaptation to climate change in a way that could not be achieved through traditional insurance (Oduniyi *et al*., 2020a).

The design of most index insurance products focuses on weather-related shocks due to the primary risk exerted unto low-input cultivators and headers by factors such as exogenous rainfall and temperature levels together with their timing (Jensen & Barrett, 2016). Proponents of index-based insurance claim that the insurance instrument offers numerous advantages over indemnity insurance thus making it a predominantly suitable product for low-income farmers, livestock holders as well as households at a micro insurance level (Carpenter, 2018).

Index insurance is often promoted as a solution to smallholder farmers and livestock owners facing many barriers in accessing formal insurance within developing countries (Jensen & Barret, 2016). This alternative form of insurance is in essence offered to

smallholder farmers within rural settings with no means of accessing commercial insurance; thus, allowing them to better climate change adaption and ultimately inspire rural development (Oduniyi *et al.*, 2020a; Amare *et al.*, 2019).

Attempts to address challenges associated with “traditional’’ insurance instruments several developing countries have adopted the use of weather index insurance. The index insurance instrument pays indemnities according to actual loss of the policyholder with respect to the weather index (i.e., the measure of rainfall or temperature). In spite of the index-based insurance shortfalls, the instrument is relatively transparent and reduces the likelihood of information asymmetry (Tlholoe, 2016). The concept of information asymmetry in the context of economic literature is concerned with adverse selection and moral hazard as aspects of asymmetric information (Castellani & Vigano, 2015).

2.4.3. Africa’s experiences with index-based insurance

Despite the novelty of index-based insurance products, developing countries especially in Africa, have seen the implementation of this relatively new insurance product (Oduniyi *et al*., 2020a). According to Tlholoe (2016), Malawi was the first country in Africa to launch an index-based insurance (IBI) project for smallholder farmers with research and technical assistance of the World Bank. The evolution of weather index insurance has seen a lot of coverage in reports and academic article since the initial introduction of index insurance to Kenya in 2005 also with the technical guidance of the World Bank. Furthermore, the country has piloted several forms of index insurance in recent years (Di Marcantonio, 2016)

According to Runganga & Mumbengegwi (2020), approximately six insurance companies in Zimbabwe have offerings of crop insurance to protect farmers against drought, barn fire, hail among which the weather index insurance positions itself as one of the products designed for small scale farmers. The study further outlines that within a broad classification of categories of agricultural insurance (indemnity based, index-based and crop revenue) in the country, index-based together with indeminity based products are the most issued to farmers.

Ghana, through its premier agricultral insurance service provider; Ghana Agricultural Insurance Pool (GAIP) has targeted smallholder farmers with the crop weather (drought) index insurance using either validated data from waether stations or statilite to determine payouts. Findings from the Ghana Metrological Agency or satilite operator are directly sent to policyholders of the insurance daily, and the insurance operates in six of the countries northern regions and limited in the south. However, farmers' perception of the product has proven to be positive as the weather index insurance has dominated the market (Ankrah *et al*., 2021)

The failure to receive payouts during a crop failure season by premium paying farmers led to the discontinuation of Ethopia's humanitarian emergency index insurance pilot project which was launched by the United Nations World Food Progreamme (WFP) around early 2006.

2.5. The relationship between farmers' socio-economic characteristics and index-based livestock insurance

2.5.1. Farmers' age, gender and marital Status

A study by Isaboke *et al*. (2016) raised an assumption that the expertise obtained through own experience in older farmers may lead to them being more likely to assess and adopt new innovations like the weather index insurance as compared to their younger counterparts. According to Bishu *et al*. (2018) older farmers appear to be more conventional in their attitude to modern practices of agriculture as compared to younger farmers. This argument is supported by the empirical findings of the study, which indicated that the age of farmers negatively and significantly influenced their decision-making on interest in cattle insurance. Tlholoe (2016) also found that the likelihood of buying IBLI was lower in male-headed households as compared to their female counterparts.

Oduniyi *et al*. (2020a) found marital status to have a negative correlation and statistical significance with the willingness of farmers to pay for IBLI. The study further outlined that this unwillingness to pay for IBLI could be linked to their family responsibilities, where the farmers prefer to take care of family with available resources other than investing them on IBLI which they are not familiar with. On the other hand, Aina *et al*. (2018) found marital status to be having a positive correlation and a very significant affect upon the adoption of IBLI at 5% significance level. Additionally, this gave the inference that household heads who are married are more likely to adopt IBLI for risk mitigation.

2.5.2. Education level

Education and information tend to run along together. However, most rural farmers lack both literacy and awareness of new technologies such as insurance. Additionally, Bishu *et al*. (2018) found the variable 'education level of the household head' to be having a positively significant influence on the number of cattle the farmer wanted to insure. Household heads with a higher education level were found to be interested in ensuring more cattle as compared to those with low levels of education or less schooling.

In support of the argument by Bishu *et al*. (2018), Kalapo *et al*. (2020) found education to have a positive and significant influence to the decision of crop farmers to participate in an agricultural insurance scheme, implying that with exposure to higher education levels of farmers' leads to a tendency to participate and obtain and agricultural insurance policy. Additionally, Nshakira-Rukundo *et al*. (2021) indicates that farmers and pastoralists who are more educated portray a higher demand for insurance as compared to the less educated.

In a study to explain the perceptions of smallholders towards weather index micro-insurance alongside risks and coping strategies in Embu County of Kenya, Isaboke *et al*. (2016) postulated that higher educational levels of household heads may contribute to better access to non-farm income and ultimately the ability to participate in weather index insurance. The study further outlined that educated farmers may have a positively enahanced perception towards the product due to their ability to access and understand

its benefits and complexities, likewise, better education may have a negative effect as a result of household heads pursuing other economic activities other than agriculture.

2.5.3. Farming experience

The study of Runganga & Mumbengegwi, (2020) alluded that the likelihood of adopting crop insurance is higher among farmers with more years of farming experience as compared to those with less years in farming. This highlight came in support of the observation of a positively and statistically significant coefficient of experience in the study. Additionally, an investigation by Afroz *et al*. (2017) into Malaysian farmers' willingness to pay for crop insurance to adapt flood risk reported a positively significant (i.e., at 5% level of significance) correlation between farming experience and the willingness to pay. These findings provided evidence of consistency with the results observed by Nnadi *et al*. (2013) who also highlighted that an increase in the number of years in farming increased participation in the Nigerian agircultural insurance scheme. This highlight was in reference to the observation of a positively siginificant relationship between farming experience and willingness to participate in the insurance scheme by the rural cassava farmers of Nigeria.

Several studies did observe a positive relationship between farming experience and willingness to pay or participate in agricultural insurance (Kalapo *et al*., 2020; Abugri, 2017; Ellis, 2017), while others observed a negative relationship (Oduniyi *et al*., 2020a; Bishu *et al*., 2018; Tlholoe, 2016), however in all these studies the relationship was not statistically siginificant.

2.5.4. Household size

Empirical findings of Bishu *et al*. (2018) indicated that the household dependency ratio had a positive and significant influence on farmers' interest in cattle insurance. This implied that households of relatively large size or a large number of dependants, be it children and or the elderly, were more likely to buy cattle insurance as compared to those of smaller size. The study further supported that households of greater dependency ratio

are more vulnerable to socio-economic risks and shock, thus they may consider cattle insurance as a means of risk mitigation. However, Oduniyi *et al*. (2020a) found the opposite of this result and indicates that a household head with the responsibility of taking care of more dependants is not likely to adopt IBLI to insure their cattle, but would rather use the resources towards his responsibility.

2.5.5. Major Sources of Income

Tang *et al*. (2021)'s investigation on Chinese farmers' trade-off between formal insurance products, that is, the weather index-based insurance and savings as an informal risk management method led to the assumption that a higher income can be an indication of higher affordability. This implied that households with a higher net income are more likely to participate in agricultural insurance. However, the study found that off-farm income negatively impacts the demand for agricultural insurance, thus placing an argument citing Jin *et al*. (2016) that instead of purchasing insurance, off-farm activities could be used by a richer farmer to recover from weather-related farm losses. Stojanović *et al*. (2019) highlighted that farm losses which decrease farm income increase the farmer's willingness to buy insurance following the study's empirical findings which found an inverse relationship (negative sign coefficient of farmer's income) between farmer income and the likelihood of willingness to buy yield insurance.

In a study to examine the willingness of Nigerian cocoa farmers to take agricultural insurance, Falola *et al*. (2013), found that farm income had a negatively significant influence on the willingness to take agricultural insurance by the farmers. The study further highlighted that the negative correlation may imply adoption of other modern risk management which may even be more expensive among farmers of high income level.To support these findings, empirical findings of Afroz *et al*. (2017) are also consistent with the negatively siginificant correlation of farm income with the willingness to pay for crop insurance. Tlholoe (2016) also found that farmers whose major income was from non-labour and off-farm sources were more willing to buy IBLI

2.6. Drivers of willingness to adopt index-based insurance

2.6.1. Land ownership

According to Tlholoe (2016), land tenure security serves as the core to every successful rural society. This is corroborated by Jabbar *et al*. (2020) outlining that the farming community's livelihoods solely rely upon agriculture, and this reliance coupled with insecure land rights makes such a community the most vulnerable to natural calamities. Maponya and Mpandeli (2012) outlines that many farmers in the context of less developed countries are subject to insecure ownership of land. Moreover, owning land potentially influences the level of agricultural production thus leading to improvements to farmer livelihoods.

On the other hand, Holden & Ghebru (2016) argue that where user rights to land are stronger or rather secure, that in itself is likely to enhance investment and ultimately bring about land productivity. Furthermore, land can act as collateral for landholders to access credit for investment towards improving the productivity of land and possibly bring about food security. The findings of Maponya and Mpandeli (2012) support these arguments of land ownership security by outlining that the low levels of adaptive capacity, technology, and finance among resource-poor farmers raise concern in Limpopo province and indicate the crucial importance of land ownership for sustainable livelihoods.

In addition, insecure tenure rights affect farmers' productivity as they discourage investment in long term development of such land, unlike with private ownership which grants owners the freedom of will and ability to invest on such land due to the collateral effect that they have on the land (Tlholoe, 2016). Land tenure security is further highlighted as being significant towards the willingness to IBLI as per findings of Tlholoe (2016). The study raised a supporting argument that farmers whose livestock was grazing on communal land had a greater likelihood of buying IBLI following their continuously high and increasing risk exposure.

2.6.2. Institutional credit and extension Services

In the face of climate change, Climate Smart Agriculture (CSA) has been a widely promoted agricultural development paradigm within developing regions like the Southern Africa. In the same light, index insurance is one among the numerous technologies and practices which serve as components of the CSA approach to agriculture (Makate *et al.*, 2019). The study of Makate *et al.* (2019), stressed the importance of simultaneous access to credit and extension, highlighting that the two institutional services allow farmers to access information as well as other needs (e.g., inputs) required for their farming endeavours.

A study by Kalapo *et al*. (2020) found credit and extension contact to be positive and highly significant at 1% and 10% level of significance respectively. Here the study of Kalapo *et al*. (2020) outlined that access to credit facilities by farmers may encourage farmers' participation in agricultural insurance so that in the wake of a risk event, the indemnity from the insurance will assist in repaying back the loan. Furthermore, with continued access to extension services, farmers' participation in agricultural insurance was more likely to be continuously encouraged. Findings of Ellis (2017) revealed that in support of the results of a negatively significant coefficient of variable extension services, farmers with access to extension services are less likely to purchase insurance as they are likely having information on a variety of other risk management strategies.

2.6.3. Climate risk perception and experience of livestock loss

The findings of Amare *et al*. (2019) provide evidence that perceived weather-related risks by livestock farming households show a positive and statistically significant relationship with their adoption of IBLI. Thus, increased farmers' perception of climate-related risks indicated increases in the probability of adopting IBLI as a risk transfer and precautionary measure against livestock death as a result of climate change. In support, Porrini *et al*. (2019) gave conclusions that farmer perspectives of using insurance instruments are linked to experiences such as previous losses. Chingala *et al*. (2017) emphasized the need for in-depth knowledge of the factors that influence farmers' perceptions of climate change. This study indicated that despite the limited information on the influence of socio-

economic factors on that perception, the behavioural response to such perceptions shapes how the farmers adapt and choose climate risk mitigation options. In a bid to identify investigate the factors influencing farmers' willingness to buy index-based insurance, Tlholoe (2016), discovered that experience of loss had a positive and significant influence on farmers' willingness to buy IBLI. This infers that farmers who had experienced livestock loss were more likely to take out an insurance policy (IBLI) than those who had not experienced any loss. On the contrary, Abugri *et al*. (2017) 's findings revealed a negative correlation of experience of damage caused by extreme climate towards participation in drought index insurance. This led to the study;s postulation that the negative correlation could be linked to the fact that even though farms experience risk, the damage caused could have triggered a different remedy/assistance instead of drought index insurance.

2.6.4. Farm size

In an investigation on farmers' willingness to purchase crop insurance within the wheat and raspberry sectors in Serbia, empirical evidence by Stojanović *et al*. (2019) indicated a positive correlation between farm size and willingness to purchase crop insurance. The variable (farm size) had a highly siginificant (i.e. at 1% level of significance) effect on the likelihood of farmers's willingness to purchase yield insurance. This argument is supported by Tlholoe (2016) who highlighted that farmers operating on a larger scale are expected to insure their livestock due to the high degree of loss they stand to experience in the event of drought incidences. Thus, the implication is that, farmers operating larger farms are more likely to experience a relatively larger loss in the even of weather peril and are thus more likely to purchase the yeild insurance. Runganga & Mumbengegwi (2020), drew conclusions that farmers cultivating on larger land are less likely to adopt crop insurance following empirical results which showed a negative coeffient of the variable; farm size. Furthermore, farm size was found to have a statistically significant effect on farmers' willingness to adopt crop insurance.

2.6.5. Awareness of agricultural insurance

According to Kalapo *et al*. (2020) increased awareness which highlights the importance of agricultural insurance to farmers might increase their chances of participation in an agricultural insurance scheme. Argument follows the study's findings which indicated awareness to be positive and statistically significant at a level of 10% significance. These findings were found to be in line with empirical results of Abugril (2017) who suggested that farmer awareness of insurance being highly significant in their results implies that the variable (farmer awareness) positively influence the participation decision in insurance by enhancing probability of participation in the drought index insurance scheme.

Empirical results of Tang *et al*. (2021) also highlighted that agricultural insurance purchase experience had a positively significant correlation with the demand for weather index insurance. Findings obtained by Ellis (2017) indicated that there is a positively significant relationship between awareness/information on crop insurance scheme and the probability of purchasing insurance. The study further outlined that the probability of purchasing the said insurance is higher for farmers with knowledge as compared to their counterparts who had no knowledge of insurance.

2.7. A conceptual framework to study farmers' participation in agricultural insurance programmes

The representative framework for this study to estimate the decision to adopt IBI relies on the standard assumption that a farmer maximizes the expected utility of end-of-period wealth by choosing production factors, including IBI, subject to physical, technical, and institutional constraints. The conceptual model is adopted from (Aina *et al*., 2018; Tlholoe, 2016) to guide this study. The approach assumes that each farmer estimates their conditional insurance premium for the use of insurance in line with their different production risk, financial risk, and risk aversion.

2.7.1. Index insurance framework

To gain a better understanding of index insurance we assume the farmer can buy ıt+1 unit(s) of insurance, from which each pay (1 – ηt+1) to compensate for any bad weather shocks caused through draught or temperature for an itemized value of livestock. Thus, the farmer's optimization problem becomes

$$\mathrm{V}(\mathrm{W}_t, \varepsilon_{i,t}) = \max_{I_t, i_t \geq 0} [u(W_t - I_t) + \beta E_t V(W_{t+1})$$

$$C_t = W_t - I_t$$

$$W_{t+1} = Q_i \varepsilon_{i,t} I_i^{\propto} a_i^{1-\propto} \eta_{t+1} + \iota_t(1 - \eta_{t+1}) - \iota_{\iota+1} \mathrm{P}_t \varepsilon_{i,t}$$

Where the term Ƥt refers to the actuarially fair unit price of weather insurance and is defined as

$$\mathrm{P}_t = \int_0^1 (1 - \eta) f(\eta) d\eta.$$

Ƥt appears in the transition equation and not in the budget constraint as it is assumed that farmers have credit to pay for the insurance premium and are able to observe their productivity level before purchasing insurance. Therefore, the optimization problem can then be written as follows under full insurance.

$$\mathrm{V}(\mathrm{W}_t, \varepsilon_{i,t}) = \max_{I_t, i_t \geq 0} [u(W_t - I_t) + \beta E_t V(W_{t+1})$$

$$C_t = W_t - I_t$$

$$W_{t+1} = Q_i \varepsilon_{i,t} I_i^{\propto} a_i^{1-\propto} (\eta_{t+1} + \underbrace{(1 - \eta_{t+1}) - \iota_{\iota+1} \mathrm{P}_t \varepsilon_{i,t}})$$

Weather insurance component

2.8. Summary and conclusions of the review

The literature reviewed revealed that many agricultural economies are supported by the contribution of the smallholder farming activities. However, many developing countries experience climate-related disasters annually leading to significant loss of lives and infrastructure, which in turn makes the implementing risk management strategies vital. Additionally, smallholder farmers are vulnerable to effects of climate change, but developing countries are still facing a low uptake of agricultural insurance as a climate

risk mitigation strategy due to lack of access to formal insurance contracts. Empirical findings of existing literature reviewed indicates that there is a strong relationship between socio-economic attributes of farmers and their willingness to participate in agricultural insurance schemes.

Africa has explored agricultural insurance particularly the index insurance, however based on the literature reviewed, and the author's knowledge implementation within the context of South Africa, particularly rural regions such as the Polokwane Local Municipality is non-existent. Moreover, smallholder farmers are faced with climate risks but have no access to such means of risk mitigation. Thus, it is imperative as in line with the aim of this study to extract a full understanding of drivers of willingness to adopt agricultural insurance (i.e., index-based livestock insurance) among smalllholders cattle farmers so as to guide potential implementation of agricultural insurance as a risk mitigation strategy which can be availed for smallholder farmers in the country.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

This chapter provides a detailed review of the research methods used in data collection and analysis of variables that were considered to be influencing smallholder farmers" decision to adopt index-based livestock insurance and those considered to determinants of willingness to adopt IBLI by smallholder cattle farmers in the Polokwane Local Municipality. The intent of the chapter is to show how the study was conducted and It starts by describing the study area, then explains the sampling and data collection procedures. The chapter lastly outlines the analytical procedures, outlining descriptive statistics and the empirical models used.

3.2. Description of the study area

This research was conducted in the Polokwane Local Municipality (PLM). Following a preliminary visit to the study area, where, interviewed smallholder farming households reported cattle to be the most important store of wealth and source of income for sustaining their livelihoods. However, most of these farmers highlighted that they had no access to formal markets to earn a reasonable income following low quality and size of their cattle herds. The main cause of this challenge was highlighted as lack of forage for grazing following extended periods of drought resulting from rainfall deficits. Thus, leading to loss of cattle or poor-quality cattle which are not saleable. These ultimately supported the decision or choice of study area in an effort to identify possible solutions to livestock production, particularly cattle in the face of climate change and potentially stimulate commercialisation of smallholder cattle production in the PLM.

3.2.1. Geographic location and population background

The Polokwane Local Municipality is located in the Capricorn district within South Africa's northern province of Limpopo and shares borders with 5 other districts of the province (see Figure 3.). The PLM is divided into, Aganang, City, Molepo/Chuene/Maja

Dikgale/Sebayeng, Mankweng, Moletji and Seshego Clusters (see Figure 2.3). Geographically, the PLM is located 23°54'00" S, 29° 27'00'' E in the province of Limpopo and covers an area of approximately 3766 km^2 which is about 3% of the total surface area of Limpopo (Leso *et al*., 2017).

The 2011 statistics indicated that the Polokwane local municipality had a population of 628 999. From the overall population, 41 876 farming households from a total of 178 001 households. Farming households were found to be involved in diverse agricultural activities (i.e., vegetable, poultry, livestock, and other crop production activities). However, a total of 12 795 were specifically engaged in livestock production, although this total was not specific to cattle production (Statistics South Africa, 2019). A community survey conducted in 2016 by Statistics South Africa indicated that the population standing of 702 190 persons (94.0% black African, 4.4% white, 0.9% coloured, and Asians at 0.6%). The substantial increase in population can be linked to the amalgamation of Aganang which resulted in 70% incorporation of both surface area and residents to the PLM. Additionally, ~40% of the PLM is urban following this approximate percentage being the total population residing within the Polokwane-Seshego Urban Complex (Polokwane Integrated Development Plan (IDP) document, 2017).

The PLM's population can be characterized as ethnically diverse, with a dominance of *Sepedi* speakers at 78.7%. Moreover, other ethnic groups are *Afrikaans* (5.3%), *English* (3.1%), *Xitsonga* speaking groups at 2.8%, and lastly *Tshivenda* contributing 2.1% (Leso *et al*., 2017).

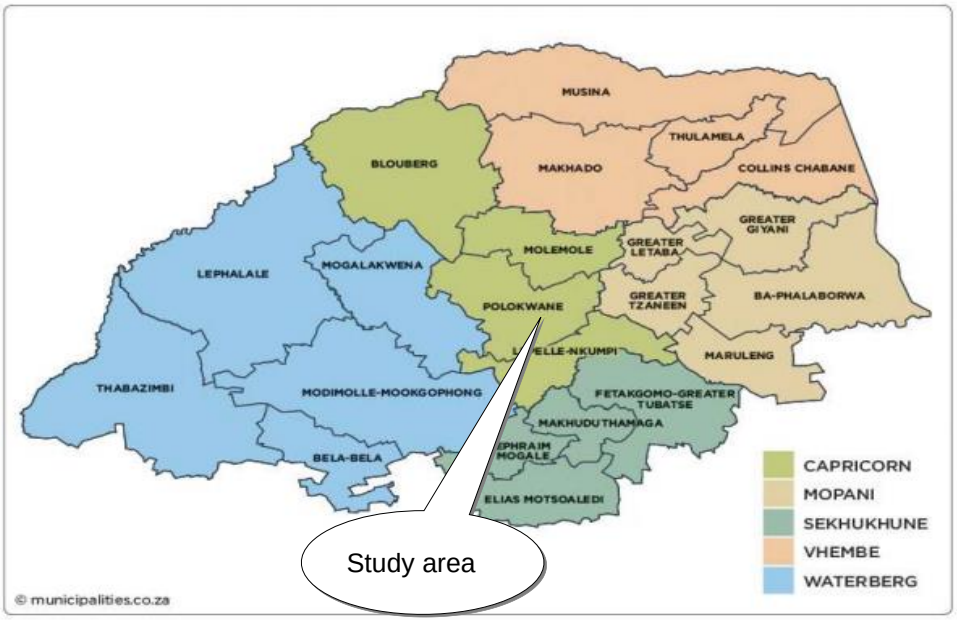

Figure 3.1: Polokwane Local Municipality Jurisdiction

Source: (Polokwane IDP document, 2020)

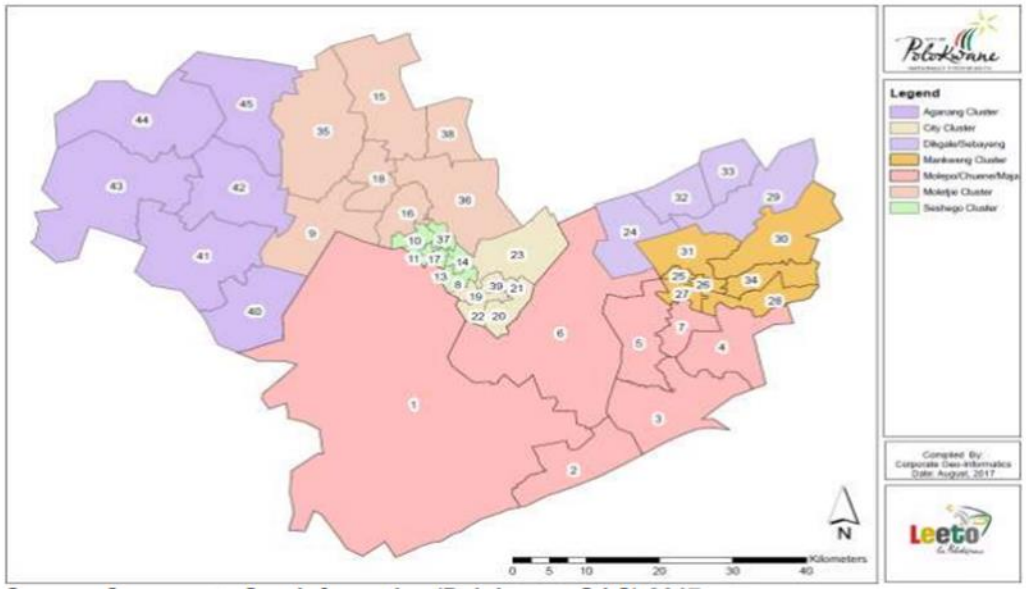

Figure 3.2: Polokwane Local Municipality cluster map

Source: (Polokwane IDP document, 2020)

3.2.2. Climate and Vegetation

The Polokwane Local Municipality (PLM) has characteristics of semi-arid climate conditions which are tempered by its position of 1230m above sea level on the plateau (Leso *et al*., 2017). According to Ramoroka (2012), the PLM area lies in the summer rainfall region with conditions of warm climate. Furthermore, conditions of frost are rare, with the highest temperatures occurring during December and January. Average temperatures range at approximately 21-22°C in January. Moreover, these average temperatures drop to a low of 11°C in July. The vegetation type within the province is diverse and includes the subtropical woodland which is known as *bushveld* in South Africa, the mountainous vegetation, and ancient indigenous forests. However, the PLM is characterized by the *bushveld* vegetation which is dominated by open savannah with much of the habitat having been transformed by agricultural activities (Leso *et al*., 2017).

The area experiences mean annual precipitation of 478mm, with most of the precipitation falling between October and March with the peak period being December/January. Generally, the lowest levels of rainfall are experienced in winter and autumn where average precipitation rate is about 4.6mm from June to August (Ramoroka, 2012).

3.3. Sampling Techniques

For the purpose of this study, a multi-stage purposive sampling procedure was used in the selection of the surveyed clusters in the Polokwane Local Municipality (PLM). The choice of this approach to sampling was motivated by the lack of updated records of cattle farmers in the area following recent and increased cattle theft cases which led to closure of kraals (discontinuation of cattle farming) among many smallholder farming families. Thus, the study followed this procedure to select only those farmers who engage in cattle production and still had the cattle in their smallholder farms.

According to Abugri *et al*., (2017), when performing a regression analysis, a sample size of $N \geq 50 + 8*M$ is acceptable, where M represents the number of independent varaiable. In this study there are 13 independent variables, thus advocating for a sample size of 50

+ 8*13 = 154 as adequate to perform regression analysis. The framework indicated in Figure 3.3 was used to outline the sampling procedure used for this study.

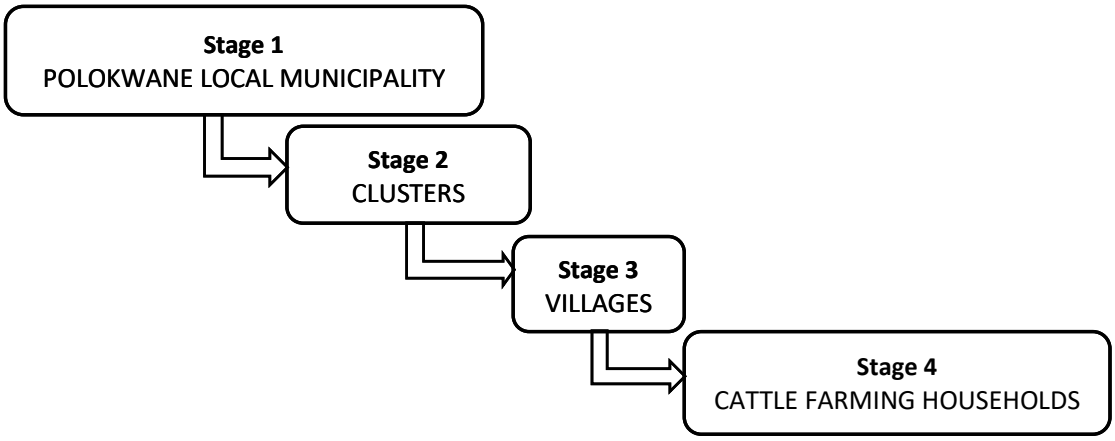

Figure 3.3: Sampling framework

Source: Author's own work, (2021)

In the first stage, the Polokwane Local Municpality was purposively selected because there was no sufficient information on livetock insurance sales made to smallholder cattle farmers or the existence of IBLI. The intention here was to assess the potential uptake (i.e, the willingness to adopt index-based livetock insurance) among smallholder cattle farmers in the study area. The second stage involved selecting the four clusters (Aganang, Mankweng, Molepo/Chuene/Maja and Sebayeng/Dikgale) as a pre-study conducted in 2019 indicated that most farming families enaged in cattle production. Clusters having farmers who were willing to participate following arrangements with committee leaders of cattle farmers in the identified clusters allowed for villages to be narrowed and identied in the third stage. Here, the identified committee leaders responsible for smallholder cattle farming groups were selected with their respective villages to allow for the final selection of farmers in the last stage. In all, 110 smallholder cattle farmers were interviewed as follows; Aganang (12), Mankweng (75), Molepo/Chuene/Maja (22) and Sebayeng/ Dikgale cluster with only one (1) farmer (the farmers' leader, who indicated that fellow community farmers highlighted lack of trust to anyone asking of their cows following recent thefts in the area) willing to participate in the

study. The consideration of the one farmer in the sebayeng cluster is supported by the ethical considerations of the study that no farmer would be forced to participate, hence a consent was the first consideration before interviewing the participants in this study.

3.4. Data Collection

This study used survey research design, wherein a cross-sectional survey on smallholder cattle farming households was carried out in the PLM region. A questionnaire was used as a research instrument for collecting both quantitative and qualitative data for the study.

3.5. Data analysis and Analytical procedures

3.5.1. Profile the socio-economic features of smallholder cattle farmers in the Polokwane Local Municipality.

To achieve the first objective of this study, descriptive statistics such as the mean, frequency and percentages were used to describe the socio-economic characteristics of the smallholder cattle farmers in the study area. To further elicit the demographics and description of the sampled farmers, the study adopted the use of pie charts, bar graphs as well as frequency tables.

3.5.2. Smallholder cattle farmers' perceptions on climate related issues as sources of risk to cattle production

In order to address the second objective, a list of possible issues related to climate change was presented to the sampled smallholder cattle farmers, with the ultimate aim of identifying their perceptions on sources of climate risk. The selection of possible sources of climate risk was based on existing literature (e.g., Tlholoe, 2016). From the data collection tool (questionnaire), the question to farmers was: What is your perception of the following climate related issues as sources of risk for your cattle farm? A Likert-type scale (1= not a concern, 2= very low, 3= low, 4= moderate, 5= high and 6= very high concern. In line with the framework adopted from Tlholoe, (2016), Principal Component Analysis (PCA) was used to allow for extraction of noticeable dimensions of the responses from the Likert-type scale under each respective category. The technique

reduces dimensionality through extraction of the smallest number of principle components (PCs), which explains most of the variation within the original multivariate dataset and providing a summary of the data without loss of significant information (Tlholoe, 2016). The PCs can be estimated as a linear function of the variables of sources of climate risk as follows:

$$PC_i = a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n$$

Where: i = number of principle components (in the range, 1…n); $a_{i1} \ldots a_{i2}$ = the component loadings and finally the sources of climate risk represented by $X_1 \ldots X_2$

3.5.3. Determinants of willingness to adopt IBLI among smallholder cattle farmers in the PLM

With respect to the third objective for this study, Contingent Valuation Method (CVM) was used to investigate the willingness to adopt IBLI among the smallholder cattle farmers in the study area. The contingent valuation method (CVM) is an appraisal technique which entails the approximation of a value placed upon goods or services by an individual. Furthermore, the technique is a direct approach to measuring the willingness to pay (WTP) that many researchers have produced tangible results and predictions in relation to non-market goods (Oduniyi *et al*., 2020a).

Table 3.1: Willingness to adopt IBLI framework

9.1. If index-based insurance was to be introduced as a climate risk management strategy such that whenever there is rainfall deficit or lack of forage, the insurance will protect you against any loss. Would you adopt it (the insurance) and obtain a policy to cover 100% of your livestock? Yes [ ] No [ ]
9.2. If No to 9.1, please state reasons.
9.3. If “YES” to 9.1. Should the premium increase by 10%, would you still be willing to pay insurance cover for 100% of your stock? Yes [ ] No [ ]
9.4. If “NO” to 9.3. Would you accept if the government offers to pay for the 10% premium increase, allowing you to pay insurance for 90% of the value of your animal stock? Yes [ ] No [ ]

Source: Tlholoe, (2016)

It is therefore through responses of the cattle farming households to the above questions (Table 3.1) that we were able to come up with the following classification for the dependant variable (Y_i^*);

Y_i = 0 indicates the farmer is not willing to adopt IBLI

Y_i=1 indicating less willingness, where a farmer is willing to adopt IBLI but not cover 100% of their stock

Y_i= 2 indicates moderate willingness to adopt IBLI as the farmer aims to 100% of their stock and lastly

Y_i = 3 indicates more willing, where the farmer is willing to adopt IBLI and cover 100% of their cattle even if the premium was to be increased by 10%

For the purpose of analysis with the probit model, the outcomes; Y_i=1, Y_i=2 and Y_i=3 where all considered as Y_i=1 to indicate willingness to adopt index-based livestock insurance. Thus, having estimated the willingness to adopt IBLI by the farmers, it is necessary to know the factors which are likely to influence farmers' decision to adopt IBLI. We assume that the willingness of the i^{th} smallholder cattle farmer to adopt Index-based livestock insurance or not depends upon an unobservable utility index (Y_i^*), that is determined by the independent variables.

Therefore, a binary probit model may be used to model such an objective (Abugri *et al*., 2017). It is further assumed that the higher the utility index, the higher the probability of IBLI adoption by the farmer, thus limiting the probability of willingness to adopt IBLI (dependent variable) Y_i to range between the values 1 and 0.

$$Y_i = \begin{cases} Y_i^* \; if \; Y_i^* > 0 \\ 0 \; if \; Y_i^* \leq 0 \end{cases}$$

The probit model following the condition of normally distributed variables is expressed as:

$$Prob(Y^* > 0) = F(X'\beta) = \int_{-\infty}^{X'\beta} \emptyset(Z)dZ$$

Where; $F(X'\beta)$ represents the cumulative degree of freedom of the standard normal distribution.

The specific empirical model used for the study is expressed as follows;

$$Y_i^* = X'\beta + \mathcal{E}_i$$

Where; Y_i^* with $Y_i^* = 1$ if a farmer is willing to adopt Index-based livestock insurance on their farmer and $Y_i^* = 0$ otherwise. These indicate a dichotomous farmer adoption decision outcome which is dependent on age of the farmer (AGE), gender of the farmer (GENDER), marital status (MARI_S), education level (EDU_LV), farming experience (FRM_EXP), experience of livestock loss (LS_LOSS), land ownership (L_OWN), farm income (FRM_INC), off-farm income (OFF_INC),), access to extension services (A_EXT), credit access (CRED_A), household size (HH_SIZE), farm size (FRM_SIZE) and awareness to agricultural insurance (AA_INSUR)

β denotes the vector of coefficients to be estimated, X_i= the vector of independent variables and the random disturbance term indicated by $\mathcal{E}_i$.

$$X'\beta = \beta_0 + \beta_1 AGE + \beta_2 GENDER + \beta_3 MARI\_S + \beta_4 EDU\_LV + \beta_5 FRM\_EXP + \beta_6 LS\_LOSS + \beta_7 L\_OWN + \beta_8 FRM\_INC + \beta_9 OFF\_INC + \beta_{10} A\_EXT + \beta_{11} CRED\_A + \beta_{12} HH\_SIZE + \beta_{13} FRM\_SIZE + \beta_{14} AA\_INSUR + \varepsilon_i$$

Additionally, the 'willingness to adopt' in this study refers to the sacrifice by cattle farmers in buying and integrating IBLI to their farms as a risk management strategy should it be introduced to their area.

Table 3.2 below indicates the independent or explanatory variables hypothesized to influence the decision of willingness to adopt index-based livestock insurance among

smallholder cattle farmers. The choice of such variables is fully guided by existing literature on the subject matter (index-based livestock insurance adoption and participation) and a review on these variables was given in the previous chapter (chapter 2) of this study.

Table 3. 2 Description of model variables for the probit model

Dependent variable		**Description**	
Willingness to adopt IBLI (Y*)		Binary: 1= if the smallholder cattle farmer is willing to adopt IBLI on their farm, 0= not willing to adopt IBLI	
	Independent or explanatory variables		
Variable label	**Variable type,**	**Description and units of measurement**	**Expected sign**
Age (AGE)	Continuous	Age of the smallholder cattle farmer (years)	+/-
Gender (GENDER)	Dummy	1 if the smallholder cattle farmer is male and 0 for otherwise	+/-
Marital status (MARI_S)	Dummy	1 if the smallholder cattle farmer is married and 0 for otherwise	+
Educational level (EDU_LEV)	Continuous	Number of years the smallholder farmer attended school (Years)	+
Farm experience (FRM_EXP)	Continuous	Number of years the smallholder farmer has been farming (Years)	+
Livestock loss (LS_LOSS)	Dummy	1 if the smallholder farmer had any experienced livestock loss due to climate change and 0 otherwise	+
Land ownership (LND_OWN)	Dummy	1, if the smallholder farmer has ownership of farmland and 0 otherwise	+
Farm income (FRM_INC)	Dummy	1 if yes, 0 for otherwise :	+
Off-farm Income (OFF_INC)	Dummy	1 if yes and 0 for otherwise	
Access to extension (A_EXT)	Dummy:	1 if the smallholder farmer receives extension services and 0 otherwise	+
Credit access (CRED_A)	Dummy:	1 if the smallholder farmer has access to credit and 0 otherwise	+
Household size (HH_SIZE)	Continuous:	The number of family members within the smallholder farming household (number)	+/-
Farm size (FRM_SIZE)	Continuous:	Total number of cattle owned	+
Awareness to agricultural insurance (AA_INSUR)	Dummy:	1 if farmers is aware of agricultural insurance, 0 for Otherwise	+/-

3.6. Limitations of the study

The study was conducted during under lockdown regulations with respect to the COVID-19 pandemic. This made accessing farmers difficult owing to the risks of face-to-face interviews, additionally, most of the farmers in the study area were old and not open to telephonic interviews. Another challenge in the study area is the ongoing cattle theft incidents which made farmers not to trust anyone who has questions regarding their cattle. Although 110 farmers were interviewed this still didn't satisfy the desired sample size, thus leading to analysis being conducted with the probit model instead of the initial model (ordered logit model) which would highlight the determinants of the level of willingness to adopt IBLI. Despite the adjustments to the initial analytical model and the desired sample of at least 154 farmers for this study, the achieved sample of 110 was sufficient in carrying out the probit regression (given the binary nature of the dependent variable) to provide credible results from the analysis.

3.7. Summary

This chapter provided a detailed description of the study area, methods of sampling used in identifying respondents (smallholder cattle farmers), an outline of the methods and instruments used to acquire data from the identified respondents. The chapter further provided the methods used in data processing and analysis, while also highlighting the empirical techniques adopted and applied to this study. To reiterate on methods chosen for this study, updated records of farmers in the identified areas for data collection were not available which led a non-probability sampling procedure (purposive sampling on the basis of cattle ownership). Furthermore, the PCA allowed for extraction of noticeable dimensions from the original Likert scale data set without loss of significant information. Finally, the probit model has seen many uses in existing willingness to pay literature and the model selection was a credible choice given the binary nature of the dependent variable (willingness to adopt IBLI) for the current study. The next chapter presents a statistical description of the smallholder cattle farmers sampled in the Polokwane Local Municipality.

CHAPTER FOUR

DESCRIPTIVE RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter provides results and discusses the descriptive analysis results of the field survey that was conducted in the Polokwane Local Municipality. The data used in this analysis were collected from 110 smallholder cattle farmers over a period of one month (November 2021). From this chapter, descriptive statistics are presented in the form of mean values, chi-square values, percentages and frequencies as well pie and bar charts.

4.2. The willingness to adopt IBLI among the sampled smallholder cattle farmers

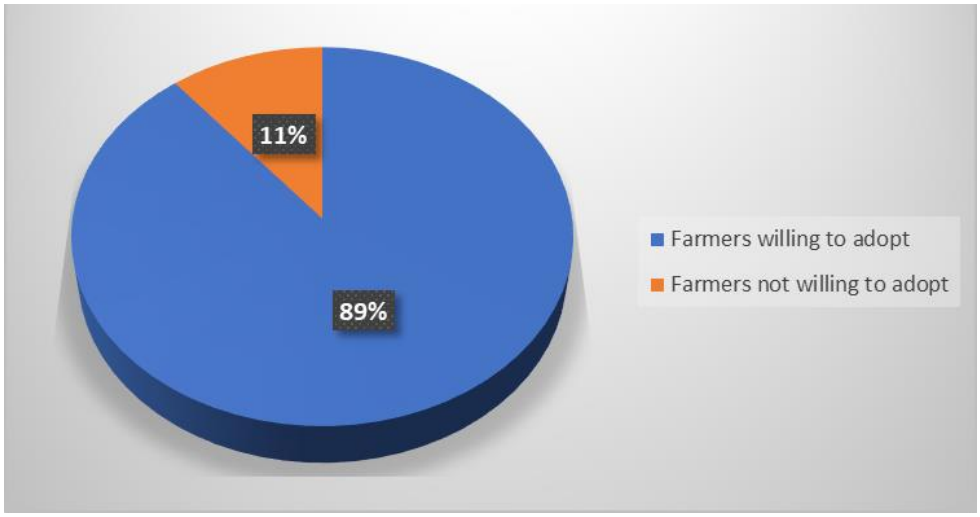

Figure 4.1: Sampled smallholder cattle farmer's decision to adopt IBLI (N=110)

Source: Survey data (November 2021)

A larger proportion at 89% (98 farmers) from the total sampled smallholder cattle farmers as depicted in Figure 4.1, indicated willingness to adopt index-based livestock insurance irrespective of the level of willingness to adopt the insurance product (IBLI). These findings imply that farmers value their livestock/cattle and are committed to protecting their smallholder farms from the adverse effects which climate change imposes livestock production. Most of the interviewed farmers elucidated that they

view the index-based livestock insurance as a good innovation which would highly benefit them given the cattle losses they experience mostly at the hands of drought since their cattle graze on communal land.

On the other hand, fewer farmers totalling 12 (11%) from the sampled smallholder cattle farmers were not willing to adopt IBLI. These farmers' reasons for not willing to index-based livestock insurance are summarised in Table 4.1 to clearly capture the different supporting information behind the lack of interest in the adoption of IBLI to cover cattle on their smallholder farms. The study survey unveiled that the farmers who were willing to adopt IBLI on their farms had varying views on the total number of cattle to cover if they were to obtain a policy for their livestock through the IBLI product. Hence, as indicated in the research methods (See, Chapter 3), the contingent valuation technique allowed for the capturing of different levels of willingness to adopt IBLI among farmers who answered "yes" to the question of willingness to adopt the insurance product on their smallholder farms if it were to be introduced in the Polokwane Local Municipality. Therefore, the different levels of willingness to adopt among the sampled farmers who indicated willingness to adopt are categorised below in Figure 4.2 showing the extent of willingness to adopt IBLI.

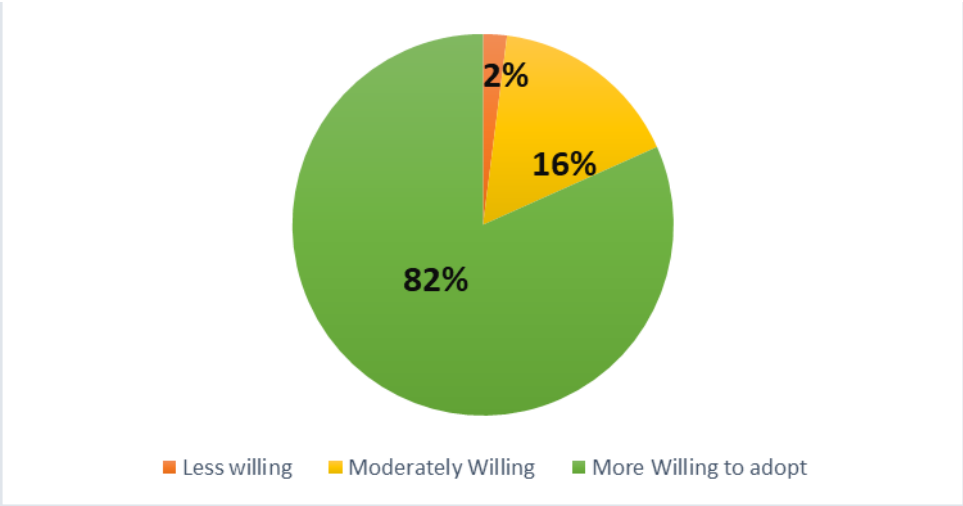

Figure 4.2: Extent of sampled smallholder cattle farmers' willingness to adopt IBLI (N=98)

Source: Survey data (November 2021)

The results in figure 4.2 revealed that from the sampled smallholder cattle farmers in the PLM, 82% of the farmers where more willing to adopt IBLI as a coping mechanism against climate change for their smallholder farms. This implies that most of these farmers are willing to accept IBLI even if premiums were to increase with 10% (see chapter 3 for the contingent valuation technique used in determination of level of willingness to adopt IBLI). The remaining 18% comprised of 16% and 2% which were the farmers moderately willing and less willing to adopt IBLI respectively.

Table 4.1: Sampled smallholder cattle farmers' reasons for not willing to adopt IBLI (N=12)

Reasons	Frequency	Percentage
Unemployment	1	8
Old age and small farm size	1	8
I don't trust insurance	2	17
I would rather insure against stock theft	3	25
I don't think I'll have money for premiums	2	17
I don't want to complicate my farming activities	1	8
Just not interested	2	17

Source: Survey data (November 2021)

Respondents who indicated that they would not be willing to adopt IBLI if it were to be introduced in the Polokwane Local Municipality were asked to provide reasons for their decision. Based on that question in the data collection tool (questionnaire), Table 4.1 indicates the reasons of such respondents. Majority (25%) of the farmers who are not willing to adopt IBLI indicated they would rather insure against cattle/stock theft than obtain adopt IBLI. On the other hand, 24% divided into three equal proportions (8% each) indicated they are not willing to adopt IBLI as they; are unemployed, old and having small farms and finally the last 8% said they don't want to complicate their current farming activities. In three groups, each accounting for 17% of the respondents not willing to adopt IBLI, farmers outlined that they had lack of trust for insurance, others didn't think they will have money for premiums while the remainder where just not interested in IBLI.

4.3. Gender distribution of sampled smallholder cattle farmers

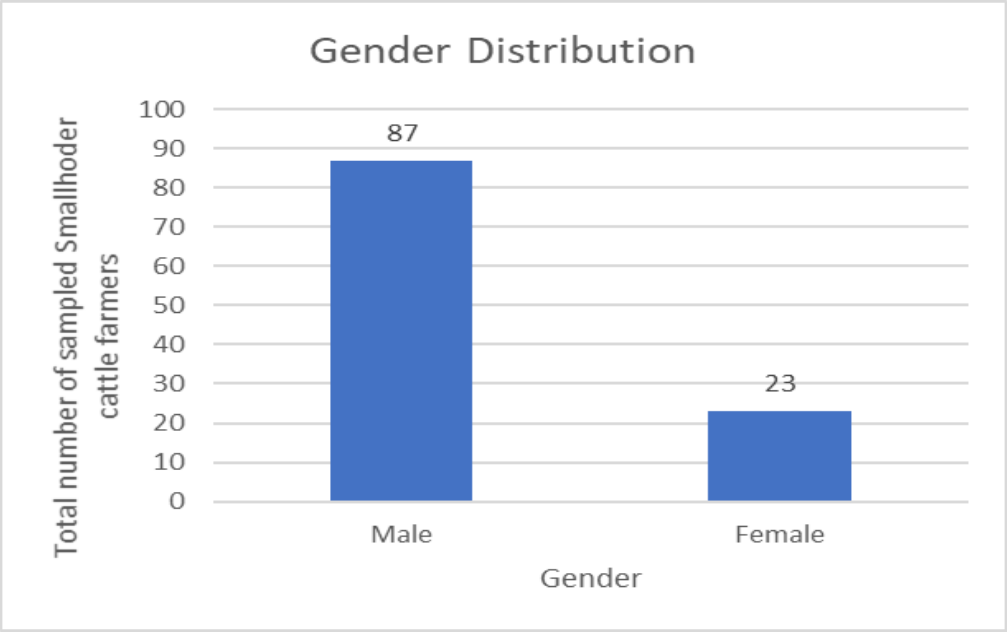

Figure 4 3 Gender distribution of sampled smallholder cattle farmers (N=110)

Source: Survey data (November 2021)

According to Figure 4.3, majority (87) of the interviewed respondents from the sampled smallholder cattle farmers (n=110) where male. On the other hand, female farmers where only 23 in number. This means there's a gender distribution of about 79% and 21% for male and female cattle farmers from the survey respectively. This may imply that most smallholder cattle farming families are male-headed in the PLM, and female headed families engaged in cattle farming are fewer in proportion.

4.4. Marital status of the sampled smallholder cattle farmers

Figure 4.4 below indicates the marital status of the sampled smallholder cattle farmers. According to Runganga & Mumbengegwi (2020), existing literature on empirical studies conducted in Africa on willingness of farmers to insure their farms revealed that marital status had a positive influenced such willingness.

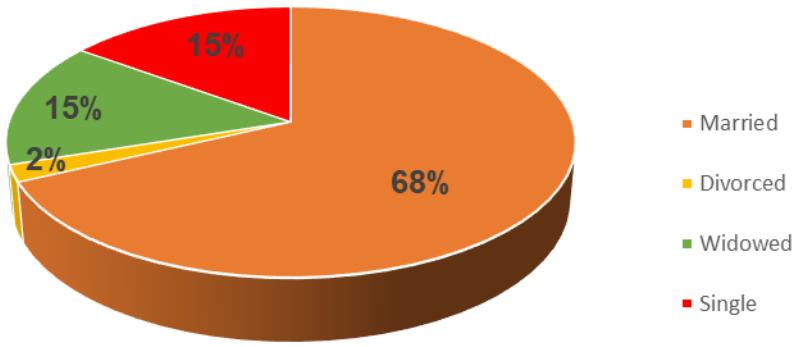

Figure 4.4: Marital status of sampled smallholder cattle farmers in the PLM (N=110)

Source: Survey data (November, 2021)

Findings of the field survey for this study revealed that majority (approximately 68%) of the sampled smallholder cattle farmers in the study where married. This may imply that most of the interviewed farmers engage in joint family decision making with spouses on farm decisions for the wellbeing of the farming family, this may in-turn contribute to a positive reaction IBLI with aim to safeguard the cattle which may be the family's source of income or store of wealth. The remaining 32% was shared by an equal percentage (15%) for farmers who were either single or widowed while 2% of the remaining sampled farmers indicated that they were divorced.

4.5. Land Tenure system of the sampled smallholder cattle farmers

Table 4.2: Land Tenure system of the sampled smallholder cattle farmers (N=110)

System of land where cattle production is practiced	Frequency	Percentage
Communal	108	98.2
Owned or Permission to occupy	2	1.8

Source: Survey data (November 2021)

The results of the field survey indicated that majority of the sampled farmers do not have land ownership. This follows a large proportion (98.2%) of smallholder cattle farmers indicating sole reliance upon communal land for production of their cattle (grazing). However, this may present a challenge which positively influences the need for IBLI as the increased competition of cattle grazing on communal land coupled with rainfall deficits pose a threat to cattle survival and ultimately farm sustainability. Moreover, the remaining 1.8% of the sampled farmers indicated that they run their production activities on land they purchased, or have acquired permission to occupy from the tribal authority.

4.6. Experience of Livestock/cattle loss due to climate change

Table 4.3: Experience of Livestock/cattle loss due to climate change (November 2019 - November 2021) (N=110)

Livestock Loss	Frequency	Percentage
Farmer experienced livestock loss due to climate change effects	38	34.5
Farmer never experience any livestock loss	72	65.5
Total	110	100.0

Source: Survey data (November 2021)

Table 4.3 provides results of farmers' experiences of cattle loss due to climate change. The survey revealed that, majority of the farmers at 65.5% had never experienced loss of cattle due to the effects of climate change. The remaining 34.5% of the farmers were found to have experienced loss of cattle due to the effects of climate change in the past 2 years (November 2019-November 2021). The sources of risk associated

with cattle loss experienced by the 34.5% proportion of farmers is indicated in Table 4.4 below.

Table 4.4: Source of risk associated with cattle losses among the sampled smallholder cattle farmers (November 2019 - November 2021) (N=38)

Source of risk	Frequency	Percentage
Drought	14	12.7
Pests and diseases	18	16.4
Combined effects of climate related issues (high temperature, drought and pests and diseases)	6	5.5
Total	38	34.5

Source: Survey data (November 2021)

From the 34.5% of the farmers who experienced cattle loss, 12.7%, 16.4% and 5.5% of the farmers lost cattle to drought, pests and diseases, and a combination of high temperature, drought as well as pests and diseases respectively.

4.7. Educational level of the sampled smallholder cattle farmers

The level of education of smallholder cattle farmers in one of the socio-economic drivers of willingness to adopt index-based insurance. Education relates to disaster preparedness behaviour of a household and helps farmers to have an understanding of insurance contracts and how to link their specific insurance needs to the policies (Tang *et al*., 2021). Furthermore, a farmer's level of education is used to measure their ability to read and relate positively to insurance acceptance (Ankrah *et al*., 2021). Evidence in Figure 4.5 below shows the educational levels of the sampled smallholder cattle farmers who were interviewed.

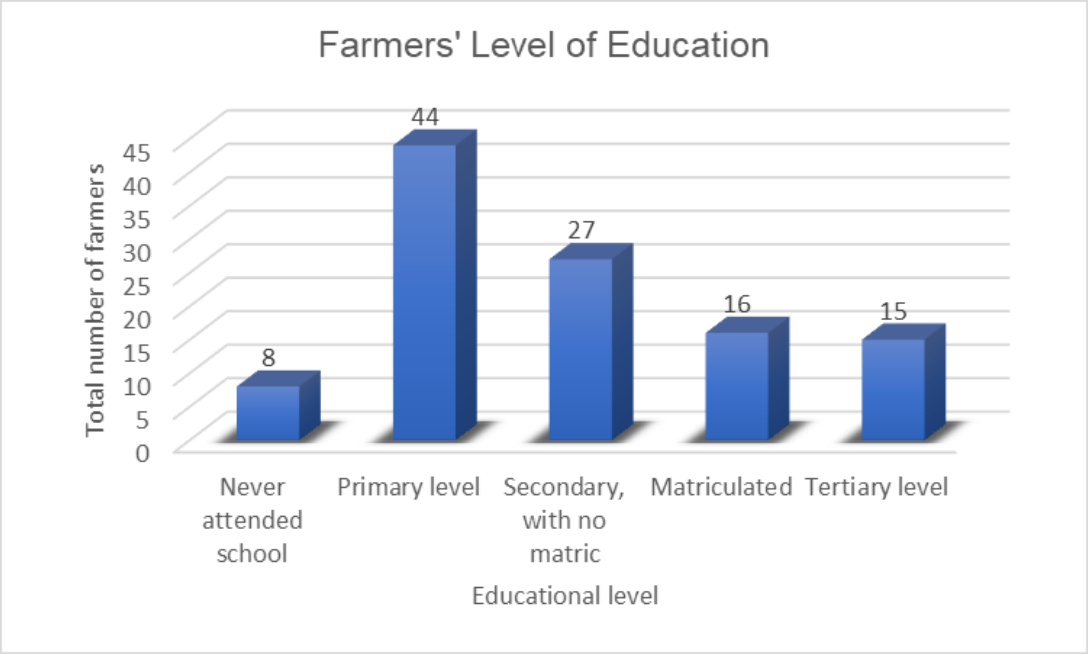

Figure 4.5: Level of education among the sampled smallholder cattle farmers (n=110)

Source: Survey data (November 2021)

The results show that majority of the smallholder cattle farmers (102) from the total sampled in the Polokwane Local Municipality have received some form of formal education. The evidence in Figure 4.5 further indicates that, from the total sampled farmers (110), about 40% of the famers (44) had only received primary education while just over 24% of these farmers (27) received secondary level education, but did not matriculate. Those who did not further their studies but matriculated accounted for approximately 15% of the farmers (16) from the total sample. The proportion of farmers who enrolled for tertiary education (15) was found to be slightly less by approximately 1% from those who matriculated but never enrolled for tertiary education. Thus, approximately 14% of the sampled farmers had tertiary education whereas, an approximate proportion of 7% from the sampled smallholder farmers (8) never went to school and have no formal education. It is evident that most of the smallholder cattle farmer in the study area had received some form of formal education, this may suggest that they will be able to understand the content of insurance contracts and positively relate to index-based livestock insurance uptake.

4.8. Household income of the sampled smallholder cattle farmers

Figure 4.6 provides an indication of the monthly household income distribution among the sampled smallholder cattle farmers in the PLM.

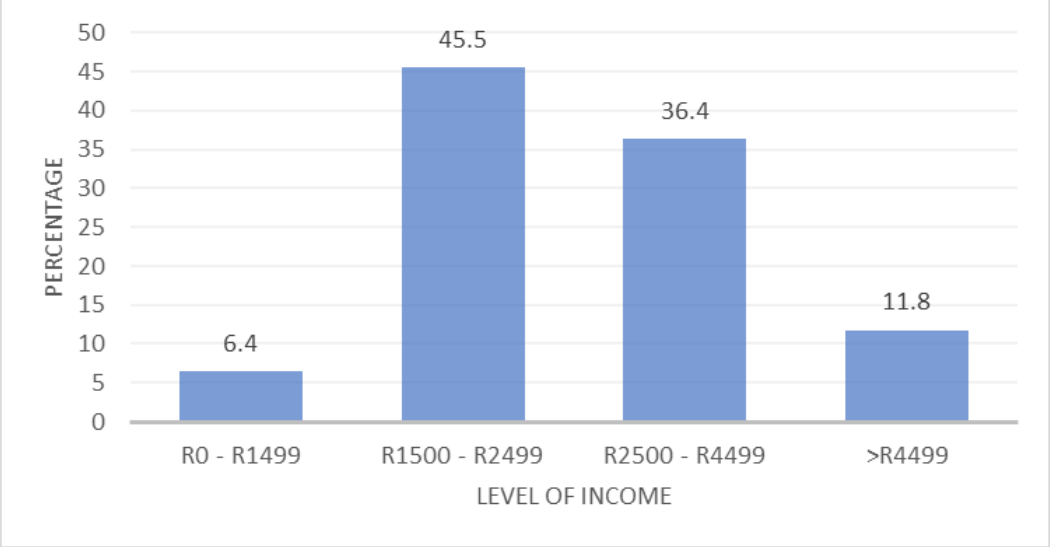

Figure 4.6: Sampled smallholder cattle farmers' monthly household income (N=110)

Source: Survey data: (November 2021)

The survey results indicate that a greater proportion (81.9%) of farmers depend on at least R1500 to R4500 monthly. This larger proportion is divided into 45.5% of the farmers having a monthly income of R1500 to R2499 and the remaining 36.4% of the sampled farmers depending on a monthly income ranging from R2500 to R4499. Additionally, fewer farmers at 6.4% indicated dependency on a monthly income of R0-R1499, while 11.8% of the remaining farmers from the sample obtained from the PLM had a monthly income level which is greater than R4499. From these results, the greater proportion of farmers relying on an income level ranging from R1500-R4499 implies that the level of income among the sampled smallholder cattle farmers is low.

4.9. Major sources of household income for the sampled smallholder cattle farmers

Table 4.5 below indicates the major sources from which the monthly income of smallholder cattle farmers in the PLM is derived.

Table 4. 5: Sampled smallholder cattle farmers' major sources of household income (N=110)

Major Sources of Household Income	Frequency	Percentage
Farm Income	3	2.7
Off-farm sources		
Formal employment	14	12.7
informal employment	10	9.1
Non-labour sources		
Pensions	71	64.5
child/social support grants	9	8.2
Gifts from relatives	3	2.7
Total	110	100.0

Source: Survey data (November 2021)

With regard to the major sources of monthly household income of the sampled smallholder cattle farmers, Table 4.5 indicates that majority (64.5%) of the respondents depend on pensions as a source of monthly income. Most of the interviewed farmers where old people which justifies majority being dependent on pensions (i.e., old age pension grants). On the other hand, 12.7% and 9.1 % of the respondents indicated dependency upon formal and informal employment respectively. Farming households which relied on child/ social support grants accounted for 8.2 % of the total sample (N=110). Finally, respondents falling under the two categories; farm income and gifts from relatives where equal in proportion at 2.7% each.

4.10. Access to credit by sampled smallholder cattle farmers

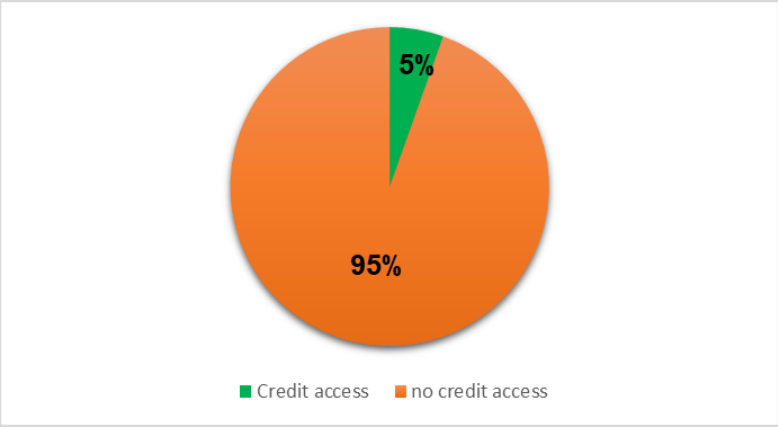

Figure 4 7: Access to credit among sampled smallholder cattle farmers (N = 110)

Source: Survey data (November 2021)

Runganga & Mumbengegwi, (2020) discovered that credit access had a positive effect upon the extend of adoption of crop insurance, while also the marginal effects highlighted that farmers who had access to credit had a greater ability in terms of premium ayments as compared to those without credit acess. The results in Figure 4.7 indicate that majority (95%) of the sampled smallholder cattle farmers in the PLM have no access to credit to finance their farms. On the other hand, only 6 of the farmers (5%) had access to credit services to finance their farming activities. This may imply that farmers may have difficulty paying higher premiums for IBLI since majority of them have no access to credit facilities to finance their cattle production activities.

4.11. Distribution of Farming experience among the sampled smallholder cattle farmers

Table 4.6: Distribution of Farming experience among the sampled smallholder cattle farmers (N=110)

Farming experience in years	**Frequency**	**Percentage**
0-9	45	40.9
10-19	31	28.2
20-29	8	7.3
30-49	16	14.5
>49	10	9.1
Total	**110**	**100**

Source: Survey data (November 2021)

The results indicated that majority (69.1%) of the farmers had 0 to 19 years of experience in cattle farming. Furthermore, the remaining 7.8%, 14.5% and 9.1% of the farmers had 8, 16 and 10 years of cattle farming experience respectively. This implies that the sampled smallholder farmers in the study area relatively having less than 20 years of experience in cattle farming. According to Tlholoe (2019), the assumption is that with greater experience in farming, there could be a lower desire to buy insurance by farmers due to a higher level of awareness to a variety of risk management strategies.

4.12. Access to extension services among the sampled smallholder cattle farmers

Empirical findings of Kalapo *et al*. (2020) indicated that extension contact had a significantly positive influence upon the use and continued participation in an agricultural insurance scheme. Thus, implying that with continued access to extension services farmers are likely to gain continuous encouragement to participate within the said insurance scheme

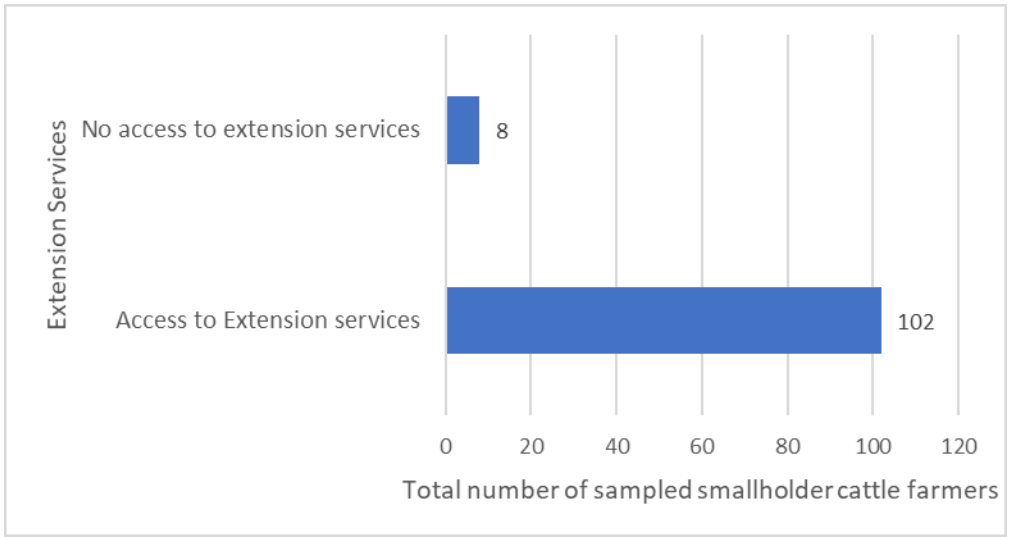

Figure 4 8: Sampled smallholder cattle farmers' access to extension services (n=110)

Source: Survey data (November 2021)

The results of this study indicate that majority (92.7%) of the interviewed smallholder cattle farmers in the PLM had access to extension services, while the remaining 7.3%

had not contact with extension agents. These findings imply that there is a relatively good service delivery from the extension offices to smallholder cattle farmers in the study area. Furthermore, thus in line with findings of Kalapo *et al*., (2020), these results can raise a good argument that post adoption, farmers in this area would continuously participate in IBLI if it were introduced to the PLM. Figure 4.9 below indicates the level of awareness on agricultural insurance among the sampled smallholder cattle farmers in the Polokwane Local Municipality. These findings provide a report from the awareness to agricultural insurance section in the survey questionnaire (research data collection instrument used). In the survey, farmers were asked if they were aware of any agricultural insurances scheme which provides insurance against risks such as, weather risks, price risks as well as production or technical risks to farmers.

4.13. Sampled smallholder cattle farmers' awareness to agricultural insurance

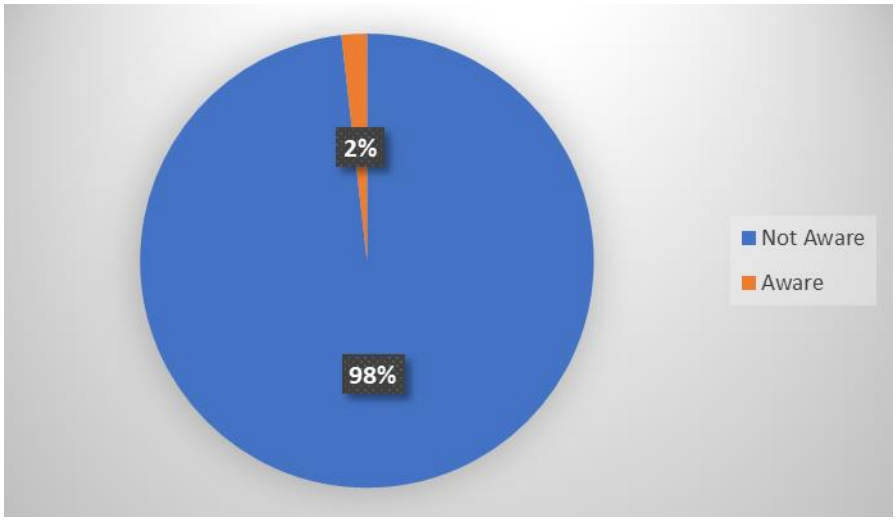

Figure 4.9: Sampled smallholder cattle farmers' awareness to agricultural insurance (N=110)

Source: Survey data (November 2021)

Figure 4.9 provides a clear indication that most of the sampled smallholder cattle farmers in the Polokwane Local Municipality are not having access to information about agricultural insurance or are simply not aware of any agricultural insurance scheme. The results of the survey revealed that only 2% (2) of the sampled farmers were aware of some agricultural insurance scheme, whereas the remaining 98% (108) of farmers sampled for the study were not aware of agricultural insurance.

4.14. Descriptive statistics of the sampled smallholder cattle farmers

Table 4. 7: Descriptive statistics of continuous variables used in the Probit regression model (N=110)

Variable	Mean	Std. Deviation	Min.	Max.	T-test (Sig. 2-tailed)
Age of farmer	62	14.448	23	102	45.019***
Educational level	8	4.544	0	17	18.612***
Farming Experience	18	17.594	1	85	10.844***
Household Size	5	2.540	1	13	19.183***
Farm Size (number of cattle owned)	12	11.999	1	94	10.140***

Source: Survey data (November, 2021)

Notes: *** indicates statistical significance at a level of 1%

The results obtained in Table 4.7 show that the average (mean) age and educational level (i.e. the number of years in school) of sampled smallholder cattle farmers are 62 and 8 years with a minimum of 23 and 0 years and a maximum of 102 and 17 years respectively. The two-tailed t-test also results revealed the highly significant (at 1% level of significance) mean difference between the farmers' ages and educational levels. Additionally, the results in Table 4.7 indicate the highly significant mean difference in the number of years in farming (farming experience) of the sampled smallholder cattle farmers. On average a farmer was found to be 18 years of farming with the minimum being a year and a maximum of 85 years. An average household size of the smallholder cattle farmers had 5 persons with the lowest having an individual person (1) and the largest household had 13 people living together. Finally, the smallest farm had 1 cow with the largest farm was found to be having a total of 94 cattle and on average farmers owned a total of 12 cattle. The two-tailed t-tests for both household size and farm size indicated high statistical significance at 1%, which infers that there is a strongly significant difference in both the number of persons living in one household and the total number of cattle owned by the farming household in the study area.

Table 4.8: Descriptive statistics of categorical variables used in the Probit regression model

Variable	**[A] Total from sample (n=110)**	**[B] Z = 0 (n= 12)**	**[C] Z = 1 (n =98)**	**Pearson Chi-Square**
% of male	79	83	79	0.702
% of female	21	17	21	
Marital status (% of married)	66.4	75	66.3	0.502
Land ownership (% of yes)	1.8	8.3	1	0.074*
Farm income (% of yes)	3.6	16.7	2	0.011**
Off farm income (% of yes)	21.8	16.7	22.5	0.647
Experience of livestock loss (% of yes)	34.6	25	35.7	0.461
Credit Access	5	0	6	0.378
Access to Extension (% of yes)	92.7	91.7	92.9	0.881
Agricultural Insurance awareness (% of yes)	2	0	2	0.617

Source: Survey data (November, 2021)

Notes: **, and * indicates the significance levels of 5% and 10%, respectively

Z=0 indicates farmers' unwillingness to adopt IBLI and Z=1 denotes willingness to adopt

The analysis of categorical variables indicated a significant difference between willingness to adopt IBLI in land ownership, and farm income. The variable land ownership had a significant difference among farmers who were willing to adopt and those who were unwilling. The results show that out of the total sampled farmers who

were not willing to adopt IBLI only 8.3% had ownership of land, whereas only 1% who had ownership to land was willing to adopt IBLI.

Farm income also had a significant difference at $p<0.05$ among the two decisions of adoption of IBLI (i.e., the willingness and unwillingness to adopt IBLI). The results indicate that from the total sampled farmers who were willing to adopt IBLI, only 2% had income from their livestock production activities (i.e. farm income), while 16,7% of the farmers who were not willing to adopt IBLI also had farm income as a major source of their monthly household income.

The remaining variables: gender of the farmer, marital status, off-farm income, experience of livestock loss, credit access, access to extension and agricultural insurance awareness all had chi-square values which indicated an insignificant difference among the two decisions of willingness to adopt IBLI.

4.15. Summary

This chapter provided a presentation of the descriptive results based on socio-economic characteristics of the farmers. From the results, there is sufficient evidence to conclude that smallholder cattle farming from the sampled farmers is male dominated at 79% over the minor 21% of female farmers. Furthermore, majority of the sampled farmers indicated willingness to adopt IBL, hence this suggests that there is potentially high uptake probability of the insurance product among the sampled farmers if it were introduced to their local economy. Finally, in addition to a summary of all the variables in the study, age, educational level, farming experience, household size, farm size, land ownership and farm income indicated statistical significance as variables to be included in the empirical analysis in the next chapter.

CHAPTER FIVE

EMPIRICAL RESULTS AND DISCUSSIONS

5.1. Introduction

This chapter provides the empirical results of the factors influencing the decision of willingness to adopt index-based livestock insurance by smallholder cattle farmers in the Polokwane Local Municipality of Limpopo Province, South Africa. Here, the results of the probit regression model are presented and discussed.

5.2. Empirical results

5.2.1. Smallholder cattle farmers' perception on components of climate change as sources of risk to cattle production

The study adopted the use of principle component analysis in analysing the perceptions of smallholder cattle farmers on climate change components as sources of climate risk to their farms/cattle production activities. The responses were measured using a Likert-type scale with a range of 1 (not a concern) to 6 (very high).

A total of 8 components of climate change were presented to smallholder cattle farmers and. To identify the dominant sources of climate risk, the principal component analysis was employed and the results summarised in Table 5.1 below.

Table 5.1: Smallholder cattle farmers' perception on climate change components as sources of risk to cattle production in the PLM

Components of climate risk	Average* (n = 110)	Principal Components		
		1	2	3
High rainfall	2.33	0.069	**0.620**	**0.544**
Low rainfall	4.47	**0.673**	**0.319**	-0.288
Flood	0.55	**-0.732**	0.150	0.243
Drought	4.72	**0.796**	0.203	-0.092
Very low temperature	2.15	**-0.430**	**0.591**	0.126
Very high temperature	4.02	**0.623**	0.164	**0.470**
Strong winds	1.28	**-0.416**	**0.464**	**-0.465**
Pests and diseases	3.48	0.068	**0.540**	**-0.369**
Eigenvalues		2.379	1.433	1.035
Total Variance explained (%)		29.739	17.918	12.942
Barlett's test of sphericity chi-square		145.952***		
Kaiser-Meyer-Olkin Measure of sampling adequacy (KMO)		0.579		

Note:

Likert-type scale: 1=not a concern, 2=very low, 3=low, 4=moderate, 5=high, 6= very high

Component loadings greater than ± 0.30 appear in bold in Table 5.1

Source: Survey data (November 2021)

From the PCA, the results of 0.579 and 145.952 were obtained for the Kaiser-Meyer-Olkin's measure of sampling adequacy and Barlett's test of sphericity chi-square respectively. This suggested Principal Component Analysis (PCA) an appropriate tool to provide a significant reduction in the number of variables identified. The three extracted PCs that had eigenvalues of at least one are compared with original 8 sources of climate risk (variables) in Table 5.1. The results indicate that the three PCs explained almost 61% of the variance of the original variables. In line with Tlholoe (2016), a principal component loading which was greater than ± 0.30 was considered significantly associated with the extracted components for n>50 observations.

From the results, average perception scores show that the most perceived source of climate risk was drought with a mean of 4.72, followed by low rainfall and high temperature with mean values of 4.47 and 4.02 respectively. The least perceived sources of climate risks were indicated to be flood, strong winds, very low temperature and high rainfall with loadings of 0.55, 1.28, 2.15, and 2.33 respectively.

The first significant principal component (PC1) was referred to as “drought and harsh weather conditions” whereby drought is linked with low rainfall, harsh weather conditions account very high and very low temperatures, flood and strong winds. Moreover, PC1 explained 29.7% of the total variation of the original variables. The perception of the sampled smallholder cattle farmers was that “drought and harsh weather conditions” affect their cattle rearing activities. Therefore, “drought and harsh weather conditions” are a significant source of climate risk perceived by smallholder cattle farmer. The second significant principal component (PC2) explained 17.9% of the total variation, and the significant loadings of the variables (high rainfall, low rainfall, low temperature, strong winds and pests and diseases) implied that smallholder cattle farmers perceive the mentioned variables as sources of climate risk on their farms. Finally, the third significant principal component (PC3) explained 12.9% of the total variation of the original variables. PC3 was referred to as “animal health risk” given it has high loadings on pests and diseases, high temperature and high rainfall which may potentially exacerbate livestock pests and diseases while strong winds can lead to animal injuries which ultimately affect the animal health. Therefore, the perception can be explained as high rainfall, high temperature and strong winds exacerbating exposure to pests, and diseases as well as injuries, thus leading to the conclusion that “animal health risk” is a climate risk perceived by smallholder cattle farmers.

5.2.2. Factors influencing the decision of willingness to adopt Index-based livestock insurance (IBLI) on their farms

A variety of previous studies (Kalapo *et al*., 2020 (Oduniyi *et al*., 2020a; Bishu *et al*., 2018; Ellis, 2017; Abugri *et al*., 2017) have partly (two-stage models) or fully adopted

the use of the probit model to investigate the factors influencing participation, interest and willingness to pay for agricultural insurance. Therefore, following a study conducted by Abugri *et al*. (2017), the probit model was selected for this study as one of the appropriate models to analyse the determinants of willingness to pay for index insurance by farmers. A test for multicollinearity was conducted using IBM SPSS 26.0 software package using the variance inflation factor (VIF) which led to the exclusion of the variable non-labour income (NONLI) which indicated a high VIF value which was above 20. However, from Table 5.2. below, the variables included in the probit model estimation all have a VIF value less than 5 with a mean VIF of 1.654. Furthermore, the study adopted the use of a correlation matrix of coefficients which indicated that multicollinearity is not a serious problem in the probit estimation model.

Table 5.2: Diagnostics to assess the degree of multicollinearity problem among the variables included in the probit model, (n=110)

Explanatory variables	**Collinearity Statistics**	
	VIF	**1/VIF**
AGE	3.544	0.282
Gender (GEN)	1.470	0.680
Marital status (MARI_S)	1.828	0.547
Educational level (EDU_LEV)	3.012	0.332
Farming experience (FRM_EXP)	1.725	0.580
Household size (HH_SIZE)	1.304	0.767
Livestock loss (LV_LOSS)	1.230	0.813
Land ownership (L_OWN)	1.231	0.812
Access to extension services (A_EXT)	1.290	0.775
Credit access (CRED_A)	1.306	0.766
Farm size (FRM_SIZE)	1.690	0.592
Agricultural insurance awareness (AA_INSUR)	1.203	0.831
Farm income (FRMINC)	1.259	0.794
Off-farm income (OFFINC)	1.060	0.943
Mean VIF	**1.654**	

Source: Survey data (November 2021)

Table 5.3 below provides a presentation of the results of the probit regression model as the model of choice for this study, and a discussion of variables which are explanatory to the decision of willingness to adopt index-based livestock insurance (IBLI). Parameter estimates of the probit model provide the direction and the probability or marginal effects indicate the magnitude of change.

Table 5.3: Probit Regression Model results of sampled smallholder cattle farmers under the Polokwane Local Municipality, South Africa 2021 (n=110)

Parameter	**Coef.**	**Std. Err.**	**Z**	**P> |z|.**	**dy/dx**
Farmer characteristics					
Constant	-4.827***	1.224	-3.943	0.000	-
Age of farmer	0.008	0.007	1.149	0.251	0.0025136
Gender of the Farmer	-0.190	0.161	-1.180	0.238	0.0282307
Marital Status	0.357**	0.153	2.337	0.019	-0.0202186
Educational level	-0.053***	0.018	-2.916	0.004	-0.0004638
Farming Experience	0.016***	0.003	4.702	0.000	-0.000029
Household Size	-0.043*	0.025	-1.764	0.078	-0.0023415
Access to Credit	0.134	0.224	0.598	0.550	0.0715769
Access to Extension services	0.490**	0.225	2.175	0.030	0.0778678
Agricultural Insurance Awareness	-0.320	0.379	-0.844	0.399	0.0338987
Major sources of income					
Farm income	0.228	0.465	0.490	0.624	-0.0107211
Off-farm income	1.124***	0.183	6.132	0.000	0.039887
Farm characteristics					
Farm Size (number of cattle owned)	-0.008**	0.006	-1.503	0.019	-0.0033617
Land Ownership	1.729*	1.023	1.691	0.091	0.0577676
Livestock loss	-0.285**	0.113	-2.524	0.012	0.0263142
Number of observations = 110					
Pearson Goodness-of-Fit Test	Chi-Square			df[a]	Sig.
	1271.782***			95	0.000

Note: *, ** and ***** i**mplies statistical significance at levels; 10%, 5% and 1% respectively

Source: Survey data (2021)

The results indicate a goodness-of fit of the model which relatively well with a chi-square of 1271.782, 95 at a highly statistical significance of 1% and 95 degrees of freedom**.** This implies that the data fits the model very well.

5.3. Discussion on significant explanatory variables

5.3.1. Marital status of smallholder cattle farmers

In this study, marital status (MARI_S) of smallholder cattle farmers was hypothesized to have a positive association with the willingness to adopt index-based insurance. Empirical evidence from the results show a positive sign of the coefficient for the variable marital status. The variable MARI_S is statistically significant at 5% level of significance. The statistical significance of this variable (MARI_S) provides enough evidence to suggest that marital status influences smallholder cattle farmer's decision of willingness to adopt IBLI. This positive association implies that sampled smallholder cattle farmers who are married are more likely to adopt Index-based livestock insurance to protect their farms in the face of climate change as opposed to non-married sampled farmers. The results conform to findings of Aina *et al*. (2018) who found marital status to be positively correlating and significantly affecting the adoption of IBLI at 5% significance level. Therefore, this infers that smallholder cattle farmers who are married are more likely to adopt IBLI as a climate risk mitigation strategy. However, findings of this study concur with those of Oduniyi *et al*. (2020a) who found marital status to have a negative correlation and statistical significance with the willingness of farmers to pay for IBLI. Furthermore, the marginal effects for the parameter (MARI_S) revealed that the probability of married farmers' willingness to adopt IBLI increases by 0.02 percentage point as compared to their non-married counterparts.

5.3.2. The educational level of smallholder cattle farmers (EDUL_LV)

Contrary to prior expectations the results in Table 5.3 showed that the estimated coefficient of educational level (EDU_LV) was negative and statistically significant at a level of 1% significance. This implies an inverse relationship with the willingness to adopt IBLI which stands to infer that the willingness to adopt IBLI declines with an increase of years of education. This means farmers who are more educated are less likely to adopt index-based livestock insurance on their cattle farms. Although these findings are consistent with arguments by Isaboke *et al*. (2016) who postulated that better education may have a negative effect on participation in weather index

insurance, there is sufficient information to conclude that these results are inconsistent with much of the previous literature. These include, Kalapo *et al*. (2020) and Bishu *et al*. (2018) who both found education to have a positive and significant influence on the decision of participation in an agricultural insurance scheme. In addition, these findings do fail to conform with Nshakira-Rukundo *et al*. (2021) who also found that farmers and pastoralists who are more educated portray a higher demand for insurance as compared to their less-educated counterparts. Conversely, the probability of willingness to adopt IBLI among smallholder cattle farmers who are more educateddecreases by 0.0004 percentage point as opposed to those who are less educated. This further suggests that a unit increase in the years of education reduces the willingness to adopt IBLI by the 0.0004 percentage point.

5.3.3. Farming experience of smallholder cattle farmers (FRM_EXP)

The empirical results highlight the positive correlation of farming experience (FRM_EXP) with the willingness to adopt IBLI which conforms with prior expectations of the study. The variable FRM_EXP was found to be highly statistically significant at a level of 1%. This provides sufficient evidence to suggest that farming experience positively affects the willingness of smallholder cattle farmers to adopt IBLI as a risk mitigation strategy in the face of climate change. The inference here is that farmers who have more experience in cattle farming are more likely to be willing to adopt index-based livestock insurance. This could be justified by the assumption that with more years in cattle farming, a farmer would be willing to do anything to protect an investment which they have spent a lot of their time and financial resources establishing. Runganga & Mumbengegwi, (2020) also indicated that more years of experience in farming positively and statistically influence the willingness to adopt crop insurance. Futhermore, findings of this study are also consistent with the results of Afroz *et al*. (2017) and Nnadi *et al*. (2013) who both found a positve correlation between farming experience and willingness to participate in agricultural insurance. Therefore, this provides sufficient evidence to suggest that the variable FRM_EXP influences smallholder cattle farmers willingness to adopt IBLI. The marginal effects for the estimated parameter of farming experience (FRM_EXP) indicate that the probability of willingness to adopt IBLI among more experienced farmers increases by 0.000029 percentage point in comparison to the less experienced.

5.3.4. Household size (HH_SIZE)

Household size is one of the important factors which influence the capacity of smallholder farmers to respond to climate risks by participating in agricultural insurance. This is supported by the study of Oduniyi *et al*. (2020a) who highlighted a household head having the responsibility of caring for a family is less likely to be willing to adopt index based livestock insurance as the family is prioritised with resource allocation (income). In line with these findings, the results of this study also revealed a negative correlation between household size (HH_Size) and willingness to adopt IBLI. The coefficient parameter for the variable HH_SIZE was found to be statistically significant at 10% level of significance. This evidence suggests that the variable HH_SIZE does affect the willingness to adopt IBLI. Furthermore, this infers that farmers who are heading a larger household are less likely to adopt IBLI to cover their cattle against risks posed by climate change. However, these findings contradict empirical results of Bishu *et al*. (2018) who discovered that the household dependency ratio had a positive and significant influence on farmers' interest in cattle insurance. Hence, the positive correlation would seek to imply that farmers with larger households are more likely to adopt cattle insurance.The results further highlighted that the probability of smallholder cattle farmers with larger household sizes not to be willing to adopt IBLI decreases by 0.002 percentage point when compared to those with lower household sizes.

5.3.5. Access to extension services (A_EXT)

Access to extension services is one of the important factors hypothesized to have a positive influence on the willingness to adopt IBLI among smallholder cattle farmers. The parameter estimates of the coefficient for the variable A_EXT as indicated in Table 5.3 revealed a positive association with the willingness to adopt IBLI. Furthermore, the variable A_EXT is very statistically significant at 5% level of significance. This implies that there is sufficient evidence to suggest that access to extension services among smallholder cattle farmers positively influences the willingness to adopt IBLI. With this being the case, this further infers that the farmers who have access to extension services/ extension agent contact are more likely to be willing to adopt IBLI as

compared to their counterparts who do not have access to extension services. These results are in line with findings obtained by Kalapo *et al*. (2020) who discovered a positive correlation between access to extension services and agricultural insurance participation. However, the empirical results of this study contradict findings obtained by Ellis (2017), which revealed that farmers with extension contact were less likely to purchase agricultural insurance owing to being exposed to more information on a variety of risk management strategies. Furthermore, the marginal effects indicate that in comparison to farmers who had no access to extension services, the probability of willingness to adopt among farmers with extension access increases by 0.07 percentage point.

5.3.6. Off-farm income of the sampled smallholder cattle farmers

The estimated coefficient of off-farm income (OFF_INC) showed a highly significant (i.e., at 1% level of significance) and positive effect on willingness to adopt IBLI, indicating that farmers who have an off-farm source of income are more likely to be willing to adopt IBLI. For instance, an increase in household income due to an off-farm source of income may increase the capacity of a farmer to be willing to explore IBLI as a climate risk mitigation strategy on their farm as they would have the money to pay regular premiums. These findings are in line with prior expectations and findings of Tlholoe (2016). On the other hand, the results are inconsistent with Tang *et al*. (2021) who found a negative correlation between off-farm income and the demand for agricultural insurance. Additionally, the marginal effects for the estimated parameter of off-farm income (OFF_INC) indicate that as opposed to farmers with no off-farm income, the probability of willingness to adopt IBLI increase by 0.039 percentage point among the smallholder cattle farmers having off-farm income.

5.3.7. Farm size of smallholder cattle farmers (FRM_SIZE)

Contrary to prior expectations, the empirical evidence with reference to Table 5.3 indicate a negative sign of the estimated coefficient of farm size (FRM_SIZE). This implies that there is an inverse relationship between the farm size (total livestock owned by the smallholder cattle farmers) and the willingness to adopt IBLI. Furthermore, there is sufficient evidence from the results to suggest that the variable

FRM_EXP affects smallholder cattle farmers' willingness to adopt IBLI. This is because the results revealed that farm size is statistically significant at a level of 5%. These findings are in conformity to the empirical evidence by Runganga & Mumbengegwi (2020) who found a negative correlation between farm size and willingness to adopt crop insurance among smallholder commercial farmers in Zimbabwe. However, findings of this study contradict the results of Stojanović *et al*. (2019) who found a positive relationship between farm size and willingness to purchase yield insurance. A supporting argument to these (negative relationship) results of the study can be the assumption that smallholder cattle farmers have a relatively low income and store their wealth in cattle, thus a low number of cattle owned may imply inability to pay potential insurance premiums or access credit facilities owing to lack of collateral. Furthermore, the marginal effects for the estimated coefficient of farm size (FRM_SIZE) revealed that a unit increase in the number of cattle owned reduces probability of these cattle farmers to be willing to adopt IBLI by a percentage point of 0.003.

5.3.8. Land ownership by smallholder cattle farmers (L_OWN)

In conformity with prior expectations, land ownership by smallholder cattle farmers was found to have a positively significant effect on willingness to adopt IBLI. The estimated coefficient for the variable L_OWN was found to be positive and significant at 10% level significance, indicating that farmers who have land ownership are more likely to be willing to adopt index-based livestock insurance as compared to their counterparts who have no ownership rights to the land which they practice cattle farming on. These findings are consistent with those of Abugri *et al*. (2017) who found land ownership to be positively and significantly (at 5% level of significance) influencing farmers' participation decision in the drought index insurance scheme. The results are also supported by Holden & Ghebru (2016) who argued that secure land rights enhance investment and can provide collateral for landholders to access credit for investment towards improving the productivity of land. In such a case the assumption is farmers need to enhance their investment in cattle would take up IBLI with the purpose of mitigating risks introduced by climate change to their farms. Likewise, the marginal effects for the estimated parameter for land ownership (L_OWN) suggest that the probability of willingness to adopt IBLI among cattle farmers

who own land increases by 0.057 percentage point as compared to their landless counterparts.

5.3.9. Experience of Livestock loss due to climate change (L_LOSS)

The results also provided evidence of the significance ($p<0.05$) of experience of livestock due to climate change towards the willingness to adopt IBLI. In line with prior expectations, experience of livestock loss was assumed to have a positive relationship with willingness to adopt IBLI as a farmer response to climate risks which affect their farm negatively. However, the empirical results in Table 5.3 indicated the opposite to our expectations. The estimated coefficient livestock loss (L_LOSS) was found to be negative and significant in influence to the willingness to adopt IBLI, which implies that farmers who experienced livestock loss are less likely to adopt IBLI. This inference can be supported by Abugri *et al*. (2017) who postulated that the negative correlation of experience of damaged caused by extreme climate towards participation in drought index insurance could be linked to the fact that even though farms are at risk, the damaged caused could have triggered a different remedy/assistance instead of drought index insurance. Contrary to the findings of this study, Tlholoe (2016), discovered that experience of loss had a positive and significant influence on farmers' willingness to buy IBLI which implied that farmers who had experienced livestock loss were more likely to take out an insurance policy (IBLI) than those who had not experienced any loss. However, the marginal effects for the estimated coefficient of livestock loss (L_LOSS) suggest that there is less (0.026) probability for smallholder cattle farmers who experienced livestock loss due to climate change to be willing to adopt IBLI

5.4. Discussion on insignificant explanatory variables

5.4.1. Age of the sampled smallholder cattle farmers

Age of the farmer in this study was hypothesized to have either a positive or negative effect upon the willingness to adopt IBLI. The variable AGE was assumed to be associated to experience, wherein older farmers are assumed to have more experience with risk and are expected to adopt IBLI to mitigate climate risk. On the

other hand, AGE was also expected to have a negative effect on the willingness to adopt IBLI based on the assumption that with old age farmers have had sufficient exposure to different risk management strategies and may be less likely to adopt IBLI. In support of these expectations, findings of this study revealed that the sign coefficient of the parameter for variable AGE was positive. This implies a positive association between the age of a smallholder cattle farmer and the willingness to adopt IBLI, which further infers that the older farmers are more likely to adopt IBLI. These findings are in line with empirical findings of Isaboke *et al*. (2016) who highlighted that experience that comes with old age in farmers may lead to a greater likelihood of assessing and actually adopting weather index insurance. However, since the variable AGE was not found to be statistically significant in this study, there is insufficient evidence to suggest that AGE has an influence on the willingness to adopt IBLI among smallholder cattle farmers.

5.4.2. Gender of the sampled smallholder cattle farmers

Evidence of the estimated coefficient for GENDER from the results in Table 5.3 show that the variable GENDER has a negative correlation with willingness to adopt IBLI. This implies that male farmers had a lower likelihood of adopting IBLI on their cattle farms. These findings are consistent with the empirical results of Abugri *et al*. (2017) who also found the sex of the farmer to negatively influence farmers' decision to participate in drought index insurance. However, the variable GENDER was not found to be statistically siginificant in this analysis, hence this suggests that there isn't enough evidence to conclude that the variable has an impact on the willingness to adopt IBLI among the sampled smallholder cattle farmers.

5.4.3. Credit access by smallholder cattle farmers (CRED_A)

Credit access (CRED_A) is one of the important factors which can enable a smallholder cattle farmer the ability to take out an insurance policy for their cattle and also meet regular premium settlements. The variable CRED_A was hypothesized to have a positive correlation with the willingness to adopt IBLI among smallholder cattle farmers. In conformity with this prior expectation, credit access (CRED_A) was found to be positively associated with willingness to adopt IBLI. These findings are in line with those of Kalapo *et al*. (2020) who also found the existence of a positive correlation

between access to credit facilities by farmers and their participation in agricultural insurance. However, with reference to Table 5.3 there is no sufficient information to suggest that access to credit affects willingness to adopt IBLI as the variable (CRED_A) was found to be statistically insignificant

5.4.4. Smallholder cattle farmers' awareness to agricultural insurance (AA_INSUR)

in this study, smallholder cattle farmers' awareness to agricultural insurance (AA_INSUR) was hypothesized to have both a positive and negative influence on willingness to adopt index-based livestock insurance. It was assumed that farmers' awareness to agricultural insurance is positively associated with participation in agricultural insurance and we expected the uptake of IBLI among farmers who are have some information or are aware to agricultural insurance. However, it was also expected that farmers who may have no previous information on agricultural insurance may be willing to adopt IBLI as a new risk management strategy on their farms. The estimated results of the probit regression model in Table 5.3 indicate that the sign for the coefficient of variable AA_INSUR is negative. Therefore, in line with prior expectations, this infers that there is negative relationship between the awareness to agricultural insurance and willingness to adopt IBLI by smallholder cattle farmers. These results contradict with findings obtained by Ellis (2017) who found a positive correlation between awareness of insurance and willingness to purchase. The empirical findings in TABLE 5.3 further revealed that there is insufficient evidence to suggest that awareness to agricultural insurance (AA_INSUR) significantly influences smallholder cattle farmers' willingness to adopt IBLI since the variable is not statistically significant.

5.4.5. Farm income of the sampled smallholder cattle farmers

Farm income as a major source of household income was hypothesized to have a positive relationship with the willingness to adopt IBLI. To our expectation, the estimated coefficient parameter for farm income (FRM_INC) was found to be positively associated with the willingness to adopt IBLI. These results did not conform to some previous studies (Abugri *et al*., 2017; Falola *et al*., 2013) which indicated a negative

correlation between farm income and willingness to participate in agricultural insurance. However, the variable FRM_INC was not statisitically significant in this study. Thus, there is not enough evidence to suggest that farm income influences the willingness to adopt IBLI.

5.5. Summary

This chapter provided the empirical results of the study and provided discussion on the results of farmers' perceptions of climate change components as sources of risk to their farms. Furthermore, the results of the probit model were discussed in detail for both the significant and insignificant variables which are summarized in the next and final chapter of this study.

CHAPTER SIX

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Recap of research objectives and methodology

Several studies (Ngarava *et al*., 2019; Mafukata, 2015; Ndoro *et al*., 2014) have highlighted the importance of livestock farming in the creation of wealth and improvement in the livelihoods of poor households in rural areas. However, with climate change currently being one of the environmental challenges in today's world (Linn & Maenhout, 2019). Limpopo as a semi-arid province experiences low and variable rainfall leading to the emergence of drought conditions whose scope of negative effects are to the extent of livestock losses (Maponya & Mpandeli, 2012). Several African countries have attempted to address such challenges by introducing Index-Based Livestock Insurance (IBLI) which serves as a micro-insurance product that responds to a specific location's forage availability over a set time using satellite tracking to determine a potential indemnity pay-out to policyholders (Ikegami & Sheahan, 2014). However, one of the key reasons to the struggles of smallholder farmers in South Africa is the inability to obtain effective insurance as a risk management option against weather extremes which threaten their production (Partridge & Wagner, 2016; Tlholoe, 2016). While, insurance proves relevant seeing how climate change's increased frequency and severity of weather extremes imply a threat to the sustainability of cattle farming and livelihoods. Therefore, the study intended to provide an analysis of the determinants of smallholder cattle farmers (who are potential stakeholders)' willingness to adopt index-based livestock insurance as a climate risk adaptation strategy in the Polokwane Local Municipality.

The specific objectives of the study were to: Profile the socio-economic features of smallholder cattle farmers in the Polokwane Local Municipality; Identify smallholder cattle farmers' perceptions on climate related issues as sources of risk to cattle production, and study the determinants of willingness to adopt IBLI. The study objectives were addressed using descriptive statistics, Principal Component Analysis and the Probit regression model respectively.

The remaining sections in this chapter are organised as follows: Section 6.2 presents conclusions based on the empirical results. Section 6.3 continues to provide policy recommendations of this study, and the chapter concludes with the suggested areas for further research.

6.2. Conclusion

6.1.1. Smallholder cattle farmers' perceptions on components of climate change as sources of risk to cattle production

From the Principal Component Analysis, the results obtained for the Kaiser-Meyer-Olkin's measure of sampling adequacy and Barlett's test of sphericity chi-square were 0.579 and 145.952 respectively. This suggested Principal Component Analysis (PCA) an appropriate tool to provide a significant reduction in the number of variables identified. The three extracted PCs that had eigenvalues of at least one were compared with original 8 sources of climate risk (variables) in Table 5.1. The results indicate that the three PCs explained almost 61% of the variance of the original variables. The results further revealed that all the original 8 variables were perceived as sources of climate risk to cattle production by the sampled smallholder cattle farmers in the PLM. The results of the PCA also provided evidence sufficient enough to reject the null hypothesis which stated that *Smallholder cattle farmers do not perceive the components of climate change as sources of risk to cattle production.*

6.1.2. Determinants of smallholder cattle farmers willingness to adopt index-based livestock insurance

The third objective was to analyse the determinants of willingness to adopt index-based livestock insurance. This objective was addressed using the Probit regression. The empirical findings indicated that farmer's willingness to adopt IBLI was positively and significantly influenced by marital status (MARI_S), farming experience (FRM_EXP), access to extension services (A_EXT), off-farm income (OFF_INC) and land ownership (L_OWN). On the other hand, educational level, household size, experience of livestock loss (L_LOSS) and farm size (FRM_SIZE) negatively and significantly affected farmers' willingness to adopt IBLI. The results provided sufficient evidence for the null hypothesis (*determinant factors do not have a significant*

influence upon the smallholder cattle farmers' willingness to adopt IBLI in the PLM) to be rejected.

6.3. Policy recommendations

The following recommendations are made in accordance with the findings of the study:

i. The study recommends the implementation of workshops which focus of creating awareness IBLI to smallholder cattle farmers as the study survey indicated that most of the sampled farmers had no knowledge of IBLI let alone any agricultural insurance scheme. Such initiatives by insurance companies and or the government will assist in design and implementation of IBLI. This will further assist farmers understand the insurance product well and have their recommendations considered in the design of the insurance product.

ii. The findings revealed that majority of the sampled farmers were more willing to adopt IBLI on their cattle farms to mitigate climate risks facing their cattle production activities. However, majority of the farmers (64.5%) in the study indicated reliance on pensions (largely old age pension grants) which may place financial strain on them if they have to use the grant for both livelihood support and insurance premiums. Therefore, the study recommends the development and provision of a government subsidy to sponsor IBLI so that farmers can afford the product premiums such that it becomes a sustainable climate risk mitigation strategy for smallholder cattle farmers.

iii. Finally, the study recommends that extension contact with smallholder cattle farmers should be enhanced because at best the sampled farmers who had access to extension services only received two visits per year. Therefore, increasing access and the number of visits from extension agents may increase information access and awareness to climate risks and coping strategies such as insurance (i.e., IBLI). Furthermore, this may improve government's design

and implementation of strategies of enhancing the smallholder farming sector in the face of climate change among

6.4. Suggested areas for further research

A similar study may be considered with (i) a fairly representative sample size using (ii) an estimation method that considers and deals with the likely existence of sample selection, and finally (iii) distinguish between the determinants of adoption decision and actual amount cattle farmers are willingness to adopt IBLI.

REFERENCES

Abugri, S. A., Amikuzuno, J. & Daadi, E. B., 2017. Looking out for a better mitigation strategy: smallholder farmers' willingness to pay for drought-index crop insurance premium in the Northern Region of Ghana. *Agriculture & Food Security,* 6(71).

Amare, A., Simane, B., Nyangaga, J., Defisa, A., Hamza, D. & Gurmessa, B., 2019. Index-based livestock insurance to manage climate risks in Borena zone of southern Oromia, ethopia. *Climate Risk Management,* 25(100191), pp. 1-15.

Afroz, R., Akhtar, R. & Farhana , P., 2017. Willingness to pay for crop insurance to adapt flood risk by Malaysian farmers: An empirical investigation of Kedah. *International Journal of Economics and Financial issues,* 7(4), pp. 1-9.

Agency for Rangeland Information and development in Kenya (ARID Kenya), 2018. *Index-based livestock insurance as an innovative tool against drought loss,* Wageningen: The Technical Centre for Agricultural and Rural Cooperation(CTA).

Aina, I., Ayinde, O. E., Thiam, D. & Miranda , M., 2018. *Willingness to Pay for Index-Based Livestock Insurance: Perspectives from West Africa. proceedings from International Association of agricultural Economists (IAAE).* Vancouver, UK, IAAE.

Ali, S., Ying, L., Nazir, A., Abdullah, Ishaq, M., Shah, T. & Tariq, A., 2020. Rural farmers'Perception and coping strategies towards climate change and their determniants: Evidence from Khyber Pakhtunkhwa Province, Pakistan. *Journal of Cleaner Production.*

Ankrah, D. A., Kwapong, N. A., Eghan, D., Adarkwah, F. & Boateng-Gyambiby, D., 2021. Agricultural insurance access and acceptability: examining the case of smallholder farmers in Ghana. *Agricultural & Food Security,* 10(19), pp. 1-14.

Barnett, B. J., 2004. *Agricultural Index Insurance Products: Strengths and Limitations,* Georgia: Agricultural Outlook Forum.

Bishu, K. G., Lahiff, E., O'Reilly, S. & Gebregziabher, M., 2018. Drivers of farmers' cattle insurance decisions: evidence from smallholders in northern Ethopia. *AGREKON,* 57(1), pp. 40-48.

Carpenter, R., 2018. *Index Insurance: Status and Regulatory Challenges,* Eschborn: Access to Insurance Initiative.

Castellani, D. & Vigano, L., 2015. An Analysis Of The Demand Of Weather Index-Based Insurance With Flexible Attributes In A Risk Management Framework. *European Scientific Journal,* 11(16), pp. 1-22.

Chingala, G., Mapiye, C., Raffrenato, E., Hoffman, L. & Dzama, K., 2017. Determinants of smallhlder farmers' perceptions of impacts of climate change on beef production in Malawi. *Climate Change,* Volume 142, pp. 129-141

Department of Agriculture, Forestry and Fisheries(DAFF), 2019. *A framework for the development of smallholder farmers through cooperatives development,* Pretoria: Directorate Co-operative and Enterprise Development: DAFF.

Di Marcantonio, F., 2016. Index-Based Insurance Challenges and Socio-Economic Considerations. The IBLI_Kenya Case. *Geoprogress Journal,* 3(1), pp. 31-48.

Ellis, E., 2017. Willingness to pay for index based crop insurance in Ghana. *Asian Economic and Financial Review,* 7(7), pp. 700-721.

Fakade, S., 2016. Potential of Jozini smallholder cattle farmers to progress from subsistence to commercial cattle farming for enhanced rural livelihood: Thesis, Pietermaritzburg: University of KwaZulu-Natal.

Falola, A., Ayinde, O. E. & Agboola, B. O., 2013. willingness to take agricultural insurance by cocoa farmers in Nigeria. *International Journal of Food and Agricultural Economics,* 1(1), pp. 97-107.

Food and Agricultural Organisation (FAO), 2012. *Smallholders and Family Farmers,* Rome: FAO.

Fonta, W. M., Sanfo, S., Kedir, A. M. & Thiam, D. R., 2018. Estimating farmers' willingness to pay for weather index-based crop insurance uptake in west Africa: Insight from a prilot initiative in Southwestern Burkina Faso. *Agricultural and Food Economics,* 6(11).

Gulseven,O., 2014. Estimating the demand factors and willingess to pay for agricultural insurance. *Australian Journal of Engineering Research,* 1(4), pp. 13-18.

Gupta, A. K., Yadav, D., Gupta, P., Gupta, V., Ranjan, S. & Badhai, S ., 2020. Effects of Climate Change of Agriculture. *Food and Agriculture Spectrum Journal,* 1(3).

Gwaka, L. & Dubihlela, J., 2020. The Resilience of Smallholder Livestock Farmers in Sub-Saharan Africa and the Risks Imbedded in Rural Livestock Systems. *Agriculture,* 10(270).

Holden, S. T. & Ghebru, H., 2016. Land tenure reforms, tenure security and food security in poor agrarian economies: Causal linkages and research gap. *Global Food Security,* Volume 10, pp. 21-28.

Ikegami, M. & Sheahan, M., 2014. Index Based Livestock Insurance (IBLI)*: Borena Household Survey Codebook,* Nairobi: International Livestock research Institute.

Isaboke, H. N., Qiao, Z., Nyarindo, W. N. & Ke, W., 2016. Explaining the Perceptions of Smallholders Towards Weather Index Micro-Insurance alongside Risks and Coping Strategies. *International Journal of Food and Agricultural Economics,* 4(4), pp. 59-77.

Isaga, N., 2018. Access to bank credit by smallholder farmers in Tanzania: a case study. *Afrika Focus*, 31(1), pp. 241-256.

Jabbar, A., Wu, Q., Peng, J., Sher, A., Imran, A. & Wang, K., 2020. Mitigating Catastrophic Risks and Food Security Threats: Effects of Land Ownership in Southern Punjab, Pakistan. *International Journal of Environmental research and Public Health,* 17(9258).

Jarzabkowski, P., Chalkias, K., Clarke, D., Iyahen, E., Stadtmueller, D. & Zwick, A., 2019. *Insurance for climate adaptation: Opportunities and limitations,* Rotterdam and Washington, DC: Global Commission on Adaptation.

Jellason, N. P., Conway, J. S., Baines, R. N. & Ogbaga, C. C., 2020. A review of farming challenges and resilience management in the Sudano-Sahelian drylands of Nigeria in an era of climate change. *Journal of Arid Environments,* 186(2021).

Jensen, N. & Barret, C., 2016. Agricultural Index Insurance for Development. *Applied Economic Perspectives and Policy,* 39(2), pp. 199-219.

Jin, j., Wang, W. Y. & Wang, X. M., 2016. Farmers' risk preferences and agricultural weather index insurance uptake in china in rural China. *International Journal of Distaster Risk Science,* 7(3), pp. 366-373.

Karimi, V., Karimi, E. & Keshavarz, M., 2018. Climate change and agriculture: Impacts and adaptive responses in Iran. *Journal of Integrative Agriculture,* 17(1), pp. 1-15.

Khan, M. A., Chander, M. & Bardhan , D., 2013. Willingness to pay for cattle and buffalo insurance:an analysis of dairy farmers in central India. *Tropical Animal Health abd Production,* Issue 45, p. 461–468.

Kolapo, A., Oladejo, O. O., Muhammed, O. A. & Kolapo, A. J., 2020. Institutional Factors and Crop Farmer's Participation in Agricultural Insurance Scheme: Evidence from South Western Nigeria. *International Journal of Environmental & Agriculture Research,* 6(5), pp. 13-21.

Leso, L. K., Elansary, H. O., Mearns, K. & Yessoufou, K., 2017. Ethnobiotany at a local scale: diversisty of knowledge of medicial plants and assessment of cultural importance in the Polokwane Local Municipality, South Africa. *Botany Letters.*

Linn, T. & Maenhout, B., 2019. The impact of environmental uncertainity on the performance of the rice supply chain in the Ayeyarwaddy region, Myanmar. ,7(11).1-29. *Agricultural and Food Economics,* 7(11), pp. 1-29.

Mafukata, M. A., 2015. Factors having the most significance on the choice and selection of marketing channels amongst communal cattle farmers in the Vhembe District. *Journal of Human Ecology,* Volume 49, pp. 77-87.

Makate, C., Makate, M., Mutenje, M., Mango, N. & Siziba, S. , 2019. Synergistic impacts of agricultural credit and exxtension on adoption of climate-smart agricultural technologies in southern Africa. *Environmental Development,* Volume 32, pp. 1-15.

Malhi , G. S., Kaur, M. & Kaushik, P., 2021. Impacts of Climate Change on Agriculture and Its Mitigation Strategies: A review. *Sustainability,* 13(1318).

Maltou, R., & Bahta, Y. T., 2019. Factors influencing the resilience of smallholder livestock farmers to agriculutral drought in South Africa: Implication for adaptive capabilities. *Journal of Disaster Risk Studies*, 11 (1),pp. 805.

Moyo, T., 2010. *Determinants of participation of smallholder farmers in the marketing of small grains and strategies for improving their participation in the Limpopo River Basin of Zimbabwe: Msc Thesis,* Pretoria: University of Pretoria.

Mapfumo, S. 2007.Weather index insurance: The Case for South Africa, Micro insurance Agency, Opportunity International Network.

Mapiye , O., Makombe, G., Mapiye, C. & Dzama, K., 2018. Limitations and prospects of improving beef cattle production in the smallholder sector: a case of Limpopo

Maponya, P. & Mpandeli, S., 2012. Impact of drought on food scarcity in Limpopo province, South Africa. *African Journal of Agricultural Research,* 7(37), pp. 5270-5277.

Mdoda, L., Mushunje, A., Olajide, A. K. & Lesala, M. E., 2020. Climate Change Effects on Agricultural Productivity in the Smallholder Farming Systems of the Eastern Cape Province, South Africa. *Journal of Human Ecology,* 71(1-3), pp. 236-244.

Ndoro, J. T., Mudhara, M. & Chimonyo, M., 2014. Cattle commercialization in Rural South Africa: Livelihoods Drivers and Implications for Livestock Marketing Extension. *Journal of Human Ecology,* Volume 45, pp. 207-221.

Ngarava, S., Phetshe, M. & Mushunje , A., 2019. Market Awareness and Participation for Cattle Farmers in the Kaonafatso ya Dikgomo(KyD) Scheme in KwaZulu-Natal Province, South Africa. *Agriculture,* 9(215).

Nnadi , F. N., Nnadi, C. D., Chikaire, J., Umunnakwe, P. C. & Ihenadcho, R. A., 2013. Analysis of rural cassava farmers' participation in the Nigeria agricultural insurance

scheme in Imo State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary,* 13(11), pp. 1-8.

Nshakira-Rukundo, E., Kamau, J. W. & Baumüller, H., 2021. Determinants of uptake and strategies to improve agricultural insurance in Africa: a review. *Environment and Development Economics,* pp. 1-27.

Oduniyi, O. S., Antwi, M. A. & Tekana, S. S., 2020a. Farmers' Willingness to Pay for Index-Based Livestock Insurance in the North West of South Africa. *Climate,* 8(3), p. 47.

Oduniyi, O. S., Rubhara, T. T. & Antwi, M. A., 2020b. Sustainability of Livestock Farming in South Africa. Outlook on Production Constraints, Climate-Related Events, and Upshot on Adaptive Capacity. *Sustainability,* 12(2582).

Okpukpara, B. C., Ukwuaba, I. C. & Adebayo, O., 2021. Determeninats of Access and Extend of Use of Agricultural Insurance Schemesby Small-Scale Farmers in Kogi State, Nigeria. *Review of Agricultural and Applied Economics,* 24(1), pp. 88-97.

Partridge, A.G. & Wagner, N.J., 2016. Risky business: agricultural insurance in the face of climate change: *Agriprobe,* 13(3), pp. 49-53

Polokwane IDP document, 2020. *Integrated Development Plan 2020/2021,* Polokwane: Polokwane Local Municipality.

Polokwane IDP document, 2017. *Integrated Development Plan*: 2017/2018, Polokwane : Polokwanwane Local Municipality.

Porrini, D., Fusco , G. & Miglietta, P. P., 2019. Post-Adversities Recovery and Profitability: The Case of Italian Farmers. *International Journal of Environmental Research and Public Heatlth,* 16(17), p. 3189.

Ramoroka, K. H., 2012. *Participation and utilisation of formal vegetable markets by sdmallholder farmers in Limpopo: A Tobit II approach Msc. Mini-dissertation ,* Polokwane: University of Limpopo.

Runganga, R. & Mumbengegwi, C., 2020. A Double-hurdle Model Estimation of Smallholder Commercial Farmers' willingness to Adopt Crop Insurance in Zimbabwe: A Caseof Mazowe district. *International Journal of Research and Scientific Innovation (IJRSI),* 7(9), pp. 339-348.

Stojanović, Ž., Rakonjac-Antić, T. & Koprivica, M., 2019. Farmers' Willingness to Purchase Crop Insurance: Evidence from Wheat And Raspberry Sectors in Serbia. *Economics of Agriculture,* 66(4), pp. 1107-1125.

Tang, Y., Cai, H. & Liu, R., 2021. Farmers' Demand for Informal Rsk Managment Strategy and Weather Index Insurance: Evidence from China. *International Journal of Distaster Risk Science.*

Statistics South Africa(StatsSA), 2019. Census 2011[Online]. Available at : www.statssa.co.za

Tlholoe , M. M., 2016. *Smallholder livestock farmers' willingness to buy index-based insurance in South Africa: Evidence from Ngaka Modiri Molema District Municipality, North West Province: MSc Thesis,* Mafikeng: North-West University.

UNFCCC, 2011. *Fact sheet: Climate change science - the status of climate change science today ,* Bonn: United Nations Framework Convention on Climate Change.

APPENDIX A: CONSENT LETTER & FORM

Faculty of Science and Agriculture

RESEARCH PROJECT TITLE: Smallholder cattle farmers' willingness to adopt index-based livestock insurance in the face of climate change: evidence from Polokwane local Municipality, Limpopo Province

Dear Participant,
You are requested to participate in above mentioned research study conducted by Maekela KF (MSc Agricultural Economics student at the University of Limpopo). You were purposively selected as a participant in this study because you are one of the smallholder cattle farmers in the Polokwane Local Municipality

1. PURPOSE OF THE STUDY

This research project aims to establish the determinants of willingness to adopt index-based livestock insurance as a risk management tool among smallholder cattle farmers the in the Polokwane Local Municipality.

2. PROCEDURES

As the investigator I would like you volunteer to participate in this study where I would request you to agree to be interviewed in person or via telephone by me.

3. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

This research will help in establishing the determinants of willingness to adopt index-based livestock insurance by smallholder cattle farmers which may assist in policy development on climate risk management in cattle production. Your cooperation will be highly appreciated; however, your participation is voluntary.

4 CONFIDENTIALITY

Information to obtained from the participants for this study will remain confidential and only be disclosed with their permission. Confidentiality of all the research data will be maintained by the investigator. Additionally, the identities of the respondents will not be revealed in the research report.

5 PARTICIPATION AND WITHDRAWAL

For this study you have the choice of participation or no participation. If you volunteer to be in this study, you may withdraw at any time without any consequences. You

may also refuse to answer any questions you don't want to answer and still remain in the study. The investigators may withdraw you from this research if circumstances arise which warrant doing so.

6. IDENTIFICATION OF INVESTIGATORS

In situation where you have any questions or concerns about the research, please feel free to contact the following individuals:

Researcher : Mr. KF Maekela
E-mail: fmaekela@outlook.com
Contacts: 0723297504

Supervisors : Dr. MA Nkoana
E-mail: andrias.nkoana@ul.ac.za
Tel: 0152684628
Prof. JJ Hlongwane
E-Mail: jan.hlongwane@ul.ac.za
Tel: 0152682372

7. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty.

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to me by …… (Enumerator). I was given the opportunity to ask questions and these questions were answered to my satisfaction. I hereby consent voluntarily to participate in this study. I have been given a copy of this form.

_____
Name of Subject/Participant

_____ _____
Signature of Subject/Participant Date:

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____ [*name of the subject/participant].* He/she was encouraged and given enough time to ask me any questions.

Signature of Investigator :_____Date:_____

APPENDIX B*:* QUESTIONNAIRE

QUESTIONNAIRE PARTICULARS			
Time	Municipality Cluster	Village/Area	Questionnaire Reference number
Date			

Please use X to complete where applicable

SECTION A: FARMERS'S DEMOGRAPHIC CHARACTERISTCS

1. NB: Household members refer to members who live, cook and eat from the same food stock together in the household for at least the last six months.

Household members (Total including household head)	**Marital status**	**Gender 1= male 2=female**	**Age**	**No. of School years**	**Highest level of formal education**	**Employment status**

Key: Use the codes mentioned in the table below to answer the table above.

Marital status	**Highest level of formal education**	**Employment status**
1 Married 2 Single 3 Divorced 4 Widowed	1 Never attended school 2 Primary level 3 Secondary level but did not complete matric 4 Matriculated 5 Tertiary level	1 Unemployed 2 Permanent employment 3 Temporarily employment 4 Contract employment

SECTION B. HOUSEHOLD KEY SOCIO-ECONOMIC CHARACTERISTICS

2. Household income on a monthly basis

2.1. Have you ever taken credit to finance your farm? Yes [ ] No [ ]

2.2. Please provide information on your major sources of monthly household income.

Household income sources	**Not Applicable**	R0-R499	R500-1499	R1500-R2499	R2500-R3499	R3500-R4499	R4500 and greater
Beef cattle production							
Dairy							
Pensions							

Formal employment/Salary							
Gifts from relatives							
Social grants							
Other: specify							

SECTION B: FARM CHARACTERISTICS

3. Land tenure system (please indicate where your livestock graze)?

Private Lease		Permission to occupy	
Communal		Other (specify)	
Renting			

4. How long have you been practicing cattle farming?

……

5. **LIVESTOCK OWNERSHIP**

Type of livestock owned	**Number owned**	**Current value per unit (R)**
Cows		
calves		
Oxen		
Heifers		
Others: specify		

6. Does your farm receive visits from extension officers or any services from extension office? Yes [ ] No [ ]

   6.1. If yes, specify frequency of visits and or describe nature of service

   ……

   ……

   ……

   6.2. If yes, who provides the services?

Government	If Other, specify

SECTION D: CLIMATE RELATED RISK AND MANAGEMENT STRATEGIES

7. What is your perception of the following climate related issues as sources of risk for your cattle farm?

(please indicate, 0= Not a concern, 1=Very low,2= Low, 3= Moderate, 4=High, and 5= Very high)

	0	1	2	3	4	5	Number of cattle lost due to the risk in the past 2 years
High rainfall							
Low rainfall							
Flood							
drought							
Very low temperature							
Very high temperature							
Strong winds							
Pests and diseases							

8. Are you aware of any agricultural insurance scheme provides insurances against the following risks?

Risk Type	**Yes**	**No**	**If yes, do you have membership to the scheme**		**If no, why are you not participating in the scheme**
			Yes	No	
Weather Risks					
Price risks					
Production/technical risks					

SECTION E: WILLINGNESS TO ADOPT INDEX BASED INSURANCE

9. Index-based insurance (IBLI) is an innovative micro insurance product that protects against potential losses of livestock due to weather fluctuations. The product uses satellite technology to monitor forage availability in a specific area over a time thus offering a payout based on the external indicator that triggers a payment which limits challenges associated with potential payment information being available to only one party (the insurer or the policy holder). This IBLI is designed to offer protection against livestock loss in situations of prolonged forage scarcity, this will ensure you can buy feed for your livestock with the payout in periods of drought which can cause scarcity of forage. This will allow your cattle to maintain good quality even under drought conditions and help avoid cattle losses.

9.1. If index-based insurance was to be introduced as a climate risk management strategy such that whenever there is rainfall deficit or lack of forage, the insurance will protect you against any loss. Would you adopt it (the insurance) and obtain a policy to cover 100% of your livestock? Yes [ ] No [ ]
9.2. If no to 9.1, please state reasons.
9.3. If "YES" to 9.1. Should the premium increase by 10%, would you still be willing to pay insurance cover for 100% of your stock? Yes [ ] No [ ]
9.4. If "NO" to 9.3. Would you accept if the government offers to pay for the 10% premium increase, allowing you to pay insurance for 90% of the value of your animal stock? Yes [ ] No [ ]

SECTION F: LIVELIHOOD ADAPTATION STRATEGIES TO COPE WITH CLIMATE CHANGE

10. When your dependency on cattle is threatened, will you take up new agricultural or economic activities?

Yes	No	Never thought of any but might do

10.1. If yes, what kind of agricultural or economic activities would you take up?

……
……
……

10.2. Please tick in the table below and rank according to your first choice of preference, where one (1) represents the most important.

Livelihood adaptation strategies	Please tick	Rank
Crop production		
Off-farm activities		
Home gardening		
Informal temporary employment		
Others: specify		

Please give us any comments in the weather or the seasons, and change in adaptation strategies from a cattle production point of view in your community.

……
……
……

THANK YOU FOR PARTICIPATING IN THIS STUDY AND KINDLY INFORMING US