ANALYSIS OF RISK MANAGEMENT STRATEGIES AMONG POTATO (*Solanum tuberosum*) SMALLHOLDER FARMERS IN NJOMBE TOWN COUNCIL, TANZANIA

SEMENI NGOZI

A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Doctor of Philosophy Degree in Agribusiness Management of Egerton University

EGERTON UNIVERSITY

NOVEMBER 2021

DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has not been submitted in this or any other university for the award of a degree.

Signature **:**  Date: **22/11/2021**

Semeni Ngozi

KD23/13040/17

Recommendation

This thesis has been submitted with our approval as University Supervisors.

Signature**:**  Date: **22/11/2021**

Prof. Patience Mshenga

Professor, Department of Agricultural Economics and Agribusiness Management, Egerton University

Signature**:**  Date: **22/11/2021**

Dr. Isaac Maina Kariuki

Senior Lecturer, Department of Agricultural Economics and Agribusiness Management, Egerton University

Signature **:**  Date: **22/11/2021**

Dr. Aloyce Hepelwa

Senior Lecturer, Department of Agricultural Economics and Business Studies, University of Dar es Salaam

COPYRIGHT

DEDICATION

For bringing me through my studies, I dedicate this thesis to the Almighty God, the source of salvation, strength, and knowledge. I also dedicate this work to my mother, for her constant support and trust, which have helped me achieve this goal

ACKNOWLEDGEMENTS

First and foremost, I am grateful to the Almighty God for his numerous favours direction and protection throughout my Ph.D. studies. I would like to express my gratitude to the World Bank through the Center of Excellence in Sustainable Agriculture and Agribusiness Management (CESAAM) for providing full funding (tuition fees, research funds, and a stipend). Egerton University has also been extremely accommodating in allowing me to enroll in this program, as well as for all of the assistance and support I received from the University's offices during the process. Professor Patience M. Mshenga, Dr. Isaac M. Kariuki and Dr. Aloyce S. Hepelwa, my supervisors deserve special recognition. My words are incomprehensible for their irreplaceable support and assistance throughout my P.h.D. studies. Thanks to Professor Jiqin HAN for her generosity and guidance during data entry and analysis at Nanjing Agricultural University for the six-month exchange visit under the Egerton university-CESAAM program. The support of my colleagues Dr. Bandiougou and Esther Mugure of Egerton University is sincerely acknowledged. My heartfelt thanks are conveyed to Dr. Alex Muremi Fulano for his encouragement and support, especially during my final defence. My mentor, Dr. Rodgers Kakuhenzire of International Potato Center (CIP), receives my acknowledgement for spending his precious time on guidance and mentorship. My beloved mother, Mwanaisha Mhalafu, and my sister Tabia Makwinja accept my profound gratitude and appreciation for all the sacrifices you have endured to finish my Ph.D. studies. Your love and prayers have followed me during this journey.

ABSTRACT

Despite the potential contribution of potato farming to household income and financial resilience among smallholder farmers in Tanzania, the enterprise is typically a risky business. The main risks are associated with production and marketing processes. These risks ultimately reduce potato revenue and limit the optimal profitability of the enterprise. Consequently, potato SHFs may experience welfare problems. This study aimed at contributing towards improved SHFs' income and financial resilience through the use risk management strategies. This is achieved through analyzing the effects of the selected production and market risks on potato farming enterprises and determining the effects of risk management strategies attributes on potato enterprise performance. Furthermore, crop-revenue insurance products and collaborative-based revenue insurance scheme (CoBRIS) contracts for SHFs were designed. A multi-stage sampling technique was employed to obtain 384 potato SHFs. A census was employed to collect data from 8 micro-insurance companies. A semi-structured questionnaire, key informant interview and desktop review were also used to collect data. Descriptive statistics, Content analysis, PACE analysis, multiple linear regression and Conditional Logit Model for data analysis were employed. This study shows that price volatility (72.6%) and bacterial wilt (67.6%) are risks that are likely to affect potato farming enterprises. Majority (66.1%) of potato SHFs perceived price volatility as the most risk that has a very high effect on potato farming enterprises. Every 1% increase in frequency use significantly improved potato enterprise performance by 0.667%. The existing crop-revenue insurance products were described in company-product characteristics, distribution channels and the target markets. MGen insurance company had the highest score (3.94 out of 5) in the aspect of product, access, cost and experience. Crop-revenue insurance companies collaborated with banks, inputs suppliers, off-takers and mobile phone service providers in offering insurance services. Furthermore, 85% of SHFs were willing to participate in the CoBRIS. Coverage level, indemnity, and trust-related factors positively affected potato SHFs' WTP for CoBRIS contracts, while premium amount had a negative effect. The study recommends policies that aim at establishing platforms such as M-Kilimo to improve market information. SHFs to increase the frequency use of risk management strategies to improve potato enterprise performance significantly. The current crop-revenue insurance business model is to be adapted and extended to potato SHFs. Facilitation of potato SHFs into membership groups is also recommended, as this builds more trust among SHFs and increases the probability of becoming more WTP for the CoBRIS contracts.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION ii
ABSTRACT vi
LIST OF TABLES x
LIST OF FIGURES xi
LIST OF ACRONYMS AND ABBREVIATIONS xii

CHAPTER ONE 1
INTRODUCTION 1
1.1 Background Information 1
1.2 Statement of the problem 5
1.3 Objectives 5
1.4 Research questions 6
1.5 Justification of the study 6
1.6 Scope and Limitation of the study 8
1.7 Operational definition of the key terms 9

CHAPTER TWO 10
LITERATURE REVIEW 10
2.1 Conducive Conditions for Potato Production and Climate Change 10
2.2 Importance of Potato enterprise to Smallholder farmers in Tanzania 11
2.3 Variability of Farm revenues amongst Smallholder farmers 11
2.4 Sources of Farm enterprise revenue risks among Smallholder farmers 12
2.5 Studies on the Effects of production and market risks on Farming Enterprises 14
2.6 Risk Management Strategies of Farm enterprises 15
2.7 Agricultural Insurance in Developing countries 19
2.8 Impact of Agricultural insurance on Smallholder Farmers' Welfare 22
2.9 Review of the selected Micro-insurance products 23
2.10 Studies on Willingness to Participate and Pay for Crop insurance among smallholder farmers 25
2.11 Summary of Literature review and the identified Research Gaps 29
2.12 Theoretical framework of the study 29
2.13 Conceptual framework 34

CHAPTER THREE 36
METHODOLOGY 36
3.1 Research Design 36
3.2 Study Area 36
3.3 Target Population of Study 37
3.4 Sampling Procedures 38
3.5 Sample Size Determination 38
3.6 Sources of Data and Methods of data collection 39
3.7 Data Analysis 42

CHAPTER FOUR 53
RESULTS AND DISCUSSIONS 53
4.1 Characteristics of potato smallholder farmers in the study area 53
4.2 Results of Objective one: Analysis of the perceived effect of the selected production and market risks on potato farm income among smallholder farmer 60
4.3 Perceived effect of Climate, Pests, Diseases and Market risks on Potato Farming Enterprise 63
4.4 Results for objective two: Determining the effect of risk management strategies attributes on potato enterprise performance among smallholder farmers 66
4.5 Results for objective three: Analysis of various crop-revenue insurance products that exist for smallholder farmers in Tanzania 88
4.6 Results for objective four: Designing a Collaborative-based Revenue Insurance Scheme (CoBRIS) for Potato smallholder farmers 100

CHAPTER FIVE 115
CONCLUSIONS AND RECOMMENDATIONS 115
5.1 Summary of the findings 115
5.2 Conclusions 116
5.3 Recommendations 117
5.4 Areas for further research 117

REFERENCES 119

APPENDICES 135
Appendix I: A questionnaire for potato smallholder farmers 135
Appendix II: Key informant interview 151
Appendix III: Candidate's publications related to this study 165
Appendix IV: Key Data Analysis Outputs 167
Appendix V: Research permit 170

LIST OF TABLES

Table 1: Distribution of respondents per village 39
Table 2: Description of variables for objective one 43
Table 3: Description of variables for CoBRIS contract 48
Table 4: Household characteristics for Potato smallholder farmers in Tanzania 55
Table 5 : Distribution of Gender, Household status, Group membership and Main income 56
Table 6: Farm characteristics of potato smallholder farmers in Tanzania 58
Table 7: Potato Production Costs and Revenues for Potato smallholder farmers in Tanzania 59
Table 8: Number, Frequency use and costs of risk management strategies 60
Table 9: Multiple regression results of the effect of risk management strategies 88
Table 10: Description of the selected crop-revenue insurance products in Tanzania 90
Table 11: Developed attributes and attribute levels for the CoBRIS contract 102
Table 12: CoBRIS attributes according to their importance to the company and clients ... 104
Table 13: Final attributes included in the CoBRIS contracts 105
Table 14: Designed CoBRIS choice sets 106
Table 15: Correlation Matrix for the developed and validated CoBRIS attributes 107
Table 16: Willingness to participate in CoBRIS contracts in Tanzania 109
Table 17: Regression results of Conditional Logit Model for CoBRIS contract attributes 111
Table 18: Results of Conditional Logit Model for Potato enterprise and Trust related factors 112
Table 19: Marginal willingness to pay for CoBRIS attributes Contract 114

LIST OF FIGURES

Figure 1: Conceptualized relationship among the key variables of the study 35
Figure 2: Map of Tanzania showing study areas 37
Figure 3: Likelihood of climate, pests, diseases and market risks affecting potato farming enterprise 62
Figure 4: Perceived effects of climate, pests, disease and market risks on potato farming enterprise 66
Figure 5: The importance of smallholder farmers preventing the consequence of climate, pests, diseases and market risk on potato enterprise performance 71
Figure 6: Ability of potato smallholder farmers to protect themselves from climate, pests, diseases and market risk 78
Figure 7: Effectiveness of traditional risk management strategies on managing climate, pests, diseases and market risks 85
Figure 8: PACE analysis of the selected crop-revenue insurance products in Tanzania 98
Figure 9: Description of the business model of crop-revenue insurance products 99
Figure 10: Business model for the crop-revenue insurance products in Tanzania 100

LIST OF ACRONYMS AND ABBREVIATIONS

ACRE	Agriculture Climate Research Enterprise
BCF	*Bima* Challenge Fund
BRAC	Building Resources Across Community
CoBRIS	Collaborative-Based Revenue Insurance Scheme
CBHIS	Community Based Health Insurance Scheme
CBO	Community-Based Organization
CCAFS	Climate Change, Agriculture and Food Security
CDTF	Cotton Development Trust Funds
CM	Choice Modeling
FSDT	Financial Sector Deepening Trust
Ha	Hectare
Kg	Kilogram
LAG	*Lusitu* Agribusiness Group
MFIs	Micro Finance Institutions
MIS	Market Information Systems
NADO	Njombe Agricultural Development Organization
NGO	Non-Governmental Organization
OECD	The Organization for Economic Co-operation and Development
PACE	Product, Access, Cost and Experience aspect of crop insurance product
SPSS	Statistical Package for Social Sciences
TADB	Tanzania Agricultural Development Bank
TCB	Tanzania Cotton Board
TMA	Tanzania Metrological Agency
TIRA	Tanzania Insurance Regulatory Authority
VIMC	Volunteer Insurance Management Committee
WB	World Bank

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Potato is the essential tuber crop globally, with an annual production of 382Metric Tones (FAOSTAT, 2017). The global production of potatoes has steadily grown from 267 million metric tons in 1990 to 385.07 million metric tons in 2014 (FAOSTAT, 2017). The people's Republic of China is currently the largest potato producer globally, with a yield of 95,987,500MT (FAOSTAT, 2013). However, China has the lowest average yield of 17.00MT/ha compared to the United States of America (46.66MT/ha), Netherlands (43.65MT/ha) and France (43.27MT/ha) (FAOSTAT, 2013). Of the world-wide production, 2.6 percent of potatoes is traded on the world market. France accounts for 19.7 percent of exports, while Belgium, the Netherlands and Russia are leading in the importation of potatoes, with 31.4 percent. Generally, the trading of processed potatoes, particularly the French fries and chips, is leading in the revenue generation in most of the fast food chains. Over half of potato production takes place in the developing countries, including African countries. Potato production has been increasing in the recent decades, rising from 2 million metric tons in 1960 to over 30 million metric tons in the year 2013. Generally, potatoes are grown under a wide range of conditions, ranging from irrigated commercial farms in Egypt and South Africa to intensively cultivated steamy highland zones of Eastern and Central Africa, primarily as a smallholder farmers' business. The major potato producing countries measured in hectares in Africa are Nigeria, Malawi, Tanzania, Kenya, and Rwanda (FAOSTAT, 2010). In Africa, about 66.67 per cent of smallholder farmers are commercialized in potato production with an average intensity of commercialization of 57.77 per cent (FAOSTAT, 2010).

In Tanzania, the crop is among the leading cash crops for smallholder farmers in Southern highlands potato producing areas. The crop contributes to household income by creating employment to farm labour, market brokers, transporters, processors, food vendors and retailers. Potatoes are more profitable than cereals such as maize and paddy, especially in the Southern highlands of the country, with experts estimating threefold higher income from the crop (Kilimo Trust, 2012). On regular, 88 per cent of all the potato produce is sold out for income generation (Mpogole, 2013). This therefore indicates that potatoes are among the highest commercialized crops in the country. In southern highlands, the crop is extremely treasured in the main producing areas with a substantial contribution of 54 per cent to household income (Kabungo, 2008). The average potato productivity per household is 6.1 MT per season whereby 4.4 MT (71 per cent) is sold, 1.1MT (18 per cent) is lost, 0.3 MT (5 per

cent) is for home consumption, 0.24 (4 per cent) is for seeds, and another 0.12 MT (2 per cent) is donated to neighbours and friends (Kilimo Trust, 2016).

Potato enterprise in most Sub-Saharan countries, including Tanzania, is a risky business. The enterprise faces many types of risks that can affect its profitability and viability. These risks include production, price or market, policy and personal risks (Cervantes-Godoy *et al*., 2013). On the other hand, potato revenue merely depends on potato yield, prices and interfaces between the price and yield. Thus, production variability and variances in the connection between pricing and individual farm-level potato yields are the primary causes of revenue variability between potato farms.

Production risks relate to the possibility that potato produces are lower than projected yield. Drought, frost, or extreme rainfall during harvest or planting are only a few of the significant sources of production risks, as do insect pests and disease outbreaks. These risks are mostly cannot be managed by the potato smallholder farmers themselves. This is because most of these risks are universal and covariate in nature, as with a particular event leading to numerous and extremely interrelated potato losses. Additionally, production risks present a challenge to farmers whose livelihoods depend on income generated from potato farming. Moreover, the risk places a constraint to the potato smallholder farmers especially on their farm income generation and loan acquirement resulted from the high-risk profile. Various agencies in most of the developing countries postulate that the fluctuations in the weather patterns could result in severe volatility in the returns from agriculture crops, with no exception to potatoes (FAO, 2016).

On the other hand, wholesale potato prices in Tanzania are very volatile with prices being high during planting and low at harvesting. However, potato smallholder farmers lack facilities for storing their potatoes to sell when prices are more favourable. This discourages smallholder farmers from selling their potatoes and removes a key incentive to invest more in potato enterprises. The fluctuations in farm incomes caused by potato yield loss, price volatility and potato post-harvest losses may subsequently present welfare problems for rural potato smallholder farmers and other potato actors along the value chain. For instance, potatoes lost through bacterial wilt and late blight reduces employment opportunities for smallholder farmers and limit sales by potato farmers, traders, retailers and agro-processors (Cervantes-Godoy *et al*., 2013). This reduces average income and welfare among value chain actors and the national income from the sub-sector.

Potato smallholder farmers deal with production and market risks through self-insurance strategies. Some of these self-insurance strategies can be ex-ante or ex-post. These strategies

include assets selling, borrowing or engaging in the manufacturing of lower risk but lower return crop varieties (Cervantes-Godoy *et al*., 2013). However, the self-insurance strategies have a tendency to not be effective, efficient or profitable. In addition, these self-insurance strategies may not be suitable to manage a significant level of risks. As a result, the traditional risk management strategies that smallholder farmers employ might in fact, push them into poverty. Agricultural insurance, on the other hand, is a financial contingency contract in which a producer transfers production and market risks to another party in exchange for a premium that reflects the insurer's actual long-term cost of accepting the risks (Cervantes-Godoy *et al.,* 2013).

In this case, the insurer pools the risks many individuals face and covers the losses incurred by any individual in that group. Furthermore, agricultural insurance essentially protects assets, stabilises income, and facilitates the adoption of agricultural production technologies such as higher-yielding varieties and smoother consumption of risk-averse smallholder farmers. Moreover, agricultural insurance can substitute for physical collateral for smallholder farmers, thereby enhancing smallholder farmers' access to credit in most developing countries. It is further believed that agricultural insurance is often time a more effective, efficient and potential financial instrument than other strategies in managing yield and market risk varieties (Cervantes-Godoy *et al*., 2013). Therefore, agricultural insurance addresses various risks originating from climate and non-climatic origins, conditional on how the insurance products are designed.

Tanzania has experienced several agricultural insurance pilot studies especially on, the Weather Index Insurance (Tanzania Insurance Regulatory Authority, 2016). The first Weather Index Insurance pilot study was designed in 2005 with the assistance of the World Bank. However, the program did not take off because most of the delivery channels pulled out of the project just before implementation. The second weather insurance pilot study followed this in 2009. In the second program, the pilot involved the Micro-Ensure, that acted as the Technical Support Unit. The Micro-Ensure participated in the indexing, contract design, and end-to-end solution on the technical aspects of the product and the coordination of all stakeholders. This might have led to the failure of the program. Currently, several Weather Index Insurance pilots are going on in the country. Micro-insurance companies run the pilots on a single crop basis. The pilot crops include sunflower in Dodoma, Cotton in Mwanza, Cashew nuts in Mtwara and Beans/Maize in Iringa Regions (Tanzania Insurance Regulatory Authority, 2016).

Despite the potential benefits that agricultural insurance offers in Tanzania, insurance companies and financial institutions are unwilling to extend insurance and financial services to

smallholder farmers, including potato farmers. This is because micro-insurance companies perceive potato enterprises as low profit, low gross margins for financial institutions and high actual and perceived risks. In addition, other factors such as high costs of running crop insurance schemes, moral hazards, inadequate reliable market studies on crop insurance, the inability of smallholder farmers to meet premium, problems in estimating actuarial premiums, indemnification levels, lack of historical, farm-level, and the smallholder farmers' preference data are the major impediments for the insurance companies in the country (Akyoo *et al.*, 2013; Ng'elenge, 2008). On the other hand, smallholder farmers perceive the high cost of insurance, delays in processing claims, poor insurance delivery systems and offering individual-based contracts as the cause of low demand and uptake of crop insurance in the country.

Generally, in most of the developing countries, smallholder farmers' awareness of crop insurance is low, as a result, most smallholder farmers were unwilling to pay for crop insurance because of unstable income, premium rate, no or low compensation, problems with distribution channels, and lack of financial knowledge (Sundar &Ramakrishnan 2013).Thus, there is an urgent need for researchers to collaborate with the micro-insurance companies and other stakeholders in the sub-sector to develop some innovative insurance products tailored to engage smallholder farmers in management, reporting and verification of the agricultural insurance products. The Collaborative-Base Revenue Insurance Scheme (CoBRIS) is one of those innovative agricultural insurance products that would work under such conditions. In this approach, smallholder farmers voluntarily form a cooperative/group and appoint Volunteer Insurance Management Committee (VIMC) that liaises with the Insurance Company to provide insurance services (CCAF, 2014). In addition, in the CoBRIS approach, smallholder farmers collaboratively work with micro-insurance companies and financial institutions. Group agricultural insurance contracts to smallholder farmers are likely to motivate more farmers to purchase insurance services than individual contracts. The Collaborative-Based Revenue Insurance Schemes are designed to provide income and financial protection against smallholder farmers' losses due to potato revenue risks. The CoBRIS mainly simplifies loss reporting, damage assessment and payment of the claims, unlike the other insurance services from the insurance companies. Hence, the designed CoBRIS contract will serve as an essential tool to managing the selected revenue risk among potato smallholder farmers. In addition, the scheme acts as a critical monetary instrument to steadily stabilize, improve smallholder farmers' income and resilience to financial hardship.

1.2 Statement of the problem

Potato smallholder farmers in Njombe town council are facing various production risk (low rainfall, excess rain, bacterial wilt and frosts, late blight) and market risk (price volatility and high potato post-harvest losses) leading to lower and unstable potato farm revenue from year to year. This further reduces potato revenues. Consequently, these risks make potato enterprises not attain their optimum profitability. Moreover, the risks discourage micro-insurance companies and financial institutions from extending insurance services and loans to smallholder farmers, as they perceive smallholders' potato farming as a risky business. However, information on potato smallholder farmers' perceptions of the selected production and market risks on potato farm income and risk management strategies' attributes and their effect on potato enterprise performance is scanty.

On the other hand, there is little information about the existing crop-revenue insurance products, target customers and the actual value these products add to smallholder farmers in Tanzania. Furthermore, it is unclear which crop-revenue insurance products' attributes potato smallholder farmers are willing to pay for in Njombe town council. Because of this, the purpose of this study was to close these information gaps by investigating the production and market risk management strategies used by potato smallholder farmers.

1.3 Objectives

1.3.1 General Objective

To contribute towards improved potato smallholder farmers' income and financial resilience through risk management strategies.

1.3.2 Specific objectives

i. To analyse the perceived effects of the selected production and marketing risks on the potato farming enterprise among smallholder farmers in Tanzania
ii. To determine the effects of risk management strategy attributes on potato enterprise performance among smallholder farmers in Tanzania
iii. To analyse various crop-revenue insurance products that exist for potato smallholder farmers in Tanzania
iv. To design a collaborative-based revenue insurance scheme for potato smallholder farmers in Tanzania

1.4 Research questions

This research answered the following questions:

i. How do the selected production and market risks perceivably affect potato farm income among smallholder farmers in Tanzania?
ii. How do risk management strategy attributes affect potato enterprise performance among smallholder farmers in Tanzania?
iii. What are the various crop-revenue insurance products for potato smallholder farmers in Tanzania?
iv. What are the attributes of the collaborative-based revenue insurance scheme?
v. How much are potato smallholder farmers willing to pay for the collaborative-based revenue insurance scheme's attributes?

1.5 Justification of the study

About 96 per cent of the potatoes in Tanzania are produced in the Southern Highlands, where Njombe town council is located (Kilimo trust, 2016). However, potato smallholder farmers in Njombe through history have been making decisions under uncertainty. Smallholder farmers do not have a control to risks such as weather calamities such as drought, floods and pest and diseases outbreak, and downward price fluctuations. On the other hand, potato post-harvest losses continue to become a threat among the potato smallholder farmers. As a result, potato smallholder farmers experience low and unstable potato revenues from year to year. In this regard, finding ways to manage the potato revenue losses caused by production risks, potato post-harvest losses and price fluctuation is of great importance to sustaining potato productivity and revenue.

One way to stabilize potato farm revenue and household income resulting from a high production and price uncertainty is to transfer risk through crop revenue insurance. However, the challenge is that insurance companies regard agricultural smallholder farmers' crop revenue insurance as a complex and costly product, hence not a profitable business proposition. The cost of designing an appropriate insurance product to cover smallholder farmer in their current setting has proved difficult, and thus, insurance availability and uptake have remained low. In addition, the lack of customized agricultural insurance products for smallholder farmers makes them not qualify for financial facilities that would assist them in acquiring required farm inputs (seeds, fertilizer and machinery). Therefore, there is a need to develop an innovative insurance product that will overcome these challenges.

One of the innovative insurance products is the Collaborative-based Revenue Insurance Scheme (CoBRIS) which covers both production and market risks at the same time. The schemes effectively respond to variability in potato revenue. The Collaborative-based Revenue Insurance Scheme (CoBRIS) model involves a group of smallholder farmers, micro-insurance companies, and financial institutions in designing, implementing, and monitoring the scheme. The collaborative-based model tends to be more effective, efficient, sustainable and beneficial to all the parties participating in the scheme. This study has come when the government of Tanzania is implementing a National Financial Inclusion Framework (NFIF2) that is implemented from 2018 to 2022. People's livelihoods, household resilience, and the creation of jobs are the goals of the National Financial Inclusion Fund (NFIF2).

In line with the NFIF2, FinScope (2013) indicated that two main factors hinder the growth of the insurance market in Tanzania. One of them is the low growth of the insurance sector due to inadequate distribution channels for the micro-insurance products, inadequate skilled insurance personnel, inadequate micro-insurance product offerings. In 2016, the Financial Sector Deepening Trust (FSDT) propelled a micro-insurance funding scheme (Bima Challenge Fund -BCF) to overcome some of these challenges. The purpose of this challenge fund is to speed up the expansion of the micro-insurance sector in the country. The initiative's primary focus is to reach the low-income market segment in the country, including potato smallholder farmers. The BCF support the development of the micro-insurance sector in the aspect such as product design, experimentation and roll-out of innovative and customer-centred insurance products making insurance services affordable, available and responsive to the risk management needs of Tanzanians.

This study complements the Tanzania’s existing knowledge by providing empirical information on the production and market risk management strategies mong potato smallholder farmers. In addition to previous research on crop-revenue insurance products in Tanzania (Akyoo *et al.*, 2013; Ng'elenge, 2008), this study adds to the body of knowledge about agricultural insurance companies by providing information on which CoBRS attributes and trust-related factors have an impact on the potato smallholder farmers' willingness to pay and how much they are willing to pay for crop-revenue insurance products in Tanzania. In addition, potatoes were selected in the study since they are one of the most marketable crops in Tanzania's Southern Highlands and provide a significant contribution to household income. The findings of this study will be disseminated through policy papers and direct debates in workshops in order to provide policymakers with useful information. The study also contributes to scientific knowledge by providing information about existing crop-revenue

insurance products, target customers, and the real value these products offer to smallholder farmers in Tanzania, as well as information about the products' target customers. The general public can also get information about the characteristics of crop-revenue insurance products that potato smallholder farmers in Njombe town council are willing to pay for, as well as other relevant information. In addition to the two publications that have been published, areas for further research in Tanzania and beyond have also been identified.

1.6 Scope and Limitation of the study

This study aimed to manage the selected production and market risks among smallholder farmers in the Njombe town council of Tanzania, dramatically improving household income and financial resilience. Specifically, the study sought to determine the effects of selected revenue risks on the farm potato revenues and risk management strategies attributes on potato enterprise performance. Furthermore, various crop-revenue insurance products that exist in Tanzania for smallholder farmers were analysed. Finally, a Collaborative-Based Revenue Insurance Scheme for potato smallholder farmers in the study area was designed. On the other hand, this study considered low rainfall, excess rainfall, late blight disease, bacterial wilt, Frost, post-harvest losses and price volatility as the selected risks. Regarding insurance companies/agents, the study considered the ones that provide agricultural insurance services to farmers in Tanzania. Moreover, potato smallholder farmers who are members of the Lusitu Agribusiness Group were also considered.

In terms of limitation, the study employed the purposive sampling technique, a non-probability technique in which only LAG members are considered. As a result, it was expected that the external validity of the study to be comprised. Lack of probability sampling is an important limitation to the study as it prevented the generalizations of the findings to potato smallholder farmers in the whole Njombe town council. In addition, the study was expected to experience the Status Quo Bias when discrete choice scenarios were presented. Status quo bias is a tendency; when discrete choices are presented, respondents tend to prefer the current scenario as opposed to making a change. This bias might have affected the magnitude of estimated willingness to pay for the CoBRIS' attributes.

1.7 Operational definition of the key terms

Collaborative-Based Revenue Insurance schemes: This model combines expertise, knowledge and capabilities of the cooperative members, micro-insurance companies and financial institutions

Coverage Level: This is the level whereby the indemnity payment will be compensated for revenue realization, which is below this level and is expressed in percentages

Crop revenue insurance products: Insurance service protects smallholder farmers from the combined effects of production and market risks. The product further offers smallholder farmers a way of managing revenue variability resulting from yield and price risks at the same time.

Household head: A person who makes major financial decisions and gives consent to participate in the designed collaborative-based revenue insurance scheme

Risk management strategies: These are the on-farm and off-farm risk management strategies that are currently employed by potato smallholder farmers in the study area

Indemnity: Refers to the amount paid under the revenue insurance coverage for a producer suffering a covered loss.

Potato enterprise performance: Refers to gross revenues generated from potato farming

Potato postharvest losses: Number of potato bags remaining in the soil when potatoes are harvested per acre

Potato price volatility: The differences between the price of one bag of potato at planting and harvesting time

Potato production risk: This study considers potato price fluctuation, post-harvest losses, low rainfall, too much rainfall, late blight, bacterial wilt and frosts as the main production risks smallholder farmers do face.

Potato market risk: These involve the potato price fluctuation and post-harvest losses

Potato smallholder farmers: Potato farmers with an average land holding size for potato production of 0.4ha and above

Premium: Is the fee charged for insurance coverage.

CHAPTER TWO
LITERATURE REVIEW

2.1 Conducive Conditions for Potato Production and Climate Change

High-quality disease-free seed tubers and a favorable environment are essential for maximizing potato yields and quality when growing crops in a controlled setting (Bradshaw & Ramsay, 2009). Potatoes require a low temperature of 15°C or less and a high elevation of 1000-1800 meters above sea level in order to grow properly and successfully. It was discovered by Asumugha *et al.* (2006) that potato is generated during both cold and dry conditions. In Tanzania, potato smallholder farmers plant two harvests per year: one in the short rainy season (September, January, and February) and another in the long wet season (March, April, and May) (February, June, July). Tanzania's most important crop is potatoes, which are grown in large quantities. In order to ensure future household food security and income, it is critical to evaluate the potential implications of climate change on potato production (Raymundo et al., 2018). In response to climate change, potato yields are projected to drop by the end of this century. The uncertainty surrounding the impact of climate change, on the other hand, varies from location to region. For example, historical temperature patterns in Tanzania's potato-growing regions (1961-2005) reveal that the temperature rose by around 1 degree Celsius during the first rainy season (March, April, May). However, during the second wet season (October, November, and December), the temperature in the potato growing areas rose by 1 degree Celsius to 1.2 degrees Celsius, a significant increase over the previous year. Temperatures are anticipated to climb by around 1.4 degrees Celsius and 1.8 degrees Celsius during the first and second rainy seasons, respectively, in the potato-growing regions of Tanzania in the 2030s due to climate change (CRAFT, 2019).

(CRAFT, 2019) further show that, in the 2050s, temperature in potato growing areas are expected to rise by about 2.6 ° C in both the first and second rainy seasons. In terms of precipitation, potato-growing areas of the 2030s and 2050s are expected to increase average seasonal precipitation level by up to 2030% in both the second and the first rainy seasons. Similarly, the longest continuous rainy season in potato growing areas is expected to increase slightly by about one day in both the second and first rainy seasons. The expected increase in the seasonal average precipitation combined with the increase in continuous rainy days in the potato growing areas can lead to an extreme increase in precipitation in the areas.

In the near future, for example, climate change in terms of temperature, in the 2030s, is expected to rise by approximately 1.4°C and 1.8°C during the first rainy sand second rainy seasons r in the potato growing areas of Tanzania (CRAFT, 2019). Further CRAFT (2019)

shows that in the 2050s, temperature in potato growing areas is anticipated to rise by about 2.6°C both the first and second rainy seasons.

On the other hand, the dry spells of potato-growing areas are expected to last long in the 2030s and 2050s, with both the second and the first rainy seasons of the 2050s (CRAFT, 2019). In the other potato growing areas, continuous dry days (CDD) are reduced by about one day, especially during the first rainy season. Therefore, in both the 2030s and 2050s, the expected increase in continuous dry days in potato-growing areas during the second and the first rainy seasons can lead to higher drought rates, along with lower rainy seasons and seasonal rainfall. This has a significant negative impact on potato yields in the region. In general, climate change adversely affects potato production. For example, in the coming decades, climate change is projected to likely lead to reduced potato yields during the major potato production season, which is the major potato production season in Tanzania. The areas most affected are expected to be Mbeya, Njombe and Iringa. This is because in the large potato producing areas that currently produced up to 20 tonnes per hectare, a potato yield loss of 4-8 tons per hectare is expected between 2051 and 2060 (CRAFT, 2019).

2.2 Importance of Potato enterprise to Smallholder farmers in Tanzania

As a gardening crop (owing to its high value) and as a food security crop, the potato (Solanum tuberosum) is a major horticulture crop in tropical highland parts of Sub-Saharan Africa. Potatoes (Solanum tuberosum) are grown in both gardening and food security situations in these locations. Potatoes are a basic food and a commercial crop in Tanzania, and they play an important role in poverty reduction by providing an additional source of income for producing households (Mende *et al.,* 2014). Furthermore, the crop offers calories and nutrition to nearly 350,000 smallholder farming households in Tanzania, as well as millions of people who live in the country's cities and towns (Kilimo Trust, 2012). A smallholder farmer-dominated industry, potato production in Tanzania is similar to that of the rest of Africa's tropical highlands, with an estimated 500,000 smallholder farmers cultivating potatoes in Tanzania. In addition, the subsector employs a variety of different actors throughout the value chain, including sellers of ware potatoes and street food vendors (The Netherlands Enterprise Agency, 2017).

2.3 Variability of Farm revenues amongst Smallholder farmers

According to Key *et al.* (2017), farm income contributes to 77 per cent of whole revenue variation for the normal smallholder farmers. Differences in the yield and price of marketed

produces could cause household farm revenue to vacillate. This variation, in turn, can present an acute threat to people's livelihoods.

Farm income is highly volatile, which can have an impact on household welfare, potato production, and environmental quality. Farm revenue volatility has an impact on important farm decisions like how much labour to utilize on-farm versus off-farm, how much income to preserve as a buffer for poor years, how much to invest in land, and how much to spend on risk-reducing inputs like pesticides and irrigation systems (*Key et al.,*2017). Because these decisions are influenced by household income unpredictability, it can have an impact on agricultural production and household wellbeing. Farm revenue variability is influenced by farm enterprise diversity, variability in output prices, input costs, production variability, government and development partners' support increases farm income volatility and off-farm income variability. However, most of the existing literature on farm income variability has focused on output price risk and production risks as the primary factors that cause variability in farm income among smallholder farmers (OECD, 2009).

2.4 Sources of Farm enterprise revenue risks among Smallholder farmers

The majority of small-scale farmers rely only on farming for a living and have little resources and capacity to deal with these dangers. As a result, any decrease in agricultural productivity can have a major impact on their food security, nutrition, income, and overall well-being. Drought, cold, bug infestation and disease, price fluctuation, unpredicted demand, and other factors can threaten smallholder farmers' agricultural revenue streams, which might jeopardize their household's food and economic security. These dangers can be divided into two categories: business risk and financial risk (Unterschaltz, 2000). The business risk, on the other hand, is directly related to a farm's production and marketing activities. Production and market risk are two types of business risk. Financial risk, on the other hand, is described as a risk arising from a company's involvement in the financial market and refers to the company's degree of debt.

The risk is mainly caused by uncertainty about future interest rates and the farmer's ability to generate the necessary income for loan repayment, among others. However, from the previous studies and theoretical knowledge, it is evident that producers often report that production and price risks are their two major concerns in reducing crop revenue. Therefore, this study will focus on potato revenue risk (production, price and post-harvest losses).

Production risk, on the other hand, refers to yield fluctuations caused by a variety of uncontrollable meteorological events such as insufficient rainfall, illnesses, and pests. Low yields may result from a lack of rain or drought. Crops could be harmed or even destroyed by heavy rainfall. In addition, insect or disease outbreaks could result in considerable crop and livestock yield losses. Farmers cannot predict how much rain will fall or if frosts, bugs, or illnesses would affect their crops when they plant seeds and fertilize their land. They must, however, determine whether or not to plant their crops. As a result, smallholder farmers' resources dedicated to the production and marketing of food have decreased. This means that smallholder farmers produce with no guarantee of what will happen to their harvest. Flooding, drought, insect, hail, and wind are the most common types of natural catastrophes, accounting for 45 percent, 37 percent, 11 percent, and 1% of crop output losses annually during the last two decades, according to statistics (Wang *et al.*, 2010).

Many research has been undertaken on smallholder farmers' sources of production and market risk. The most serious problem about crop production, according to Wang *et al*. (2010), is yield hazards generated by yearly yield volatility. Drought was the most important cause of production risk, according to Mesfin (2014), with 26.71 percent of respondents ranking it first and having the highest rating of 234.49. Pests and crop diseases, declining soil fertility, and a lack of drought-resistant varieties are all causes of production hazards in Ethiopia.

Smallholder farmers rated production/yield risk as the most serious, according to Korir (2011). This type of threat is made up of weather and pest attacks. In Arusha, Tanzania, Akyoo *et al*. (2013) investigated agricultural production hazards, coping methods, and crop insurance possibilities. The findings reveal that, pests and disease were identified as the most damaging threats to vegetable smallholder farmers in Tanzania, followed by drought. Another study by Daninga and Oiao (2015) found that the primary production hazards faced by cotton smallholder farmers in Tanzania are weather circumstances such as a lack of rainfall and unpredictable rains. The study further reveal that, these smallholder cotton growers were found to be among the most vulnerable in the country.

Market risk, on the other hand, is associated with fluctuations in production and input prices, with output prices fluctuating mostly in response to seasonal variations. For a variety of reasons, such as shocks, international trade policies, inventory levels and weather occurrences in addition to financial commodities market speculation, demand and supply mismatches, and market faults to name a few, this could occur (Twine *et al.,* 2017). When a commodity's predicted price differs from its actual price, this is referred to as "price risk." When it comes to all commercial activities, notably agricultural commodities, where price adjustments have been

necessary in recent years, uncertainty is a crucial issue to consider (Banterle & Vandone, 2013). As a result, market risk is mostly the result of price instability in the long run. Produce producers are exposed to market risk when they make production and marketing decisions on inputs and labour that are dependent on the price they expect to receive after harvest, which may be different from the actual price received. Agricultural price volatility, on the other hand, has increased significantly since 2000 when compared to the previous two decades, generating a source of uncertainty that can have a significant impact on the income and well-being of smallholder farmers (Banterle & Vandone, 2013). Aware of seasonality, smallholder farmers face a greater risk since seasonal patterns are unpredictable. For example, changes in the start and end dates of different seasons, as well as changes in the length of different seasons, all affect price variance. In agricultural markets, there are typically significant information asymmetries as well as a lack of an efficient communication infrastructure. Furthermore, when smallholder farmers plant their crops or invest resources to cultivating them, they have no notion what prices their commodities will fetch when they are sold (Banterle & Vandone, 2013).

2.5 Studies on the Effects of production and market risks on Farming Enterprises

Production and market risks are key contributor to substantial economic losses in the developing countries, contributing to poverty and income disparity. In some locations where food insecurity is already prevalent, production and market risks are likely to affect agricultural output, production stability, and household income, according to most studies (Greg *et al.*, 2011). According to Harvey *et al.* (2014), most of crops were lost due pests, disease, storage issues, or extreme weather occurrences. The resulting income loss was very diverse between households, with modest to severe effects. According to the findings, approximately 29 percent of smallholder farmers lost less than a quarter of their crops to the cyclone, while 10 percent lost more 75 percent of their harvests. The global markets have recently fuelled agricultural commodity price volatility to the point where smallholder farmers typically consider the price to be as dangerous as yield (weather events and natural disasters). Smallholder farmers believe that this non-weather risk has a significant impact on their income, and it is the most systemic of all the agricultural risks (Janowicz-lomott *et al.*, 2015).

Smallholder farmers' fear are validated by the reality that agricultural product market price volatility has a significant impact on the crop revenue. In the study of the relationship between price volatility and smallholder wellbeing, Barret *et al.* (2008) discovered that higher price risk and low potato prices had a detrimental on smallholder farmers and deter them from

selling their potatoes. The downside risk, in which the actual price is lower than projected, is a major issue for smallholder farmers. This means that crop prices may be so volatility that what appears profitable when planted may become unprofitable when prices fall in the months ahead (Banterle & Vandone, 2013). Potatoes prices are more volatile, which removes a fundamental motivation for smallholder farmers to increase their investment in potato production. According to NewTimes (2014), losses in Rwanda have forced smallholder farmers out of commercial farming due to downward prices fluctuations in potatoes. The price of potatoes fluctuates, which can be an issue for smallholder farmers who lose money despite their efforts in the production process, and also for potato consumers who have difficulty finding potatoes in the country. As a result, the government is forced to invest in potato imports. Smallholder farmers, on the other hand, are affected by the increasing price variation. Price fluctuation can have a negative impact on farm profitability in both circumstances (Dick, 2010; Mohan, 2007; Pasaribu, 2010; Wolf, 2012). As a result, risk management measures are becoming increasingly critical for smallholder farmers.

2.6 Risk Management Strategies of Farm enterprises

Managing crop revenue risks and uncertainty in agriculture is crucial as they affect other sectors of the economy (Kammar & Bhagat, 2009). The production, financial, market and institutional risks and a farmer's attitude toward risk significantly impact the choice of risk management strategies (Kisaka-Lwayo & Obi, 2012). There are strategies that farm operators can use to reduce farm revenue exposure to risks which include modern and traditional risk management tools. These risk management strategies are crop insurance, forward contract, and futures, among others. However, before a farmer has decided on the risk management strategy to employ, he needs to understand the risk management process. Understanding the management process will help smallholder farmers have a suitable defence mechanism against the potential risk. In addition, understanding the risk management process will help smallholder farmers make informed decisions about which risk management tool to employ to manage a particular risk. Smallholder farmers can avoid, avert, share, transfer, spread, and take risk using a variety of risk management strategies in agricultural enterprises (Singh, 2010). The decision to use a certain tool is based on the smallholder farmers' risk tolerance and willingness to take risks. As a result, risk management solutions are designed to give some protection when the repercussions of an action are unknown. It involves choosing among alternatives to reduce the impact of various risks emanating from production and marketing processes. Agricultural risk management, according to Hardaker *et al*. (2004), is the systematic use of management

strategies, policies, processes, and practices to detect, analyse, assess, treat, and monitor risk. Risk management strategies, on the other hand can be categorized into four: accept, control, transfer and avoid (Bauer & Bushe, 2003). Generally, agricultural risk management plays a vital role in developing the agricultural sector as it raises food production and improves poverty conditions (Banterle & Vandone, 2013). Agricultural risk management options for smallholder farmers are numerous. Some risk management strategies are focused on a single type of risk, while others address many risks. The majority of smallholder farmers employ a range of on-farm risk management techniques. Risks, willingness, and ability to accept risks change from farm to farm, which influences risk and management tactics employed by smallholder farmers. For example, a smallholder farmers assume that the loss is minor in intensity and that it occurs seldom. In that situation, the smallholder farmer decides to accept the risk, but smallholder farmers avoid the risk if the loss is considerable and the frequency of occurrence is great.Instead, when the potential for loss is modest but the frequency of occurrence is high, and when it's huge but the frequency of occurrence is low, smallholder farmers prefer to control and transfer the risk, as opposed to large-scale farmers who opt to manage but not transmit the risk. Hardaker *et al.* (2004) classified them into two categories: risk management methods that take place on the farm and risk sharing strategies that take place off the farm. Korir (2011) distinguished between risk management tools that are used in advance of a risk event and risk management tools that are used after a risk event. The ex-ante risk management procedures are those that are implemented by smallholder farmers in order to mitigate possible losses before a problem occurs. Ex-post risk management procedures are implemented by smallholder farmers after a risk has occurred in order to aid them in coping with the resulting financial loss. Risk management strategies can be classified into three categories: minimization, transfer, and copping. Jaffee *et al.* (2010) classified risk management strategies into two categories: measures taken at the household level and measures taken at the community level. Each of the risk management methods discussed above has a different impact on the farm company, but none of them is capable of protecting the farm from every type of risk. The focus of this study, on the other hand, was on smallholder farmers' risk management techniques for dealing with specific production and marketing hazards in their operations.

2.6.1 Review of the Selected Risk Management Strategies

To manage yield unpredictability, smallholder farmers use a variety of production actions. Enterprise diversification, contract farming, and crop insurance are just a few of the solutions available. Today's agricultural commodity markets, on the other hand, provide

significant challenges. Price volatility has increased both the risk and the opportunity for producers. Smallholder farmers' awareness of pricing risks has increased as commodity prices have become more volatile, and their marketing skills have improved. Smallholder farmers have used a variety of tactics to deal with price volatility, including minimum price contracts, market knowledge, and keeping records. Some marketing strategies reduce risk by lowering pricing variability, while others involve transferring risk to others. Smallholder farmers, on the whole, employ a mix of market risk management measures in their farming operations. Smallholder farmers have historically utilized enterprise diversification as a method to deal with price and weather-induced production variability. Diversification of farm activities can be viewed as a calculated decision to increase the value of numerous farming functions. Enterprise diversification, according to Bartolini *et al*. (2014), spreads risk and is a good risk management technique.

Smallholder farmers can diversify their income by doing different things, doing the same thing in different places, or doing the same thing over longer periods of time. Participation in these activities is critical for raising household income in rural areas. As a result, enterprise diversification is viewed as a means of securing revenue and improving food security. One of the key techniques for pursuing viability in rural regions is to boost farm revenue by assigning home labour to on-farm diverse activities (Bartolini *et al.,* 2014). A diversification approach allows profits from one business to compensate for losses from another. In this approach, agricultural diversification decreases possible farm revenue variability while limiting risk. Makate *et al.* (2016) also looked at how crop diversification affects crop productivity as well as household resilience (income, food security, and nutrition) in rural Zimbabwe. Crop diversification is a realistic climate-smart agricultural technique that improves crop output and resilience in rural smallholder farming systems, according to the study. As a result, price, yield, and income risk can be managed through enterprise diversity of output (Makate *et al.,* 2016).

Crop insurance is another approach that helps farmers cope with crop losses by smoothing agricultural yield. It is an ex-ante risk management instrument. Crop insurance protects farmers against losses in crop yield caused by pests and diseases, droughts, and floods, among other things. Weather index insurance activated by a rainfall index, individual yields triggered by observed yield shocks on the farm, or area-based yield triggered by a decline in the average yield in a given location are all examples of crop insurance (JessAntón, 2012). For example, the FARMF programme encourages smallholder farmers to purchase crop insurance to cover for weather-related yield losses while also making production finance more accessible (FARMAF, 2015).

Price uncertainty, on the other hand, might be considerably decreased if smallholder farmers could enter into advance contracts such as contract farming with buyers. Market contracts, for example, can be made with either an individual or a firm. The smallholder farmer is generally aware of the prices that will be paid in advance. A livestock feed mill, for example, might arrange to buy a farmer's grain at a set price, or a tobacco company might do the same with its crop. Some businesses that buy produce from farmers during harvest also offer inputs (Manfredo & Richard, 2007). Contract farming is seen as a way to expand smallholder farmers' incomes by offering new market options. This contract eliminates a significant amount of down side price risk. According to Trang (2013), a substantial percentage of rice smallholder farmers in Vietnam seek to sign interconnected agreements with local agricultural enterprises to address agricultural hazards associated with rice growing. Smallholder farmers' concerns about erratic pricing are partly shown by the fact that these interconnected contracts often reward them with somewhat higher prices than the markets (Trang, 2013). In a similar vein, Mwambi *et al*. (2016) investigated the impact of contract farming on avocado smallholder farmers' revenue in Kenya's Kandara district. The research shows that contract farming alone isn't enough to boost household, farm, and avocado income.

In Africa, the majority of smallholder farmers lack access to trustworthy and timely market information. As a result, using market information systems (MIS) to provide real-time prices has become a theoretically realistic risk management technique (Burger, 2017). Smallholder farmers should use timely information to help them decide whether or not to sell (now or later, altering points of sale), as well as to increase their bargaining power in the event of an urgent transaction. Market information systems acquire, process, and disseminate data about the current state and dynamics of agricultural markets. This enhances governmental policies by increasing market awareness and openness, resulting in more equitable and efficient resource allocation among smallholder farmers (FARMAF, 2015). Smallholder farmers can utilize MIS to guide production and marketing decisions, such as deciding what, when, and where to sell their goods based on market data, lowering market risks through informed decision-making.

Producers' collaborative models can help with risk management and increasing the number of capable individuals who can participate in high-risk/high-reward activities (Ethan, 2009). The models may also play an important role in increasing food security and creating job possibilities. According to Bernard *et al.* (2010), producers' collaborative models significantly alleviate rural poverty by lowering agricultural costs, increasing

market access, and improving output prices among smallholder farmers. Furthermore, the models provide a wide range of services to smallholder farmers, including access to information, technologies, loans, cheaper agricultural input prices, and negotiating better conditions for contract farming (FAO, 2007). Small agricultural producers and marginalized groups, such as young people and women, are specifically supported by the models. Furthermore, the models economically and socially empower their members and produce long-term rural employment through business models that are resilient to economic and environmental shocks (FAO, 2015).

2.7 Agricultural Insurance in Developing countries

In many ways, agricultural insurance is based on the same principles as other types of insurance, with the distinction that it is exclusive to agriculture, much as insurance can be restricted to health or property only. Insurance is defined as a signed contract between two parties including the exchange of a premium from one party to another party in consideration for the other party's responsibility to pay a set sum to the other party in the event of an unanticipated occurrence (Kwadzo *et al.,* 2013). It operates by exchanging a small sum of money on a regular basis in order to compensate for a large but unknowable loss that is anticipated to occur in the future.

In this case, smallholder farmers and other agricultural stakeholders are required to pay a sum of money to an insurance agency. The purchase of agricultural insurance does not reduce the risk of an event occurring or the uncertainty associated with it; nevertheless, it does lessen the impact of the event on an individual's financial circumstances (Danso-Abbeam *et al.,* 2014). Advocates of agricultural insurance as a risk-coping method assert that small-scale farmers follow more profitable planting trends, improve farm adoption of technology, and spend more, so improving their welfare and ensuring the nation's food supply. Agricultural insurance is a risk-coping method for smallholder farmers who face a variety of challenges (Binswanger-Mkhize, 2012). As a result, crop insurance's beneficial role in increasing smallholder farmers' access to financing has gotten more attention recently (Trang, 2013).

In order to do so, smallholder farmers must be provided with a means to finance losses in the event of a shock and assistance in managing the effects of shocks more effectively. They must also be provided with a means to minimize risk by compensating them for damages, which will allow them to increase investment and income (Nahvi *et al*., 2014; Nnadi *et al.,* 2013). The agricultural insurance sector in developing countries is divided into three primary organizational structures. The first is the public sector, which is usually heavily subsidized; the

second is wholly private commercial agricultural insurance markets; and the third are public-private partnerships (RAP, 2011). Because agriculture plays such a significant role in the economies of most developing nations, agricultural insurance has primarily been provided by governments as a risk management tool (Trang, 2013). Some of the justifications for the government's agricultural insurance policy intervention include the protection of rural households from poverty and financial institutions from loan defaults, the severity of rural farming households' production, disaster relief funding, and the development of social safety.

Despite the fact that crop insurance is supposed to protect farmers, historically, public sector-funded crop insurance has had a dismal track record (RAP,2011). A number of factors, including excessively low premium rates, unclear boundaries between commercial and social goals, a lack of management and control over adverse selection and loss assessment due to information asymmetry, high transaction costs, and insurer liquidity and solvency in the event of a significant catastrophic event, all contributed to the insurer's poor performance (Hazell, 1992). Transferring responsibility to the private sector and developing public-private partnerships have both been offered as solutions to the challenges associated with crop insurance. It has also been argued that crop insurance program designs that are more flexible, such as individually assessed crop insurance products, are important for crop insurance improvement (Trang, 2013).

2.7.1 Selected types of Agricultural Insurance Products

The two primary types of agricultural insurance accessible to smallholder farmers are indemnity-based insurance and index-based insurance. Indemnity-based insurance is more expensive than index-based insurance. Indemnity-based insurance is based on the actual loss suffered by the farmer, with claim payments made in reaction to the loss occurring. When an insured risk occurs, agricultural insurance firms hire an experienced agronomic to monitor the crop and estimate any losses resulting from that risk. This category of insurance benefits smallholder farmers in the event of a loss based on ground confirmed loss quantifications. For its part, index insurance relies on the employment of triggers to arbitrate actual crop losses and loss assessments (Barnett *et al.,* 2005). This category makes use of past data, such as rainfall or agricultural yield statistics, in order to predict potential future losses and define insurable risk limitations. This index is used to track agricultural insurance contracts during crop production seasons as a result of these developments.

An agricultural insurance policy that is based on area yield is a type of insurance in which the total yield of a geographical region is used to determine both the indemnities and the

premiums. If the difference in value between the area yield and a predetermined critical yield level is positive, the indemnification is equal to the difference in value between the area yield and the critical yield level. Regardless of their individual crop production, participating producers in a certain area would all receive the same indemnity per insured unit of land regardless of their location. They would also all pay the same premium rate (Barnett *et al.,* 2005). Area-yield crop insurance offers several advantages over individual-yield crop insurance, the most important of which is that it lowers information asymmetry. Administrative costs are reduced as a result of the widespread availability of data on the distribution of local food and the elimination of the need for specific production histories for verification. Because indemnities would be based on area yield rather than producer yield, altering production tactics would not have a substantial impact on the amount of indemnity received by a producer in a given year. As a result, moral hazard is significantly reduced when area-yield insurance schemes are implemented (Barnett *et al.,* 2005). On the other hand, if a farmer's yield risk is unrelated to systemic yield risk, area-yield insurance is completely worthless to him (basis risk).

Weather index-based insurance is another product that seeks to address the issues of moral hazard and adverse selection in the insurance market. An indemnity is paid out instead of individual policyholder losses since the product is based on values from a weather index that serves as a substitute for actual losses. Typically, agricultural yields are used as the index's foundation, which is based on some objective metric such as rainfall or temperature that has a strong correlation with the variable of interest (Collier *et al*., 2010).

The occurrence of a threshold in the proxy variable signals the beginning of payments. There is no relationship between the payment rate for this product and the actual loss experienced by the insured. Compared to traditional individual yield crop insurance, weather index insurance offers some of the same benefits as area-yield insurance, such as minimizing the risk of fraud and adverse selection in the crop production process (Collier *et al.,* 2010). More importantly, in many cases all that is required to provide the necessary indexes is for a weather station to do its job. As a result of these advantages, administrative expenses are reduced. It is possible that the insured farmers will be exposed to the basis risk, which could result in a loss and a lack of indemnification from the company.

It is an agricultural insurance product that supplements yield-based crop insurance policies by altering the yield indemnity to account for price fluctuations during the crop season. The insurance protects the policyholder against declines in agricultural yields as well as price variations. When expected revenue falls below a certain level, income plans assist producers

plan their budgets, acquire bank loans, and reduce credit costs to input suppliers. Income plans help producers plan their budgets, secure bank loans, and reduce credit costs to input suppliers (Cole & Gibson, 2010). The expected revenue is often determined before a crop is planted by multiplying expected or average historical production by an index of expected harvest price before planting. Rather than that, the harvest price index is typically constructed prior to planting based on the average price of a harvest period futures contract for the season in question. The base price is the anticipated harvest price at the time of harvest. The revenue guarantee is calculated based on predicted revenue and a predetermined percentage or coverage level, which is based on the expected revenue. Predicted harvest prices are computed by taking an average of harvest futures contract prices at the end of the harvest season. The actual revenue is computed by taking the harvest price and the actual production into consideration. A revenue insurance indemnity is paid if real income falls short of the final revenue promise (Cole & Gibson, 2010).

2.8 Impact of Agricultural insurance on Smallholder Farmers' Welfare

Zhao and Chai (2016) conducted research in Mongolia to determine the influence of crop insurance on farmer income. The difference in difference (DID) method, propensity score matching (PSM), and a hybrid PSM-DID treatment effect estimate were all employed to determine the effectiveness of crop insurance on farm revenue. According to the study, smallholder farmers who participated in the crop insurance program had revenues that were on average 29.1 percent more than those who did not participate in the crop insurance program. Furthermore, the income discrepancy was statistically significant at a ten percent threshold of significance, according to the findings. A further study conducted by Key *et al*. (2017) looked into the impact on income risk and wellbeing in the United States of America caused by various sorts of government programs. The regression analysis that was used to investigate the drivers of household income volatility and to identify patterns in household income volatility over time is described below. According to the findings of the study, crop insurance helps farmers in the study area to lower the volatility of their total revenue. Furthermore, the study discovered that crop insurance pay-outs provide the greatest value for money to growers because they reduce the chance of losing their entire crop. Consequently, it was determined that crop insurance may reduce income fluctuation, lower shocks, and provide more money for future investment, ultimately resulting in higher long-term income. Sherman (2010) discovered that micro-insurance systems are effective in addressing the issues associated with informal coping techniques. The study also discovered that micro-insurance is one of the ex-ante strategies that

is aimed towards poor households, and that it provides farmers with a stable household income by stabilizing the income of the household. The outcome is that smallholder farmers' living conditions improve since they no longer have to spend a significant percentage of their savings on risk management (Churchill & Matul, 2012). Aside from that, agriculture insurance can help farmers increase their agricultural productivity by allowing them to invest in more profitable, but potentially riskier, farming operations (The Actuary Magazine, 2015). Kim *et al.* (2017) conducted an investigation in the Kansas Farm Management Association in the United States of America to determine how crop insurance payments affect farm business viability. In this study, the Cox Proportional Hazard Model and the Propensity Score Matching (PSM) technique were both employed to analyse the data. According to the statistics, farms that have crop insurance live an average of seven years longer than farms that do not have crop insurance, on average. Crop insurance, by lowering the rate of farm failure, has been shown to be favourably associated with the survival of farm businesses.

A study conducted by Nkere (2016) in Kenya's Narok County looked into the impact of crop insurance and financing on the wheat productivity of smallholder farmers. According to the findings, both insurance and finance had a positive impact on the production of the study's subjects. According to Asseldonk *et al.* (2015), crop insurance and rural lending are linked in Zambia. They also looked into the potential benefits of crop insurance and rural lending. Agriculture's income may be increased significantly through crop insurance systems, because they link smallholder farmers to production finance. Smallholder farmers who do not have access to collateralized agricultural loans can use the schemes to finance inputs such as fertilizer, which is a significant benefit. As a result, fertilizer was utilized by half of the smallholder farmers.

Microfinance institutions, on the other hand, make money by combining loan distribution with insurance uptake since smallholder farmers are less vulnerable to weather-related disasters when they purchase insurance, which reduces the likelihood of default (Swedish International Development Cooperation Agency, 2012). As the research presented above demonstrates, agricultural insurance plays an important role in increasing farm production, food security, and the ability to obtain loans from financial institutions, while also potentially providing significant benefits to smallholders in terms of income smoothing and enhancement.

2.9 Review of the selected Micro-insurance products

Micro-insurance can be created in a number of different ways. Different agricultural insurance forms may be acceptable depending on the risk insured, activity levels, employed

assets, and risk exposure, among other factors. Microfinance institutions are frequently used to promote and distribute the product to target groups (mostly smallholder farmers in low-income economies) (Cohen & McCord 2003). For example, in an individual insurance product, a smallholder farmer can be insured through micro-insurance programs like the BRAC program, but the costs are twice as high as programs that use group pricing. To keep the program financially viable, a high participation rate among the target group is essential (Churchill 2006). Therefore, the following provides an overview of common types of micro-insurance products.

Kilimo Salama, a weather index crop insurance system developed in Kenya in 2009, is a Swahili word that means ‘safe agriculture' in English. Syngenta Foundation for Sustainable Agriculture (SFSA) in Kenya is implementing *Kilimo Salama* in collaboration with UAP Insurance and Safaricom Company (Kerer, 2013). The program intends to reach 500,000 smallholder farmers in Kenya, Rwanda, Tanzania, and two additional Sub-Saharan African nations. It is an index-based weather crop insurance plan designed to assist smallholder farmers who operate in dangerous and uncertain environmental conditions by providing compensation in the event of adverse weather. Smallholder farmers' investments in farm inputs (seed, fertilizer, and pesticides) are protected by the product against extreme weather risk (drought or excess rainfall). The initiative collects premiums and makes payments to smallholder farmers using solar-powered weather sensors and cell phone payment technologies (Wairimu, 2013). Furthermore, the *Kilimo* Plus initiative was rated as good by the majority of Kenyan smallholder farmers. This indicates that the smallholder farmers had a favourable opinion of the initiative. As a result, the campaigns had a favourable impact on the perception of fertilizer and certified seeds among Kenya's smallholder farmers (Kiratu1 *et al.*, 2014).

The Apollo and Pan African micro-insurance product is an index-based weather agricultural insurance product aimed at maize producers in 10 central and eastern Kenya counties. The product was aimed at maize smallholder farmers in drought-prone or flood-prone areas. Freshco Seeds and mass-market insurance service providers joined with Apollo and Pan Africa. Equity Bank served as the distribution channel for 13 of the products, while Apollo served as the risk carrier and Swiss Re supplied Pan African insurance and reinsurance (Kerer, 2013).

The Jubilee Index-based Weather Insurance is one of the insurance products offered by the Jubilee Insurance Company, which was founded in 2011. The index-based weather insurance system intends to safeguard SHFs in Kenya's arid and semi-arid regions from adverse weather conditions (Kerer, 2013). Sorghum, maize, and horticulture growers across the country are covered by the product. The Jubilee insurance firm has joined with the East Africa

Challenge Fund to give financial support for the development of the insurance product; Planet Guarantee manages farmer training and awareness, and SwissRe provides reinsurance support (Business Daily, November 14, 2012).

The Swahili phrase *Bima ya Ukame*, which means "drought insurance," was first used in Tanzania. This is a smallholder farmer insurance program that began in 2011 with the goal of increasing cotton yield by protecting farmers from drought. The initiative began by providing services to cotton smallholder farmers who were part of contract farming organizations. Tanzania Cotton Board (TCB) works with Bunda District Council, Ginners, MicroEnsure, and cotton growers to implement the initiative. TCB's function is to connect cotton smallholder farmers with insurers and ginners, as well as distribute inputs, through the Cotton Development Trust Fund (CDTF). The government offers education and extension services through the district council, while MicroEnsure was tasked with managing smallholder farmers' insurance services. Farmers were divided into groups throughout implementation, with each group led by a lead smallholder farmer (Daninga & Qiao, 2015). Smallholder farmers have so far benefited from input loans and farming education.

2.10 Studies on Willingness to Participate and Pay for Crop insurance among smallholder farmers

Several studies have been undertaken on rural households' willingness to participate and pay. The majority of the research employed the contingent valuation approach to determine the factors impacting willingness to pay, estimate willingness to pay, and estimate willingness to pay. In Iran, Nahvi *et al.* (2014) investigated the factors that influence rice smallholder farmers' involvement in crop insurance. A descriptive statistics and a logit regression model were used in the research. The key influences affecting insurance demand were found to be level of education, age of farmers, acreage level, number of contacts with agriculture specialists, and rate of annual income from rice farming. Smallholder farmers' willingness to pay for crop insurance in Pakistan was investigated by Ghazanfar *et al*. (2015). Heckman selection models and the contingent valuation method were used. Smallholder farmers wanted to pay the least amount of premium possible, according to the report. In addition, smallholder farmers' willingness to pay for crop insurance was found to be influenced by landholdings and farm income. Other characteristics, such as land ownership, farm income, credit, loss experience, land tenure, and predicted yield, were also found to have a substantial impact on crop insurance willingness. In Malaysia's North West Selangor Integrated Agricultural Development Area, Abdullah *et al*. (2014) evaluated the readiness of smallholder farmers to subscribe for crop

insurance. In order to determine crop insurance willingness to pay, the researchers utilized a contingent valuation method based on a logistic model (WTP). In the study, it was discovered that the key predictors of desire to pay for the insurance plan are age, farm size, and insurance price. However, in the research region, traits relating to social capital were not included as a factor in determining willingness to pay for crop insurance coverage.

Sadati *et al*. (2010) conducted multiple regression analysis to investigate the characteristics that influenced the adoption of crop insurance among smallholder farmers in Behbahan county, Iran. A Pearson correlation was also employed to evaluate the association between crop insurance indicator adoption and the characteristics that were hypothesized to impact crop insurance scheme participation. Multiple regressions revealed that the proportion of drylands, extension engagement, agricultural income, and insurance satisfaction were the only characteristics that predicted crop insurance acceptance.

Afroz *et al*. (2017) investigated Malaysian smallholder farmers' willingness to pay for crop insurance in order to adjust to flood risk. A descriptive statistics and a logit regression model were used in the research. The respondents' average monthly crop insurance premium is 11.6 USD /ha/season, according to the survey. In addition, the age of the household head, attendance at the training course, farm revenue, experience, and farm size are all key factors that influence the readiness to pay for crop insurance, according to the study (Afroz *et al.,* 2017).

Wairimu (2013) performed research on smallholder farmers' attitudes toward weather index crop insurance. These factors influence smallholder farmers' judgments on whether or not to engage in weather index insurance schemes, as well as the direct impact of weather index insurance (Kilimo Salama insurance system) on food security. To evaluate the elements that influence participation and the level of involvement, the researchers used a double hurdle model. The size of the farm, the sex and age of the household head, the extension service, and the size of the household all had a major impact on the insurance scheme rating, according to the study Wairimu (2013). Furthermore, the distance to the insurance system, registered Agrovet, and faith in insurance brokers have all had the opposite effect. The willingness to pay of smallholder farmers participating in the *Kilimo Salama* project, however, was not estimated in the study. As a result, the average amount that smallholder farmers are willing to pay for CoBRIS contracts was determined in this current study. Smallholder farmers' willingness to pay for cow insurance and factors impacting farmers' participation in the WTP in Shaanxi Province, China were investigated by Xiua *et al*. (2012). To check the link between the WTP and the influencing factors, the study used the contingent valuation method and the Heckman-

two stage model to conduct an econometric analysis. According to the report, the present premium is within the acceptable range for smallholder farmers. Farmers' readiness to pay and their acceptance of the premium were both influenced by their understanding of the allowance and their willingness to accept it.

Ethiopian families' willingness to pay for the CBHIS (community-based health insurance plan) was explored by Mamo and Bekele (2017). The willingness to pay for the community-based health insurance scheme in the area was determined using the double bounded dichotomous contingent valuation method. The mean willingness to pay and its determinants were also calculated using the interval regression model. It was also determined that approximately 79 percent of homes were willing to pay for the plan, with the average willingness to pay per household being $10 per year. Households' willingness to pay for the community-based health insurance scheme is influenced by factors such as the household head's education level, family size, level of awareness for the scheme, respondent's trust in scheme management, households' perception of the quality of health service, and annual household income, according to the study.

In the Fogera area of Ethiopia's northwestern region, Adane *et al.* (2014) analysed households' maximum willingness to pay for the plan. To determine the greatest WTP among the homes, the researchers used a double-bounded structure. The study used a multiple linear regression model to find influential factors for smallholder farmers' willingness to pay, and found that gender, household size, and schooling experience were all significantly associated with the willingness to pay.

Smallholder farmers' expectations of various forms of government assistance have an impact on their intentions to participate in and pay for the crop insurance scheme in question. It is also important to note that smallholder farmers' expectations of various types of government support influence their willingness to participate in and pay for the crop insurance plan in question. Tundui and Macha (2014) conducted research in rural Tanzania to determine the impact of social capital on the willingness of households to pay for the Community-Based Health Insurance scheme. The researchers utilized unidirectional (single-bonded dichotomous choice) bidding games to gather information on smallholder farmers' willingness to pay for Community-Based Health Insurance programs. Social capital variables such as membership in a social organization or network, trust among community members, trust in scheme management, and household income level all had a positive and significant impact on a household's willingness to contribute to a community-based health insurance scheme, according to the findings.

Olila *et a*l. (2015) conducted a study in Kenya to see whether smallholder farmers were willing to pay for attribute-specific weather-based crop insurance contracts. A Discrete Choice Experiment was used to determine the preferences of farmers regarding crop insurance design parameters (DCE). This study used a random parameter logit (RPL) model to conduct its research. According to the findings of the study, farmers are willing to pay for a variety of quality-assigned attributes associated with weather-based crop insurance. On the other hand, the study conducted by Sibiko *et al*. (2018) looked into the preferences of smallholder farmers in Kenya for weather index insurance. According to the results of the survey, many smallholder farmers are confused about how the insurance plan works. As a result, if appropriate rainfall data and thresholds were delivered on a regular basis, smallholder farmers' willingness to pay for weather index insurance would be considerably increased. Also revealed was that smallholder farmers prefer approaches that reduce basis risk, and that offering insurance contracts to small groups rather than individual farmers could increase insurance acceptance.

Much of the recent research on determining the desire to engage in and pay for crop insurance products in most developing countries has tended to focus on family and farm characteristics, as evidenced by the articles described above. However, little research has been done on smallholder farmers' preferences and willingness to pay for certain features of weather index insurance contracts. As a result, determining the desire to participate and pay in relation to the qualities of a specific insurance policy is critical. Crop insurance contracts and policies could be better tailored to the needs of smallholder farmers in various circumstances with this knowledge. Furthermore, little attention has been paid to how trust-related issues influence smallholder farmers' willingness to participate in crop insurance and pay for it. Through farmer social capital, collaborative-based companies have the ability to influence farmers' willingness to engage in and pay for crop insurance programs. As a result, this study looked at social capital and potato enterprise-related aspects to get a better picture of how these factors affect potato SHFs' decision to engage in the CoBRIS.In addition, the study wanted to see how smallholder farmers reacted to specific modifications in contract design. To assess potato smallholder farmers' participation in CoBRIS and how CoBRIS attributes, trust-related factors, and potato enterprise-related factors influenced potato SHFs' participation in CoBRIS, a Discrete Choice Experiment (DCE) and Conditional Logit Model (CLM) were utilized. The study also calculated how much potato smallholder farmers were prepared to pay for the CoBRIS' benefits.

2.11 Summary of Literature review and the identified Research Gaps

In general, there is extensive literature on analysing different types of risks faced by smallholder farmers and their effect on farm yield. Additionally, many researchers have also established the different kinds of risk management strategies and how these strategies affect farm income. Moreover, the relationship between the socio-economic characteristics of smallholder farmers and the risk management strategies employed by smallholder farmers at the farm level has also been established. However, in crop insurance, most studies focused on the challenges and opportunities presented by the existing insurance products primarily in developing countries. However, there is still a knowledge gap to be filled. First, the perceived effect of the selected production and market risks on farming enterprises among smallholder farmers is under-researched, especially in most developing countries, including Tanzania.

Additionally, the effect of the risk management strategies' attributes on the performance of farming enterprises is still limited. Studies on the existing crop-revenue insurance products, companies that offer the crop-revenue insurance services and comparison of the existing crop-revenue insurance products in tin relation to product design, access, costs and experience of the crop-revenue insurance products are also limited. Information on the description of the business model of the crop-insurance products in most developing countries is little. Finally, most of the studies on willingness to pay for crop insurance employed the contingent valuation method. This method only considers crop insurance products and not different attributes associated with the product. Furthermore, smallholder farmers are only asked whether they are willing to participate or not, then if they are willing to pay for the crop insurance product, the maximum amount is determined. In other words, the Contingent Valuation Method (DVM) does consider specific attributes of the crop insurance that might make smallholder farmers participate and finally willing to pay for the particular qualities. Therefore, this calls for the research on determining the willingness of smallholder farmers to participate and pay for the crop insurance's attributes specific.

2.12 Theoretical framework of the study

In this section, the study focuses on the main theories that served as a foundation. The study is based on risk and risk management strategies, decision theory, insurance risk theory, utility maximization theory, discrete choice theory and social capital theory.

2.11.1 Decision theory

Decision theory is a decision-making paradigm that was established in the mid-twentieth century with the help of numerous academic fields. The theory is a multidisciplinary approach to making decisions in the face of unknown variables and an uncertain decision-making environment (Parmigiani *et al.,* 2010). The hypothesis was established with the help of numerous academic disciplines in the mid-twentieth century. Economists, statisticians, psychologists, political and social scientists, and philosophers are common users of the idea (Jeffrey, 1992). Furthermore, the utility function of payoffs is used to deduce its genesis from economics. According to the idea, decisions are made by calculating utility and probability, determining ranges of options, and formulating methods for making a good selection. Many disciplines, including economics, risk analysis, corporate management, and theoretical behavioural ecology, have used the idea to solve real-world problems (Maguire & Albright, 2005). In general, decision theory provides a framework for economic agents to make rational decisions in the face of uncertainty. The theory provides conceptually easy processes for options given a certain set of alternatives, consequences, and correspondence. Furthermore, decision theory is concerned with strategies for deciding the best course of action when a number of options are available and the implications of each cannot be predicted with certainty (Parmigiani *et al*., 2010).

Option	$Pr(S_1)$	$Pr(S_n)$
A_1	$Pr(C_{11})$	$u(C_n)$
……	…..	……..
A_m	Pr(Cm)	$u(C_{nm})$

As a result, each option has an expected value that is determined jointly by the functions u and Pr. Option A1's expected value, represented by E (A1) is, for instance, $u(C_{11})\ Pr(S_1)+ u(C_{1n}).Pr(S_n)$. More generally, if the number of possible states is finite

$$E\ (A1) = \sum_{k=0}^{n} u(Cji).\,Pr(S1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (1)$$

Now, what standard decision theory recommends choosing the option with the highest expected value. This is known as the maximization of the expected utility hypothesis.

In this study, potato smallholder farmers face uncertain conditions that dictate how much risk to take and which risk management strategies smallholder farmers should employ

for the specified amount/type of risk. Therefore, it is vital to include decision theory in this study.

2.11.2 Insurance risk theory

Risk insurance theory considers a number of elements while developing and implementing various insurance products. The theory incorporates risk analysis for certain populations, premium rate determination, indemnity amount, reinsurance required to minimize risk for primary insurers, and capital to reserve to pay prospective claims from the insurer's perspective. On the consumer side, risk-averse consumers who utilize insurance to manage the risk of loss are stated to be driving demand for insurance (Liu, 2013). In the anticipated utility framework, the producers' preferences are represented by a monotone increasing and strictly concave von Neumann-Morgenstern utility function u. The total revenue of the producer is said to be subject to a variety of risks, including random production and random pricing, which affect each crop. Stochastic gross revenue is a deterministic function R of a vector of n non-negative random variables.

$$\tilde{x} = (\tilde{x}1, \tilde{x}2, \ldots\ldots\tilde{x}3, \ldots\ldots\tilde{x}n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

With joint cumulative distribution function defined over the support

$$X \equiv [0\ \ \bar{x}]x \ldots\ldots\ldots\ldots x[0\ \ \bar{x}n] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where x̄>0 for i=1……….n Hence the producers, gross revenue is R(X) when X= (x1…………..xn) ε X is realised

$I(Z) \geq 0$

For all Z ε z and the premium is assumed to depend only on the actuarial value of the policy

$$Q = c[E\ I(Z)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

With c (0) =0

c(e) ≥ 1 for e≥ 0

The probability operator is denoted by E. In one particular case of interest, transaction costs are proportional to claims that are

$$\mathrm{c(e)} = (1 + \gamma) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where e is the loading factor and γ is non-negative. In this study, it is assumed that losses are perfectly observed.

Under the limitations specified, an optimal insurance contract was found by determining the insurance premium and indemnity function that maximizes the insured producers' expected utility of gross revenue. As a result, it's critical to use this idea as the basis for determining the collaborative-based revenue insurance scheme's coverage level, premium, and indemnity amount.

2.11.3 Utility Maximization theory

Consumer utility serves as the foundation for evaluating willingness to pay (WTP) in terms of change in welfare in utility maximization theory. Consumers are eager to establish and pay for preferences that help them get the most out of their time. An individual's preferred utility function can be written as: $u(x,q)$ where $x = x_1.....x_m$ is a vector of private goods and $q = q_1.....q_m$ is a vector of public goods. Individuals choose private goods, and public goods are considered exogenous. An individual maximizes utility subject to income *y*. The direct utility function $v(p,q,y)$ is given by:

$$V(p,q,y) = \max\{u(x.p) \mid p.x \le y\}..... \quad (6)$$

The derivative of the expenditure function produces the Hicksian or utility constant (compensated) demand function, with the subscript signifying the Marshallian or ordinary demand curve (Deaton &Muellbauer, 1980).

$$u_i(p,q,u) = mp_i(p,q,u)... \quad (7)$$

Willingness to pay refers to the highest amount of money a person is willing to spend for a better situation (utility maximization) or the maximum amount of money an individual is willing to pay to escape a worse situation. The indirect utility function is used to define WTP as follows:

$$v(p,q^*,y-WTP) = v(p,q,y) \quad (8)$$

Where $q^* \ge q_i$ and increases in q are advantageous $\frac{\partial v}{\partial q} > 0$, implying that a higher consumption level of *q* leads to higher utility).

The majority of smallholder farmers are at risk of losing money. As a result, new advancements in revenue insurance, which tries to safeguard against revenue loss, have lately broadened the options for controlling these types of risk. Smallholder farmers must determine whether or not to use novel risk management instruments like a collaborative-based revenue insurance scheme (CoBRIS) to manage the risks associated with low revenue in this situation. In order for a smallholder farmer to make such a decision, he or she must examine how to

maximize profit from the innovation as well as how to achieve the highest level of utility, or else resentment will arise (McConnell *et al.,* 2009; Sadoul *et al.,* 1996). Smallholder farmers, on the whole, have a degree of utility that they wish to achieve and make decisions based on that level of usefulness. Given many utility levels 'K,' a farmer, for example, will select the level that adheres to the highest level of utility within his budget. The random utility theory is used to model such discrete choice scenarios (Lubungu *et al*., 2012). Potato smallholder farmers are unfamiliar with the concept of revenue insurance; thus this would be an altogether new product for them. The decision to buy a potato revenue insurance plan is comparable to the decision to buy a new product. As a result, the utility maximization assumption is the foundation for the innovation's adoption. The predicted benefit of adopting a technology should outweigh the cost of not adopting it (Aidoo et al., 2014). A smallholder farmer in this case decides to buy potato income insurance as a risk management technique. Lancaster (1966) believes, on the other hand, that buyers gain from the product's varied attributes rather than the product as a whole. Furthermore, smallholder farmers' participation in crop insurance schemes is determined by the benefits derived from the insurance program's varied features (Olila *et al.,* 2015). As a result, these characteristics encourage farmers to obtain crop insurance policies. As a result, the study took into account a discrete choice theory. In a study, smallholder farmers are asked how much they are ready to pay for product features and attribute level, which falls under the stated preference theory (Kouame & Komenon, 2012). When particular features are required for the product in question, the Discrete Choice Experiments is preferred for the willingness to pay. DCE is now the most acceptable option to use. The parameters of the CoBRIS contract were deemed an important aspect in this study, hence the DCE questionnaire was utilised. When a smallholder farmer faces many hazards that affect his gross earnings, it's usually best to buy a single insurance plan with a variety of features that covers all sources of risk at the same time. In theory, revenue insurance could be a useful instrument for smallholder farmers to manage revenue risks, thereby increasing household income and making them more financially robust.

2.11.5 Social Capital Theory

Since small communities first developed and humans engaged with the expectation of reciprocation and trust, the concept of social capital has existed (Platteau & Moore, 1994). Social capital is viewed as an equilibrium term in several theories. Repeated cooperation also tends to expand the available social capital stock. High levels of social capital, in turn, allow for the continuation of social cooperation. The circularity of the relationship between the act

of collaboration in the present and the likelihood of reciprocal cooperation in the future is captured by social capital theory through social equilibrium. The social capital hypothesis stresses the special benefits of social networks' trust, reciprocity, information, and cooperation. Networks, norms, and trust are examples of elements of social structure that promote coordination and collaboration for mutual gain (World Bank, 2001). Social capital and the adoption of the technology/products in question have been linked in studies.

In a study on climate change adaptation tactics, Balew *et al*. (2014) discovered that social capital influenced smallholder farmers' adoption of climate change adaptation techniques. In terms of insurance supply, having a lot of social capital makes community-based health insurance more likely to succeed (Woolcock & Narayan 2000). In this current study, social capital is represented by trust-related indicators (horizontal and vertical trust variables).

2.13 Conceptual framework

This study conceptualizes that potato farm income among smallholder farmers in Njombe town council is influenced by selected production (Late blight, frosts, bacterial wilt, low rainfall, and excess rains) and market (price volatility) post-harvest losses) risks. Smallholder farmers, according to Cervantes-Godoy *et al.* (2013), are disproportionately sensitive to the effects of risk. Because of this sensitivity, the repercussions of these risks can be severe, locking smallholder farmers in a cycle of poverty or driving them farther into it. Torero (2011) also cites the impact of risk and high transaction costs on their capacity to get markets to operate for them, which has a snowballing negative effect. Additionally, this study assumes that potato enterprise performance is influenced by the number of RMs used, cost of risk management strategies, frequency of risk management strategies, and the effectiveness of risk management strategies employed by potato smallholder farmers.

On the other hand, existing crop-revenue insurance products in Tanzania and the designed CoBRIS are assumed to influence the accessibility of agricultural insurance services, thereby affecting potato enterprise performance.

Further, the willingness to pay for the CoBRIS attributes was expected to be affected by the characteristics, trust-related factors and potato enterprise-related factors. Finally, improved potato enterprise performance, availability of agricultural insurance products, designed CoBRIS, and willingness to pay for the CoBRIS attributes improved income and financial resilience among potato smallholder farmers in Njombe town council. Figure 2 shows the conceptualized relationships among key variables of the study.

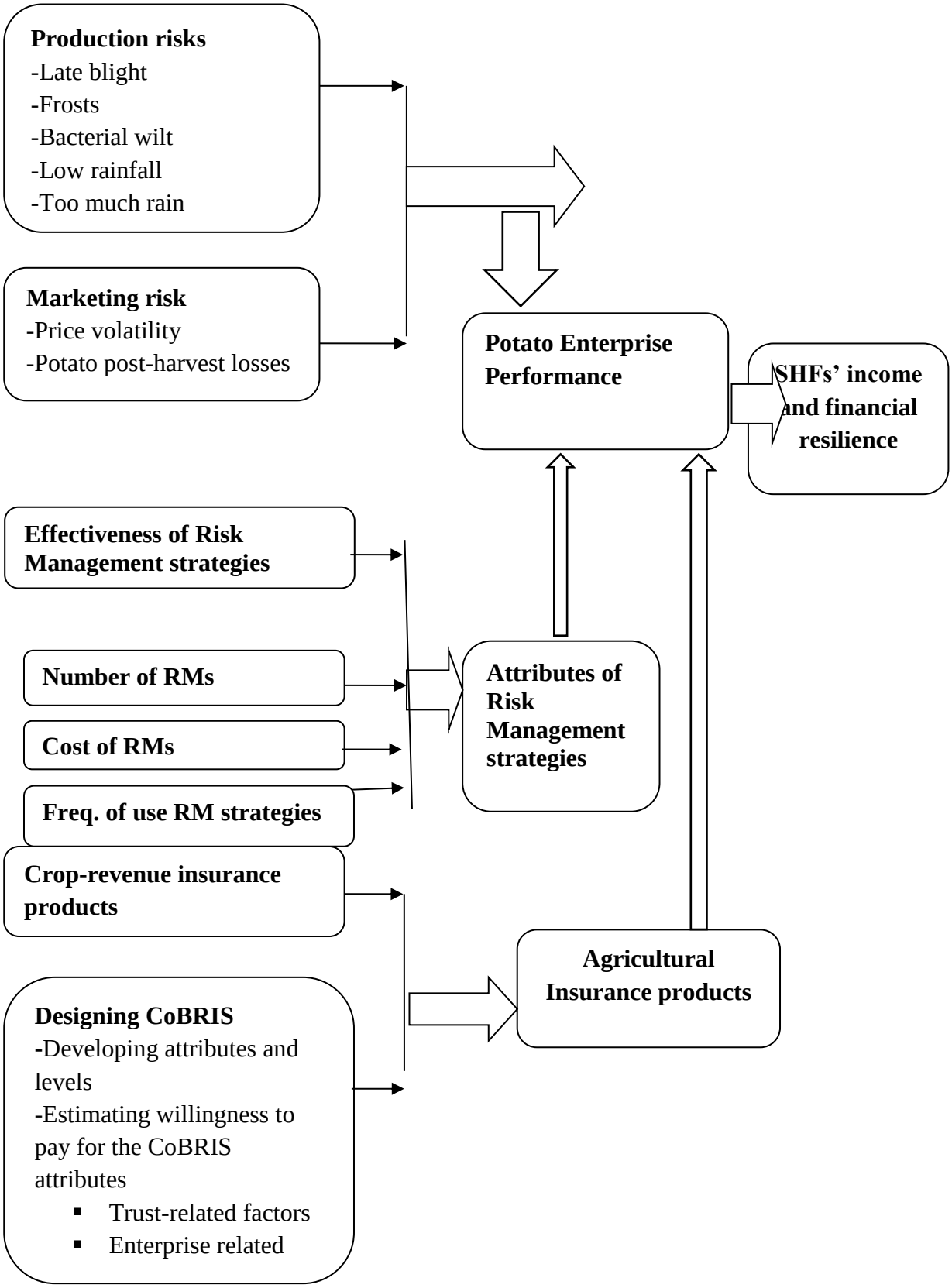


Figure 1: The conceptualized relationship among the critical variables of the study

CHAPTER THREE
METHODOLOGY

3.1 Research Design

This study employed a cross-sectional survey whereby data were collected at one point in time. A cross-sectional study design allows researchers to compare many different variables at the same time. This type of research is mostly employed to determine the prevailing characteristics at a certain point in time. For example, a cross-sectional study might be used to determine if exposure to specific risk factors might correlate with particular outcomes.

3.2 Study Area

The study was conducted in Njombe Town Council, where Lusitu Agribusiness Group (LAG) is located. The council lies between Longitudes 34°0’ and 35°30’East and Latitudes 8°30’ and 9°30’South. The council has a total surface area of 3,212 sq. km, equivalent to 15.2 per cent of the total regional land area. Currently, the council has two divisions with 13 wards. According to the United Republic of Tanzania (2013), the council’s population was 130,223, 53.1 per cent was female. Njombe town council is relatively homogeneous, with gently undulating plains intersected by seasonal streams. The council has two main features: the highland zone of the council is situated on the western escarpment, which covers most parts of the Igominyi division, with rainfall ranging between 1,200-1,400mm per annum. The soil is acidic with the extreme north. The northern-west part of the council gives way to a lower zone covered by black and loam soil, experiencing rainfall ranging between 1,000 to 1,200mm annually. The council experiences temperatures ranging from 150 centigrade to 210 centigrade. The minimum temperature occurs in May to August when the temperatures go down as far as negative two degrees centigrade. The council receives rainfall once a year between October/December to March/April each year. The seasonal rains last for roughly 110 days between October/December and January to March/April. This is also the main crop planting season for all crops.

Agriculture is the main economic activity in the council. About 78 per cent of the residents depend on agriculture as the primary source of household income (URT, 2013). Njombe town council has cold weather, fertile soil, and reliable rainfall, a favourable agriculture conditions. This enables the council to be the biggest producer of Potatoes and Maize in terms of food crops in the region. Irish potato is the leading food and cash crop in Njombe town council. In addition, potato (8.4MT/Ha has the highest production per hectare compared to Maize (2.5MT/Ha), Beans (3.2MT/Ha) and Wheat (2.9MT/Ha).

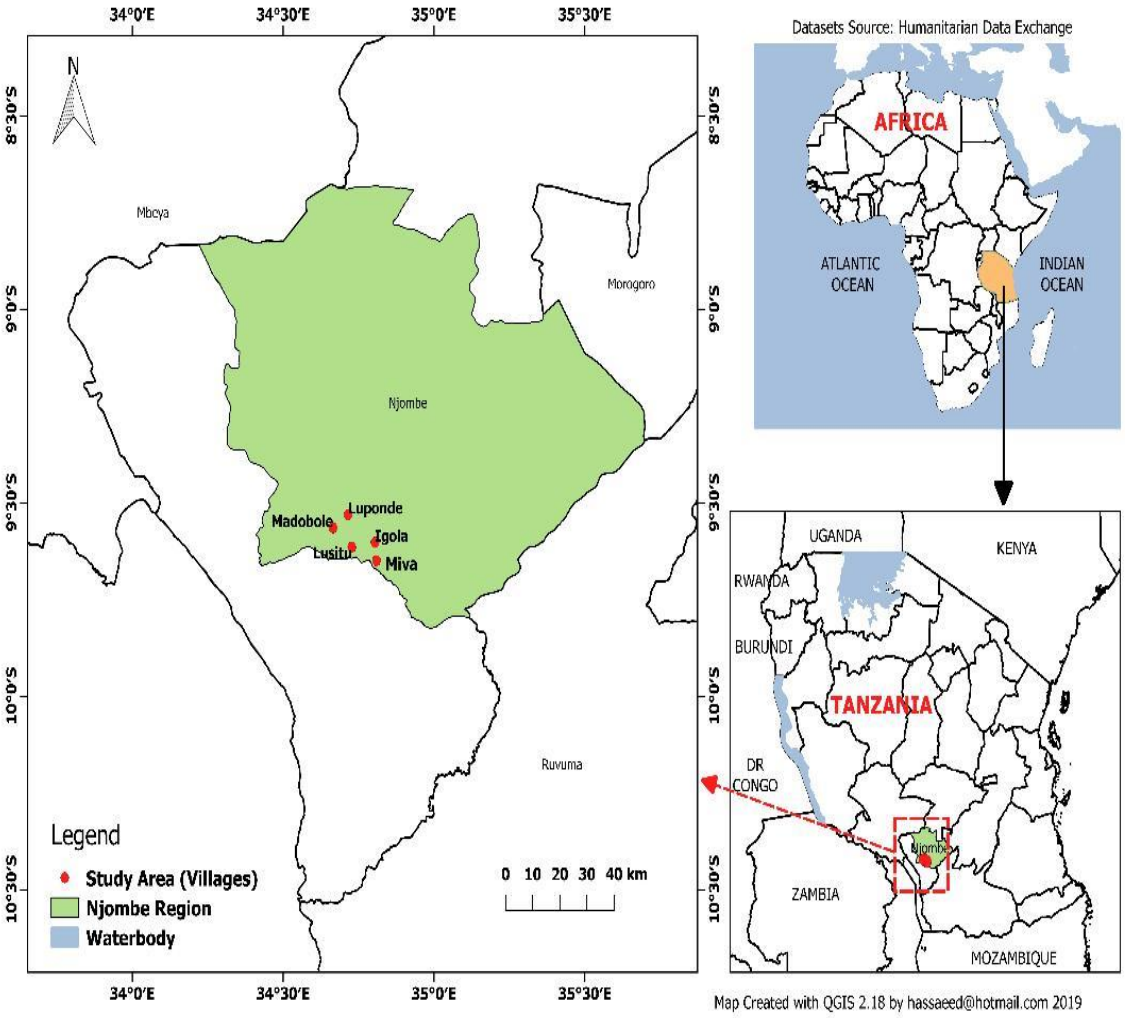


Figure 2: Map of Tanzania showing study areas

Source: ICPAC Geoportal and Humanitarian Data Exchange (2017)

3.3 Target Population of Study

The target population for this study was the potato smallholder farmers who are members of a Lusitu Agribusiness Group in the study area. Lusitu Agribusiness Group is a group of potato smallholder farmers which is located in Igominyi division, Njombe town council. The group is registered with Registration No 413332 under the Business Registrations and Licensing Agency (BRELA). This Group has a total of 2000 members who are potato smallholder farmers from the villages of the Igominyi division. Currently, the group is implementing the Lusitu Potatoes Pack House and Marketing Project in partnership with Kilimo Trust Tanzania. From the target population, the respondents who were members of the Lusitu Agribusiness Group were considered for this study. In addition, the study

considered insurance agents/companies offering agricultural insurance services for smallholder farmers in Tanzania as a target population and respondents.

3.4 Sampling Procedures

The study employed a multi-stage sampling technique where the first stage involved the purposive selection of the Igominyi division from Njombe Town Council. In stage two, Luponde ward, where Lusitu Agribusiness Group operates was purposively selected from Igominyi division. In stage three, five villages, namely Lusitu, Luponde, Mbega, Miva and Igola were also purposively selected from Luponde ward. These villages were selected for the study because most potato smallholder farmers are active members of Lusitu Agribusiness Group. Then, a proportionate stratified sampling technique was used to determine the number of potato SHFs from each village. As a result, 115 respondents were from Lusitu, 77 from Luponde, 58 from Mbega, 96 from Miva and 38 were from Igola village. Finally, the actual smallholder farmers of Lusitu Agribusiness Group were randomly selected from each of the five villages. During field visits, the source lists these potato smallholder farmers from each village was provided by the coordinator of Lusitu Agribusiness Group to make a sample of 384. For the insurance agents/companies, a census was employed whereby seven insurance companies, namely ACRE Africa, UAP insurance company, MGen insurance company, Jubilee Insurance company, Sanlam Insurance company, National Insurance Corporation of Tanzania STRATEGIES insurance company in Dar es Salaam, were involved.

3.5 Sample Size Determination

The sample size of this study was determined using the following formula by Groebner *et al*., (2011).

$$n = \frac{\left(pqz^2\right)}{d^2}$$

Where, '*n*' is the sample size, 'z' = 1.96 (standard variate at a given confidence level = 0.05), '*P*' is proportion of the population of interest. The study assumes that 50% of the potato smallholder farmers in the study area are members of Lusitu Agribusiness Group as a result, the study sets p = 0.5 which assumes maximum heterogeneity (i.e. a 50/50 split), *d*' is the margin of error that is acceptable and it set at 0.05and *q*' is the variable and is computed as *1-P*.

Therefore, the sample size to be used is determined as:

$$n = \frac{(0.5 * 0.5)(1.96 * 1.96)}{(0.05)^2} = 384$$

The 384 respondents were proportionately distributed among the five villages (Lusitu, Luponde, Mbega, Miva and Igola) in Njombe town council. Precisely, a proportionate to size sampling technique was employed to distribute the respondents. The formula is represented as follows:

$$nA = \frac{NvillageA}{(TotalN} * Tn$$

Where ***nA*** represent sample size from each village

NvillageA represent members of Lusitu Agribusiness Group in each village

TotalN represent members of Lusitu Agribusiness Group in all villages

Tn is the total sample size of the study

Therefore, respondents were distributed as follows:

Table 1: Distribution of respondents per village

Village	Members of LAG in the village	Sample size from each village
Lusitu	600	115
Luponde	400	77
Mbega	300	58
Miva	500	96
Igola	200	38
Total	**2000**	**384**

Finally, the actual respondents were randomly selected from the source list provided by the program coordinator in the villages.

3.6 Sources of Data and Methods of data collection

Primary and secondary data were used in the investigation. Questionnaires and semi-structured interviews were used to obtain primary data. Interviews with key informants and desktop reviews were also used. A pilot test was done to determine the questionnaire's validity and reliability. According to Cooper and Schindler (2010), a pilot test is undertaken to uncover

design and instrumentation flaws and offer proxy data for selecting a probability sample. A pilot study, according to Babbie (2006), is when a questionnaire is provided to a small group of people with the goal of pre-testing the questions. The pilot test is an activity that aids the research in identifying if the questionnaire design has problems, restrictions, or other flaws. It enables essential adjustments to be made prior to the study's execution (Kvale, 2007). To examine the instrument's clarity, complexity, and validity, a pilot test was conducted on five randomly selected potato smallholder farmers in Madobole community, Njombe.

A minimum of 1 percent of the sample should be used for the pilot test, as a rule of thumb (Cooper & Schilder, 2010). The size of the pilot test was within the recommended range.

3.6.1 Objective one: Analysis of perceived effect of the selected revenue risks on potato farm income among smallholder farmers

In addressing this objective, the study employed a questionnaire to collect data on perceived effect levels of the selected production and market risks on potato farm incomes in the study area. Senkondo (2000) suggested this method, referred to as risk analysis, using a structured questionnaire. The technique specifically used a five-point Likert scale approach to quantify the perceived effect levels of the selected revenue risk on potato farm incomes. Potato smallholder farmers were first asked to rank the likelihood of risks affecting potato farm incomes. The ranks were 1=Very unlikely, 2= Unlikely, 3= average/moderate, 4=Likely and 5= Very likely. Then, smallholder farmers were also asked to rank the perceived effect levels of the selected revenue risks on potato farm incomes using a five-point Likert scale where 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high.

3.6.2 Objective two: Determining the effect of risk management strategies' attributes on potato enterprise performance among smallholder farmers

The questionnaire was used to collect data on the effect of revenue risk management strategies on the potato enterprise performance. The study first identified the various revenue risk management strategies that potato smallholder farmers use to manage potato revenue risks. Then data on the number of risk management strategies, types of risk management strategies, the total cost of risk management strategies and frequency of risk management use were collected. These data were used to determine the effects of various risk management strategies' attributes on potato enterprise performance. Specifically, data on the number of risk management strategies used, frequency of risk management strategies use, the effectiveness of

risk management strategies and the Costs of risk management strategies. Additionally, data on risk management strategies employed by potato smallholder farmers and their perceived effectiveness on managing risks were also collected. A five-point Likert scale with a rank of 1=strongly disagree, 2= Disagree, 3= Neutral, 4=Agree, and 5=Strongly agree were also collected.

3.6.3 Objective three: Analysing various crop-revenue insurance products that exist for potato smallholder farmers in Tanzania

Key informant interviews and desktop reviews were employed to collect data on various crop-revenue insurance products for potato smallholder farmers in Tanzania. Specifically, respondents from ACRE Africa, UAP insurance company, MGen insurance company, Jubilee Insurance company, Sanlam Insurance company, National Insurance Corporation of Tanzania and STRATEGIES insurance company in Dar es Salaam were involved in the key informant interview. The study collected data on the insurance companies that offer crop-revenue products and the kind of crop-revenue insurance products in terms of the program name, year the company started offering crop-revenue products, product type, name of the Organization, Location/countries of the operation and regions of operation, risks covered (diseases, drought, excess rains, prices, post-harvest losses) contract structure-area based/individual base/weather index, involvement of the company in agriculture insurance services, product maturity, description of the key distribution channels, targeted markets (in terms of income, location, gender, economic activity), premium per hectare insured and the number of farmers insured per year. Additionally, data on the aspect of product design, contract distribution, benefit delivery, experience, access and costs of the crop-revenue insurance products were collected. On the other hand, the study gathered data on how the crop-revenue insurance business model operated in Tanzania.

3.6.4 Objective four: Designing a collaborative-based revenue insurance scheme for potato smallholder farmers

To address this objective, the study collected data in three stages. In the first stage, the literature review was used to collect secondary data. Specifically, data on attributes and attributes levels were collected. The data were then used to develop attributes and attribute levels of the CoBRIS contract. In stage two, the study employed key informant interviews to collect data from ACRE Africa, UAP insurance company, MGen insurance company, Jubilee Insurance company, Sanlam Insurance company, National Insurance Corporation of Tanzania

and STRATEGIES insurance company in Dar es Salaam. The key informant interviews were used to validate the attributes and attribute levels identified during systematic analysis. Then generic and D-efficient method with SPSS was used to generate the choice sets of attributes and attribute-level. In stage three, a discrete choice experiment (DCE) through a questionnaire was employed to collect data from potato smallholder farmers. The DCE analysis is a popular market research technique that marketers use to determine what features a new product should have and how it should be priced. It requires research participants to make a series of trade-offs. Analysis of these trade-offs reveals the relative importance of component attributes. In addition, the use of the Discrete Choice Experiment helps to ascertain a consumer willingness to purchase products at specific price points and which attributes are most desirable by smallholder farmers in the study area. The contract will consist of attributes, level of attributes with five scenarios (Contract A, Contract B, Contract C, Contract D and Contract E).

3.7 Data Analysis

SPSS and STATA software were used to manage data. The data collected were analysed using descriptive statistics (mean, percentage, frequency and cross-tabulation) and Factor analysis. In addition, multiple linear regression model, Conditional Logit model, content analysis and PACE analysis were employed.

3.7.1 Analysing perceived effects of the selected production and market risks on potato farm incomes among smallholder farmers

Descriptive statistics were used to describe smallholder farmers' perceived effect of the selected production and market risks on potato farming enterprise from a five-point Likert scale of very low, low, average/moderate, high and very high/severe.

Table 2: Description of variables for objective one

Variable	Description	Measurement	Exp. sign
Likelihood of production and market risks to affect potato farming enterprise			
FROSTFARM	Likelihood of frosts to affect potato farm	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate,4=Likely 5=Highly likely	None
EXTRAINSFARMS	Likelihood of extreme rains to affect potato farm	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate,4=Likely 5=Highly likely	None
LOWRAINFARMR	Likelihood of low rainfall to affect potato farm	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate,4=Likely 5=Highly likely	None
LATEBRIFARM	Likelihood of Late bright to affect potato farm	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate,4=Likely 5=Highly likely	None
BACTEFARM	Likelihood of Bacterial wilt to affect potato farm	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate, 4=Likely 5=Highly likely.	None
PRIVOLATILITYREVES	Likelihood of potato price volatility to affect potato revenues	Ordinal 1=Veryunlikely,2=Unlikely, 3=average/moderate, 4=Likely 5=Highly likely.	None
POPOSTHARVLOSSREVES	Likelihood of potato post-harvest losses to affect potato revenues	Ordinal 1=Very unlikely,2=Unlikely, 3=average/moderate, 4=Likely 5=Highly likely.	None

Variable	Description	Measurement	Exp. sign
Perceived effect of the selected production and market risk on potato farming enterprise			
EFFFROSTREVE	Effect of frost on potato revenues	Ordinal 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high/severe	None
EFFRAINSOREVE	Effect of too much rains on potato revenue	Ordinal 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high/severe	None
EFFDROUOREVE	Effect of low rainfall on potato revenue	Ordinal 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high/severe	None
EFFLATEOREVE	Effect of Late blight on potato revenue	Ordinal 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high/severe	None
EFFBACTOREVE	Effect of Bacterial wilt on potato revenue	Ordinal 1 = very low, 2 = low, 3 = average/moderate, 4 = high and 5 = very high/severe	None
EFFVOLAONREVE	Effect of potato price volatility on potato revenue	Ordinal 1 =very low, 2 = low, 3 = average/moderate, 4 = high 5 = very high/severe	None
EFFPPLOSSESONREVE	Effect of Potato post-harvest losses on potato revenues	Ordinal 1 =very low, 2 = low, 3 = average/moderate, 4 = high 5 = very high/severe	None

3.7.2 Objective two: Determining the effect of various risk management strategies attributes on potato enterprise performance among smallholder farmers

To address this objective, multiple linear regression model was employed to determine the effect of revenue risk management strategies on potato enterprise performance (PEP). The general form of multiple linear regressions is expressed as follows:

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2 + \beta kXk + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Y=Dependent variable

B0 =intercept

β1 β2……. βk=Coefficients of explanatory variables

X1, X2, X3, X4…Xk=explanatory variables. Therefore, function can be specified as follows: PotatoEnterprisePerformance=f(NumberriskMastrategies,EffectivenessofriskMastrategies,TotalCostriskMastrategies and FreqriskMastrategies)

$$\text{Potato Enterprise Performance (PEP)} = \beta 0 + \beta 1(\text{NumberriskMastrategies}) +, \beta 3(\text{TotalCosts riskMastrategies}) + \beta 4(\text{FreqriskMastrategies}) + \beta 5(\text{EffectivessRMStrategies}) + \mu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Table 3: Description of variables for objective two

Variable	Description	Measurement	Exp. sign
Effect of on-farm risk management strategies attributes on potato enterprise performance			
	Dependent variable		
POTAEPERFORMANCE	Potato gross revenues	Continuous TZS	None
	Independent variables		
NURISKMAGESTRATEGIES	Number of risk Management strategies per season	Continuous	+/-
FREQRISKMASTRATEGIES	Frequency of use of risk Management strategies	Continuous	+/-
TOCOSTSRISKMASTRATEGIES	Total costs of risk management strategies	Continuous (TZS)	+/-
EFFECTIVENESSRISKMASTRATEGIES	Effectiveness of risk management strategies	Continuous	+

3.7.3 Objective three: Analysing various crop-revenue insurance products that exist for potato smallholder farmers in Tanzania

To address this objective, descriptive statistics, thematic content and PACE (Product design, Access, Cost and Experience dimensions of the product) tool were used to analyse various crop-revenue insurance products that exist for smallholder farmers in Tanzania. The PACE analysis specifically was employed to analyse the existing crop-revenue insurance products and assess the client value of the existing products compared to other crop-revenue insurance products in Tanzania. Additionally, the PACE analysis was used to highlight gaps and strengths in product design, distribution and delivery, and costs, each of which can improve the overall value of the existing crop-revenue insurance products.

3.7.4 Objective four: Designing a collaborative-based revenue insurance scheme for potato smallholder farmers

In addressing this objective, data were analysed in two stages whereby in stage one, attributes and attribute levels were developed and validated. In stage two, the study estimated the willingness to pay for the designed collaborative-based revenue insurance scheme.

Stage one: Developing attributes and attribute levels for Collaborative-based revenue insurance scheme (CoBRIS)

Literature review and Content analysis were used to develop and validate the attributes and attribute level for the collaborative-based revenue insurance scheme. In this study, Content analysis was used to quantify and analyse the presence and meanings of attributes in the validation process. Additionally, an optimal orthogonal design from SSPS software was employed to construct CoBRIS scenarios.

Stage two: Estimating the willingness to pay for the developed CoBRIS' attributes

In estimating the willingness to pay, the study employed the Conditional Logit Model(CLM), a popular model in discrete choice analysis (Train, 2003). The first step is to specify a main-effects model, assuming preference heterogeneity for all CoBRIS contract attributes.

The model is expressed as:

$$Ynt = \beta 0 + \beta 1nX1nt + \beta 2nX2nt + \mu \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \quad (11)$$

Where Ynt is the binary variable that takes a value of 1 if a farmer n chooses a CoBRIS contract in the choice scenario t and zero; otherwise, $\beta_0$is constant, β_1 and β_2 are coefficients of the CoBRIS contract attributes, X_1nt and X_2nt are the CoBRIS attributes and μ is an error term Therefore, the empirical model is expressed as:

$$\text{CoBRIS contract} = \beta 0 + \beta 1\text{Premium} + \beta 2\text{Indemnity} + \beta 3\text{Coverage level} + \beta 4\text{TrustamongSHFs} + \beta 5\text{TrustbetweenSHFs, MICs andFIs} + +\beta 6\text{Potato post} - \text{harvest losses} + \mu \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . \ldots \ldots \ldots (12)$$

Finally, the WTP amount is obtained by working out the total derivative of utility (Ynt) with respect to changes in the premium rate and other CoBRIS contract attributes.

$$\text{dYnt} = \text{d}\beta 0 + \beta 1\text{ndPnt} + \lambda\text{ndXnt} + \text{d}\mu \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (13)$$

Setting this equation equal to zero, we can solve for WTP of CoBRIS attributes

$$\frac{\text{dPnt}}{\text{dXnt}} = -\frac{\lambda\text{n}}{\beta 1\text{n}} = \text{WTP of CoBRIS attributes} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (14)$$

Where

WPT= Mean WTP of SHFs for CoBRIS

X_{nt}= CoBRIS contract attribute

Pnt=Premium rate

λ_n= Coefficient to be estimated for other CoBRIS contract attributes

β_{1n}= Coefficient to be estimated for the premium rate

Generally, equation (15) above represents the marginal willingness to pay (WTP) of smallholder farmers for change in CoBRIS contract attribute Xnt.This is achieved by dividing an attribute coefficient and the price cost. This also gives an average WTP. Therefore, mean WTP

$$\text{WTP} = -1X \frac{\text{Coefficient of CoBRIS contract attributes}}{Coefficient\ of\ premium} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (15)$$

Table 3: Description of variables for CoBRIS contract

Variable	Description	Measurement	Exp Sign
Dependent Variables			
Yn	1 if SHF choices a CoBRIS contract in the choice sets and 0 otherwise	Dummy 0=No 1=Yes	
Independent Variables: CoBRIS contract attributes			
RISKCOVEREDCoBRIS	Risk covered by the CoBRIS contract	**Nominal** Low rainfall Excess rains Bacterial wilt Late blight Frostbite Potato price Post-harvest losses	+
CoBRISCONTRCT CONTENT	Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses	**Dummy** 1=Potato Yield only 0=Otherwise 1=Yield-Potato price 0=Otherwise 1=YieldPost-harvest losses 0=Otherwise	+
CoBRISPREMIUM	Cost of CoBRIS contract per acre	**Continuous** (TZS/acre)	-
COVERAGELEVEL	Coverage level purchased as a percentage of the total yield or , revenue per acre covered	Continuous (Percentage)	+

Table 4: Description of variables for the CoBRIS contract-continuation

Variable	Description	Measurement	Exp Sign
INDEMNITY	Expected payment in the case of yield loss, revenue loss	Continuous (TZS)	+
Trust-related factors			
TRUSTAVs	High level of trust among villagers	**Ordinal** 1=Strongly disagree, 2=Disagree 3=Neutral, 4= Agree 5. Strongly agree	+
TRUSTALAG	High level of trust among members of Lusitu Agribusiness Group	**Ordinal** 1=Strongly disagree, 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
VsTAKADYOU	Most villagers take advantage of you to achieve their own goals	**Ordinal** 1=Strongly disagree, 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	-

Variable	Description	Measurement	Exp Sign
RETUPICKEDPROPOWNER	Most villagers would return what they pick up to the original owner	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
TRUSTNEIGHBORS	Most of the neighbors in the village can be trusted	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
TRUSTLAGLEADERSONCMAGMENT	Lusitu Agribusiness leader are trusted among the members on conflict management	**Ordina**l 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
TRUSTLAGLEADERSONFUNDS	Lusitu Agribusiness leader are trusted among the members on good funds management	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree	+

Variable	Description	Measurement	Exp Sign
		5=Strongly agree	
TRUSTFORFTs	**Trusting Financial institutions**	**Ordina**l 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+

Variable	Description	Measurement	Exp Sign
TRUSTFORINSURA	Trusting insurance providers	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
VsCONCEISSUESOFOTHERS	Villagers concern issues that not only relate to themselves, but also relate to others	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+

Table 4: Description of variables for the CoBRIS contract-continuation			
VsHELPSOMEONE	Villagers will provide help if someone really needs it	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
LENDINGMONEYNEIGHBOR	Lending money to your neighbor if he/she needs it when is affected by risk damage	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
FAMILYMEMBEROFVILLAGE	Become a family member of the whole village	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
SUPPORTPROJECT	Supporting a project that might not benefit you most but benefit other villagers	**Ordinal** 1=Strongly disagree 2=Disagree 3=Neutral, 4= Agree 5=Strongly agree	+
Potato enterprise-related variables			
PERCPOSTHAEVLOSSESS	Potato post-harvest losses per ha	Continuous (MT)	+/-

CHAPTER FOUR
RESULTS AND DISCUSSIONS

This chapter is divided into four main sections. The first section describes descriptive results, including the socio-economic and institutional characteristics of the household potato farmers in the study areas.

The second section discusses the likelihood of climate, pests, diseases and market risks affecting potato farm income, perceived effect of climate, pests, diseases and market risks on potato farming enterprise among smallholder farmers. Importance of preventing the consequences of climate, pests/disease and market risks, the results of the multiple regression model on the effect of risk management strategy attributes on potato enterprise performance, the ability of potato smallholder farmers to protect themselves against climate risks, pests-diseases risks and marketing risk the traditional risk management strategies employed by potato smallholder farmers is also discussed. Additionally, section four of this chapter describes crop-revenue insurance products and business model for crop-revenue insurance products for potato smallholder farmers in Tanzania. It compares the selected crop-revenue insurance products using PACE analysis. Development of attributes and attribute levels for CoBRIS, validation of the CoBRIS' attributes, experimental design and construction of CoBRIS choice sets and the determination of willingness to participate and pay for the developed CoBRIS' attributes are discussed in section five.

4.1 Characteristics of potato smallholder farmers in the study area

This section presents descriptive statistics of the socioeconomic variables of potato smallholder farmers in the study area. These variables include both continuous and categorical ones. Tables 5, 6, 7, 8, and 9 present characteristics of potato smallholder farmers in terms of household characteristics and farm characteristics.

4.1.1 Household Characteristics

Results show that the average age of potato household head was 39.34 years in Njombe town council. This implies that more middle-aged people are engaged in potato farming than younger ones. This finding could be attributed to the fact that youth are mainly limited with resources including land, as a result, they are only able to have less or one acre of land; hence less of them area engaged in potato production. For example, Ahaibwe *et al*. (2013) young people face significant restrictions when trying to actively participate in agriculture, pointing out that they are at a disadvantage compared to major age group.

The findings are in line with Daniel (2015) that the middle age group is more active than the younger group in potato farming. Additionally, Kilimo Trust (2017) pointed out that, the distribution of age among SHFs shows that 30 percent of them were aged between 18 to 35 years (36 percent) followed by 35 to 45 years (32 percent). Kabungo (2008) also reported that age influences potato farming since activities associated with the production process are very tough and require energetic people.

In terms of respondent's education levels, the findings point out that potato smallholder farmers had a mean of 7.29 years spent in school. This suggests that on average, potato, smallholder farmers in Tanzania had attained primary school level. This also means that the majority of household heads in the research area were literate enough to be able to acquire and implement agricultural production technology obtained from a variety of sources, such as agricultural extension agents and the news media. Furthermore, it is anticipated that educated potato small - scale farmers will be more profit-oriented than those who have had no formal education. Similar results were reported by Daniel (2015) that the majority of Irish potato smallholder farmers had primary education in the Njombe town council. Additionally, Okello *et al*. (2015) pointed out that, on average, potato smallholder farmers in Njombe spent 6.34 years schooling.

Moreover, the results show that potato smallholder farmers had a mean household size of five, implying that potato smallholder farmers had a larger household size than the national household size of three members in the Njombe region. The size of a household has an impact on the availability of family labour and the expenses of production. When it comes to working together in home economic tasks, having a large household is an invaluable asset. This, on the other hand, occurs when essentially all household members are involved in the production and provision of services in order to contribute to the home's economy. For potato smallholder farmers, on the other hand, a large household size means greater food and non-food spending, which forces the households to dedicate more land for potato production, resulting in additional economic benefits that help them fulfil their basic needs. Increased household size, according to Ayuya *et al.* (2015), entails greater expenditure on food and non-food items, which forces households to experiment with new low-cost initiatives that may provide extra economic benefits in order to meet their fundamental needs.

Furthermore, the findings reveal that potato smallholder farmers had an average of 18 animals per household. This shows that potato smallholder farmers rely on agriculture and livestock as their primary source of income and livelihood. The various animals kept in the study area include dairy animals, poultry, rabbits, and sheep. These results are consistent with

Okello *et al*. (2015) that potato smallholder famers in Njombe also raise various types of livestock such as dairy cows, poultry, rabbits and sheep. In addition, the study shows that, livestock are held as a source of food and income as a stock of assets and therefore play an important role in household wealth rankings. The size and type of herd determines whether the household is very wealthy, moderately wealthy, or considered poor. Large animals (such as cows and donkeys) are associated with wealthy households, and small animals such as Rabbits and poultry (such as chickens, ducks, pigeons) are associated with poor households.

The average household income for smallholder farmers in the research area was 4,464,432 TZS (4,464,432 USD) (1929.31 USD). Potato production, on the other hand, accounts for approximately TZS 2,634,645 (1138.57 USD) of the annual household income in Tanzania. This means that potato is an extremely valuable crop among potato small farmers, and that it makes a significant contribution to household income as a result of its high value. Mende *et al.* (2014) noted that potato production was the most important source of revenue in the Mbeya and Makete districts in Uganda. The annual income from both on-farm and off-farm activities contributed to the overall annual household income, according to Okonya *et al.* (2019). Mende and *et al.* (2014) also discovered that the majority of households had been compelled to engage in non-agricultural activities in order to increase their incomes. By immediately raising household income and providing funds for investment in farm inputs to increase agricultural production, non-agricultural activities filled the void left by agricultural activities. According to the findings of the study, livestock rearing was also one of the primary sources of income for the majority of potato households. The cattle keeping industry serves a variety of functions in the study region, including facilitating revenue generation, employment, and draught power generation (Mende *et al.*, 2014).

Table 4: Household characteristics for Potato smallholder farmers in Tanzania

Variable	Mean	Standard deviations
Age of the household head (years)	39.34	13.02
Education (years)	7.29	2.83
Household size	5.00	2.23
Number of animals	18.00	6.00
Annual income of the household head (TZS)	4,464,432	647,565

4.1.2 Gender, Household status and Main income earner among potato smallholder farmers

Table 6 presents categorical variables of potato smallholder farmers in the study area. Specifically, the table presents gender, household status, and the main income earner of potato smallholder farmers. Results show that 73.80 per cent of potato smallholder farmers in the study area were male, whereas 26.20 per cent of them were female. Regarding household status, 83.60 per cent of potato smallholder farmers' households are male-headed, while 16.40 per cent of the interviewed smallholder farmers were female-headed households. This implies that potato is a male-dominated crop in the Njombe town council. This could be attributed to the fact that potato is considered a cash crop in the study hence more male in the enterprise. Mpogole *et al*. (2013) reported that, on average, 88.00 per cent of all potato produced by farmers is sold out. This indicates that potato is among the highly commercialized crops in Tanzania. In terms of main income earners, the findings show that 84.30 per cent of the interviewed respondents are the primary income earners in the study area. On the other hand, only 15.70 per cent of them are not the primary income earners. This implies that potato farming has become a primary source of income; hence, most potato smallholder farmers in Tanzania are primary income earners.

Table 5: Distribution of Gender, Household status, Group membership and Main income earner among potato smallholder farmers

Variable	Description	Frequencies	Percent
Gender of respondent	Male	282	73.80
	Female	100	26.20
Household status	Male headed	321	83.60
	Female headed	63	16.40
Main income earner	Yes	323	84.30
	No	60	15.70

4.1.3 Potato Farm Characteristics

In terms of potato yield, the findings show that, in the rainy season, potato smallholder farmers had a mean of 87.06 bags, while in the dry season, farmers had a mean potato yield of 100.65bags. This means that potato smallholder farmers had the mean of potato yield significantly higher (100.65 bags) than (87.06 bags) in the rainy seasons. This variation might

be explained by the fact that there are low incidences of pests and diseases in the dry season that affect potato farms, hence higher potato yield than in the rainy season. These findings are in line with Nyunza and Mwakaje (2012) pointed out that potato output varied from 39 bags to 105 bags of round potato per acre with an average of 64.9 bags per acre. Nyunza and Mwakaje (2012) further indicated that potato yield variation was related to numerous variables, including amounts of farm inputs application, planting time (early or late), and soil fertility. Other reasons highlighted by smallholder farmers were the type of seeds used, the quality of farm supplies utilized, the ability to manage pests and to wilt. Regarding landholding size, the mean landholding size was 7.49 acres among potato smallholder farmers in Tanzania. This suggests that most potato smallholder farmers in the country are smallholders with an average landholding size of 2.9 ha. This is unsurprising, as Wolter (2008) reported that smallholder farmers in Tanzania farm on small plots range from about 2.0 to 7.5 acres (or about 0.9 to 3 ha).

Regarding the area under potato production, the findings reveal that 1.77 acres of land were allocated for potato production in the rainy season. In contrast, in the dry season, smallholder farmers were allotted 1.65 acres. This indicates that potato smallholder farmers in Tanzania allocated a significant larger land size during the rainy season than in the dry season. This could be attributed to the fact that, in the dry season, smallholder farmers are forced to irrigate their farms due to low rainfall. As a result, the cost of production becomes higher than in the rainy season; hence small land size is allocated.

Regarding the number of bags lost during harvesting, the findings show that smallholder farmers lost an average of 7.97bags of potatoes per acre in the rainy season. In the dry season, an average of 8.09 bags of potatoes were lost by potato smallholder farmers. This indicates that the mean number of potato bags lost during the dry season was significantly higher than in the rainy. The higher mean number of bags lost during the dry season could be associated with the fact that most potato smallholder farmers employ hand hoe to harvest potatoes. Since it was the dry season, the soil became so dry as the hand hoe becomes ineffective, leaving more potatoes in the soil, hence higher potato post-harvest losses among smallholder farmers. These findings align with Kilimo Trust (2017) that poor supervision during harvesting of potatoes and an absence of proper post-harvest handling techniques resulted in postharvest losses that stand at 18 per cent in the study areas. Additionally, Tadesse *et al*. (2018) noted that the quantity of potato postharvest losses at producer was the highest compare to the local traders, wholesalers and retailers along the value chain.

Table 6: Farm characteristics of potato smallholder farmers in Tanzania

Variable	Mean	Standard deviations
Landholding size of the household	7.49	17.02
The area under potatoes (acres) in season two	1.65***	1.31
Area under potato (acres) in season one	1.77***	1.49
Potato yield (100kg Bags) in season one	87.06**	70.75
Potato yield (100kg Bags) in season two	100.65**	90.54
No of bags lost during harvesting in one acre per season one	7.97***	5.54
No. of bags lost in one-acre during harvesting per season two	8.09***	5.01

Note: ***Significant at 1%

4.1.3 Potato production Costs and Revenues

Potato smallholder farmers had a mean of 1,264,752 TZS (equivalent to 545.11USD) total production and marketing costs for one acre per season in the study area. This amount of money is mainly used in purchasing clean seed potatoes, transport their potatoes to the big market, frequently spray their farms with fungicides and pesticides hence higher potato cost of production and marketing. These findings are in line with Daniel (2015) that in Njombe town council, the cost of production and marketing per acre was TZS 1,273,889 (equivalent to 549.05 USD) higher compared to Wanging'ombe district because in Njombe urban district majority of potato farmers depend on irrigation while farmers in Wanging'ombe district depends on rain-fed agriculture. Moreover, according to Nyunza and Mwakaje (2012), the vast majority of poor and low-productivity smallholder farmers sold their potatoes to village traders or fellow farmers, whereas large producers and rich smallholder farmers sold their potatoes to wholesalers in metropolitan regions.

In terms of potato revenue, in the rainy season, potato smallholder farmers had 2,520,090 TZS (equivalent to 1086.16USD) as revenue in the study area. On the other hand, earned potato revenue of TZS 2897603.52 (equivalent to 1248.87 USD) in the dry season. This indicates that potato smallholder farmers had a significant higher TZS 2,897,603 (equivalent to 1248.87 USD) potato revenues in the dry season compared to the rainy season. The possible explanations for this could be that, in the dry season, smallholder farmers had a higher potato yield of 100.65 bags than in the rainy season, hence higher potato revenues. Additionally, potato smallholder farmers might probably have allocated a large land on potato production

during dry season, hence increasing the likelihood of having higher yield, thereby making potato revenues higher. A study by Glauben *et al*. (2003) reveal that larger farms allow smallholder farmers to achieve economies of scale, use better and cheaper technologies, and increase potato income, making agriculture much more economically viable. Moreover, fewer pests and diseases in dry seasons therefore higher yield, which is translated to higher revenue than in the rainy season among potato smallholder farmers.

Table 7: Potato Production Costs and Revenues for Potato smallholder farmers in Tanzania

Variable	Mean	Standard deviations
Potato revenue in season one-rainy (TZS)	2,520,090*	317,991
Potato revenue in season two-dry (TZS)	2,897,603*	315,703
Annual potato farm income (TZS)	2,634,645	317,260
Total production and marketing costs for one acre	1,264,752	749,281

Note: *Significant at 10%

4.1.4 Number, Frequency of use and average costs of Risk Management strategies among potato smallholder farmers

Regarding the number of risk management strategies, potato smallholder farmers employed an average of 5 in the number of risk management strategies in the study area. This indicates that most potato farmers use a combination of strategies in managing revenue risks as a result of more farm potato income. Namwata *et al*. (2010) also revealed that an increased household income was significantly positively associated with the number of technologies adopted. In terms of the frequency of risk management strategies used, the findings show that potato smallholder farmers had an average of 20 times. This suggests that potato smallholder farmers frequently faced climate, pests-disease and marketing risks as a result, they increased the frequency of risk management strategies use.

Additionally, the findings postulate that potato smallholder farmers had a mean of TZS 388,383.11(167.39USD) as the costs for employing risk management strategies per one acre per season in the study area. Potato smallholder farmers incurred this cost in the management of climate, pests-disease and marketing risks that are associated with potato enterprise. The risk management strategies potato smallholder farmers employed in controlling these risks included the use of seed potato, fungicides and pesticides, irrigation costs, harvesting for the

second time and transporting their potatoes to the market. Okonya *et al*. (2019) also revealed that the top four most important constraints identified by smallholder farmers for potatoes were diseases, high costs of planting material, high cost of fungicides, and insect pests in Rwanda.

Table 8:Number, Frequency use and costs of risk management strategies among potato smallholder farmers

Variable	Mean	Standard deviations
Number of Risk Management strategies	5	1.54
Frequency of Risk Management strategies use	20	5.49
Average costs for RMstrategies /acre / season	388,383	311,961

4.2 Results of Objective one: Analysis of the perceived effect of the selected production and market risks on potato farm income among smallholder farmer

4.2.1 Likelihood of Climate, Pests, Diseases and Market risks affecting Potato Farming Enterprise

In terms of the likelihood of low rainfall to affect potato farm income, the results pointed out that 32.1per cent of respondents reported it is very likely for low rainfall to affect potato farm income. In comparison, 14.9 per cent reveal that it is likely for the low rainfall to affect potato farm income in the study area. This is true that low rainfall affects potato farming enterprises, which resulted in most potato farmers using irrigation systems as a risk management strategy when it comes to low rainfall. These findings are in line with Daniel (2015) that in Njombe town council, most smallholder farmers depend on irrigation; hence their potato farm income is less affected by the presence of low rainfall. Figure 3 further shows that 63.5 per cent of smallholder farmers reported that it is very likely for excess rainfall to affect potato farming enterprise, whereas 23.5 per cent of them revealed that it is likely for the excess rainfall to affect it. This implies that excess rainfall is a major challenge that affects potato farm incomes. This could be contributed by the fact that; excess rainfall is a conducive environment for the development of fungal pathogens responsible for the late blight disease, thereby affecting potato farm income among smallholder farmers in the study area. According to the URT (2016) report, change of weather conditions such as excess rainfall affects potato production, hence potato farm incomes in Njombe.

Moreover, the findings revealed that 66.1 per cent of the interviewed smallholder farmers reported that it was very likely for the frostbite to affect potato farming enterprise compared to the 15.7 per cent who said the bite was likely to affect potato farming enterprise in the study

area. This implies that about 81.8 per cent of smallholder farmers in Njombe town council revealed that frostbite is likely to affect potato farm income among them. URT (2016) also reported that change of weather conditions such as frost affects potato production, affecting income from potatoes among smallholder farmers.

The findings show that 60.6 per cent of potato smallholder farmers reported it is very likely for the late blight disease to affect potato farming enterprise, whereas 27.4 per cent said that late blight disease could likely affect it. This implies that most potato smallholder farmers (88 per cent) agree that late blight disease affects potato farming enterprise in the study area. Okonya *et al.* (2019) also discovered that potato late blight is the most commonly reported disease in the potato crop (58 per cent and 72 per cent of the respondents in Rwanda and Burundi, respectively).

The results pointed out that 67.6 per cent of all the smallholder farmers in the study area reported that bacterial wilt was very likely to affect potato farming enterprises. It was further revealed that 18.5 per cent said that the disease was likely to affect potato farming enterprises. This suggests that bacterial wilt is a crucial potato disease in the study area, with 86.1 per cent of smallholder farmers reported that it is likely for the disease to affect their potato farming enterprises. Okonya *et al*. (2019) reported that bacterial wilt disease was the most critical potato disease in Rwanda and Burundi. In the same line, Kagona (2008) pointed out that 100 per cent of the smallholder farmers were aware of the occurrences of bacterial wilt in their field and how it spreads in the study area. Therefore, the results confirmed that bacterial wilt is a great problem and threat to the Malawi potato industry (Kagona, 2008). In addtion, Okello *et al*. (2015) showed that most of smallholder farmers grow potatoes in the same plot each season. These practices have led to the emergence of pests ans diseases in the study area.

Regarding the likelihood of price volatility to affect potato farming enterprises, results show that 72.6 per cent of potato smallholder farmers reported that price volatility is very likely to affect potato farming enterprises, whereas 17.2 per cent price volatility is likely to affect their farms. This suggests that the majority (90 per cent) of potato farmers in the study area perceived that price volatility was likely and very likely affecting their potato farm income in the study area. In line with these findings, Daniel (2015) revealed that market risk is the major challenge that smallholder farmers face in the Njombe urban and Wanging'ombe district. Nyunza and Mwajake (2012) went on to point out that pricing in big markets were extremely low during harvest, and that prices were around three times higher during the post-harvest period than at the peak of harvesting.

Furthermore, the findings show that 43 per cent of potato smallholder farmers reported that post-harvest losses are very likely to affect potato farming enterprises. This might be explained by the fact that most potato smallholder farmers use hand hoe to harvest potatoes; as a result, there is a possibility of more potatoes being left in the soil, which lead to a decrease in yield, thereby reducing potato farm incomes. These findings are in line with Kilimo trust (2017) that most potato smallholder farmers were not using good post-harvest handling techniques; hence, the likelihood of post-harvest losses affecting potato farm income is very high. Tatwangire and Nabukeera (2017) also pointed out that the use of various harvesting tools such as hand hoe is strongly associated with serious damage to potatoes. This damage is greatest when harvested manually.

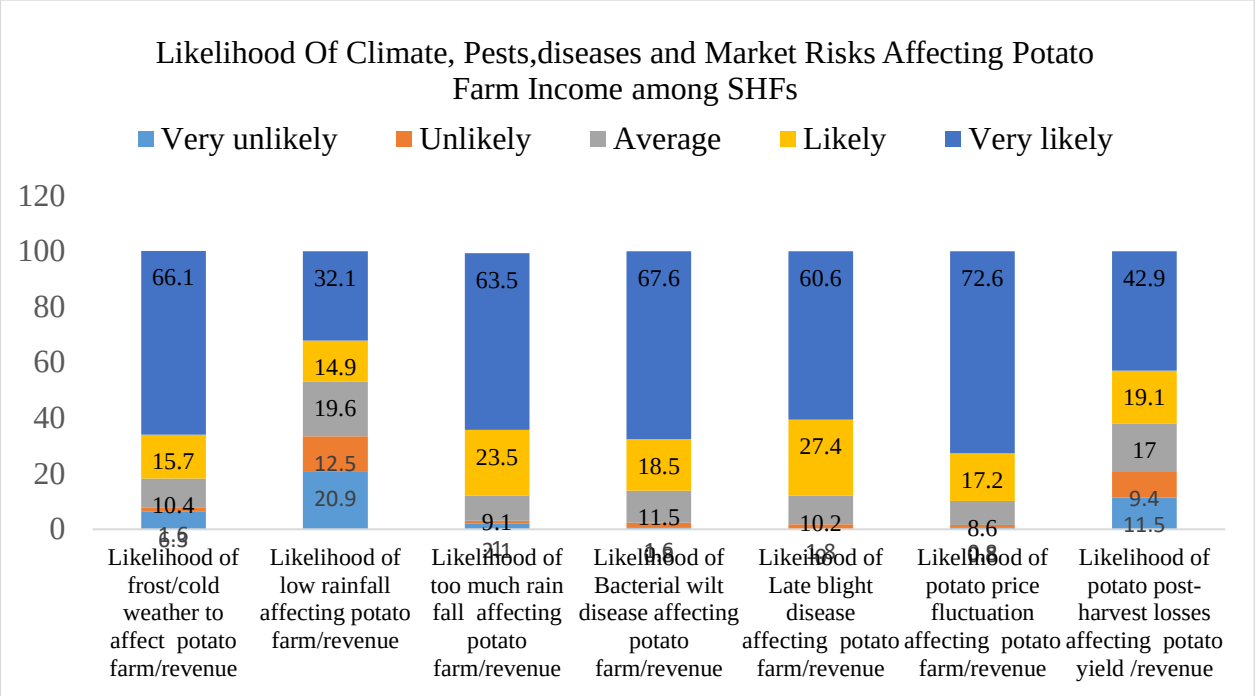


Figure 3: Likelihood of climate, pests, diseases and market risks affecting potato farming enterprise

4.3 Perceived effect of Climate, Pests, Diseases and Market risks on Potato Farming Enterprise

4.3.1 Perceived effect of climate risks on potato farming enterprise

The majority of research found that climate change is likely to impair agricultural productivity, production stability, and household income in some places that already have significant levels of food insecurity, particularly in the tropics (Greg *et al.,* 2011). Change of weather conditions, e.g. low rainfall, excess rainfall and frostbites affect potato production. Regarding low rainfall, 12.3 per cent of smallholder farmers perceived that low rain had a very high effect on the potato farming enterprise in the study area, whereas 14.1 per cent of them said that low rainfall had a high effect on it. In other words, less than half of the smallholder farmers perceived the effect of low rain on potato farm income to be high. This implies that most respondents do not feel the effect of low rainfall on their potato farms. This could be explained by the fact that most smallholder farmers plant their potatoes in the rainy season. Additionally, most of them irrigate their potato farms during the dry season; as a result, they perceive the effect of rainfall to be very low on their potato farm incomes**.**

The results further show that about 40.5 per cent of the respondents perceived that excess rainfall had a very high effect on the potato farming enterprise, whereas 32.4 per cent reported that excess rainfall had a high effect on their potato farms. This implies that, majority (72.9 per cent) of potato smallholder farmers perceived that excess rain had a high to very high effect on the potato farming enterprise. This is because excess rain causes high moisture content in the soil, which is a good condition for fungal pathogen development. Hence, late blight disease, a fungal-like disease that thrives in wet weather, is responsible for potato losses in the fields. Some studies have found that wet weather supplies enough moisture for various crops to avoid the need to irrigate them entirely. These same weather conditions, on the other hand, could have a significant negative impact on the potato harvest. For example, smallholder farmers may see an increase in diseases such as late blight hence negatively affecting potato farm incomes. Nolte *et al*. (2001) pointed out that farmers have to spend £20m a year on fungicides to contain the late blight disease. Further, the study revealed that potato farms sometimes need to be sprayed as often as 15 times in a growing season, which is expensive for farmers and can also reduce their potato farm income.

In terms of frostbite, the findings show that 41.5 per cent of smallholder farmers perceived that frostbite had a very high effect on the potato farming enterprise in the study area. Moreover, 24.8 %per cent of the respondents reported that frostbite had a high effect on the potato farming enterprise. This reveals that over half of the sampled potato smallholder farmers

perceived that frostbite had a high to very high effect on potato farming enterprise. This implies that frost damage causes significant losses in potato production, thereby affecting potato farming enterprises. For example, Kuldeep *et al*. (2012) reported that an acyclic frost occurred in Punjab that severely affected potato tubers' formation and development, which then caused considerable losses to potatoes. The study further pointed out that adverse climatic conditions such as frost caused quantifiable damage to the potato crop resulting in reduced tuber yield and marketable yield in the study area. Similarly, Shumetie and Alemayehu (2017) have shown that climatic risk such as frostbite can reduce agricultural productivity and production stability, thereby affecting household income. For example, if the product has an inelastic demand, consumers' total expenditure on the product, and thus farmers' revenue will rise when price increases and fall when price decreases. Thus, good harvests will bring reductions in total farm incomes while bad harvests will bring increases in farm incomes.

4.3.2 Perceived Effects of Pests and Disease risks on Potato Farming Enterprise

In terms of bacterial wilt, the findings show that 46.2 per cent of the smallholder farmers perceived that the disease had a very high effect on the potato farm income. On the other hand, 24 per cent of the respondent reported that bacterial wilt had a high effect on the potato farming enterprise. In other words, majority (70.2 per cent) of the smallholder farmers perceived that bacterial wilt had a high effect on their potato farming enterprises. This could be contributed by the fact that; bacterial wilt is a soil born disease, so most smallholder farmers believe it is difficult to control; hence it affects their potato farm income. Kagona (2008) also revealed that bacterial wilt is the most severe disease among potato smallholder farmers. The study further pointed out that the disease is severe because it does not have any treatment once diagnosed, and the plant is attacked at an early stage, then nothing will be harvested. This clearly showed that bacterial wilt is the most complex disease in their farming. According to the findings of a study conducted by Kamau (2005), many round potato smallholder farmers in Kenya were unable to control bacterial wilt, and as a result, the disease affected round potato productivity in the study region as a result. The same year, Okonya *et al*. (2019) found that crop losses due to pests and diseases such as bacterium wilt for potatoes ranged between 33 and 38 percent in Rwanda and Burundi, depending on the variety of potato. Pests and diseases, according to the findings of the study, diminish the profitability of root and tuber crops, endanger food security, and act as a deterrent to investment among smallholder farmers. Pests and illnesses also reduce agricultural yields, increase production costs, and reduce the storability and marketability of

crops. They also increase the risk of farming as a source of income or as a commercial enterprise.

About 44.0 per cent of potato smallholder farmers in the study area perceived that late blight disease had a very high effect on potato farming enterprise, whereas 32.6 per cent said that the disease had a high effect. This shows that 76.6 per cent of the respondents perceived that late blight disease had a high to very high effect on their potato farming enterprises. This is because the incidence of late blight disease is very high. As a result, majority of potato smallholder farmers perceive that their potato farming enterprises are highly affected by the disease. These findings align with NADO (2017) that in the last production season 2015/2016 most potato farms were severely affected by late blight disease. Kilimo Trust (2017) also revealed that late blight disease had been the main challenge facing potato farmers, and therefore the majority of interviewed farmers were using fungicides to control the diseases. The study further pointed out that, in Rungwe, all smallholder farmers were using fungicides, and consequently, the use of these chemicals has been among the significant determinant of potato yield in Tanzania.

4.3.3 Perceived Effects of Market Risks on Potato Farming Enterprise

The results from figure 4 reveal that 66.1 per cent of the smallholder farmers in the study area perceived price volatility to have a very high effect on the potato farming enterprise, while 20.8 per cent said price volatility had a high effect. This implies that 86.9 per cent of potato smallholder farmers perceived that price volatility had a high effect on the potato farming enterprise. This could be explained by the fact that potato is a seasonal crop; hence the price is expected to be highly volatilite. Furthermore, according to Nyunza and Mwijake (2012), seasonal market overflow and scarcity were the primary causes of fluctuations in round potato prices. According to a poll, prices in major markets were extremely low during harvest, while prices during the post-harvest period were around three times higher than the peak harvesting price. Furthermore, according to URT (2016), the most significant problem in the study region was the inability to predict the price, which fluctuates from one day to the next. According to Kabungo (2008), the price of potatoes changes significantly from year to year, season to season, and even from place to place depending on the availability of transportation. According to the findings of the study, a significant amount of variation in potato prices can be ascribed to variations in the time of selling and the state of the market.

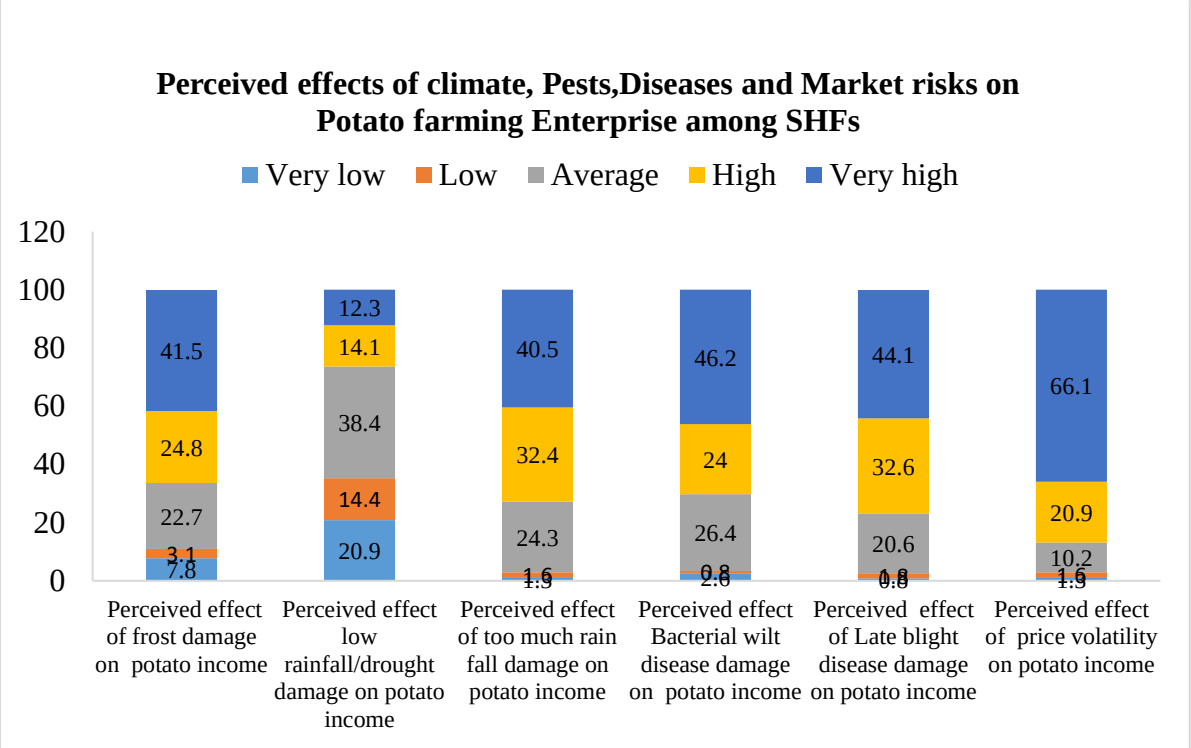


Figure 4: Perceived effects of climate, pests, disease and market risks on potato farming enterprise

4.4 Results for objective two: Determining the effect of risk management strategies attributes on potato enterprise performance among smallholder farmers

4.4.1 Importance of preventing the consequences of climate, pests, diseases and market risks on potato enterprise performance among potato smallholder farmers

Agricultural farms have volatile income. This can be explained by crop yields, weather, disease and price risk. According to Nigel Key *et al*. (2017) agricultural income volatility influences key agricultural decisions. For example, how much income should be spent on farm inputs that reduce risk such as pesticides and irrigation. Additionally, fluctuations in agricultural income influence these decisions and can have a significant impact on agricultural production and household well-being. Therefore, potato smallholder farmers need to prevent the consequences of climate, pests-disease and marketing risks in Tanzania.

4.4.2 Importance of preventing consequences of climate risks on Potato enterprise performance

Under climate-related risks, the study considered the importance of preventing consequences of low rainfall, too much rainfall and frost bite on potato enterprise performance among smallholder farmers. In terms of low rainfall, the findings highlight that 44.1 per cent of potato smallholder farmers reported that it is imperative to prevent the consequences of low

rain on potato enterprise performance. On the other hand, the results show that 16.7 per cent of the surveyed farmers said it is somewhat important to prevent the consequence of low rainfall on the performance of potato farms in the study area. This implies that about 60.8 per cent of potato smallholder farmers perceived that it was important for their potato farms to be protected from the consequences such as total crop failure due to low rainfall in Tanzania. Mpandeli *et al.* (2015) hypothesized that lower rainfall has negative effects on the agricultural sector, resulting in a decrease in agricultural activities, resulting in low yields and a scarcity of seeds for subsequent cultivation among smallholder farmers in South Africa, according to their findings. In the sensitivity analysis study, Kachulu (2018) observed that, when compared to the crop output in 2010, maize yield will be reduced by 20 percent under subsistence farming in the seventh decade, according to the results of the study (2061 to 2070). While on the other hand, some smallholder farmers in the potato industry may have believed that it is critical to manage the effects of low rainfall in order to benefit from higher potato prices during the dry season, as a result of a lack of potatoes available in the market, resulting in improved potato enterprise performance. Kachulu (2018) went on to say that adaptation to climate change consequences (such as reduced rainfall) enhanced total welfare by 24 percent and revenues by 44 percent among smallholder farmers as compared to when no adaptation was implemented.

In terms of frost bite, the results illustrate that 75.2 per cent of the potato smallholder farmers indicated that it was very important for their potato farm to be prevented from the consequence of frost bite. On the other hand, 14.1 per cent of the respondents reported that it was somewhat important to prevent the consequences of frost bite on potato enterprise performance among potato smallholder farmers. This display that almost 90 per cent of all the interviewed farmers postulated that it was important for their farms to be protected against the effect of frost bites as it might negatively affect potato enterprise performance. Potato smallholder farmer believed that, it was important to manage frost bites because frost injury can cause significant damage to potato plants and failure to apply enough water can result in greater damage hence negatively affect potato enterprise performance. These findings are in line with the one from the key informant interview that potato smallholder farmers are not able to manage the frost that affects their potato farms.

Additionally, it was revealed that frost bite is not frequently happening but once it happens it destroys all the crop in the farm. For example, in the 2019/2020 dry season, potato farmers in Luponde and Miva village experienced complete crop failure due to frost bites in June and July 2019. Smallholder armers were not able to harvest even one bag of potatoes. Grey (2014) pointed out that many smallholder farmers encountered severe late icing in

October 2013, which resulted in a significant drop in yield for the season. It has been stated that frost bite can completely wipe out a season's grape harvest in Australia, resulting in billions of dollars in losses and millions of dollars in output losses (Gobbet, 2018). This suggests that frost bite is a significant concern that viticulturists in Australia must be aware of and handle.

Regarding excess rainfall, findings that indicate 64.8 per cent of the surveyed farmers revealed that it was very important to manage the consequence of too much rainfall on potato enterprise performance. On the other hand, 23.5 per cent of all the interviewed potato smallholder farmers believed it was somewhat important to prevent their potato farms from too much rainfall. This implies that almost over three-quarters (88.3 per cent) of the potato smallholder farmers in the study area postulated the importance of managing the risks such as the occurrence of late blight disease, which is associated with too much rainfall. This could be true because when potato smallholder farmers experience too much rainfall, there is a possibility of having a high incidence and spread of late blight disease. Furthermore, this outbreak spread quickly under favourable conditions such as wet weather because the pathogen can produce huge numbers of wind-dispersed spores. This is because too much rainfall is a favourable condition for fungal pathogens development, which are responsible for the late blight disease. Late blight, if not controlled it can cause up to 100 potato yield losses hence negatively affecting potato enterprise performance. Furthermore, if the illness is not controlled, it has the ability to devastate entire fields in a short period of time. For example, Nasir (2016) reported that late blight disease is prevalent throughout the key potato production areas in Ethiopia. Researchers have estimated losses ranging from 6.5 percent to 61.7 percent among potato smallholder farmers, according to their findings. The disease, according to Nasir (2016), is predicted to cause annual losses of more than $5 billion in the agricultural industry worldwide, and as a result, the pathogen is considered a danger to global food security. As a result, it is critical for potato smallholder farmers in Tanzania to avoid the negative implications of excessive rainfall on the functioning of their potato companies.

4.4.3 Importance of preventing consequences of Pests-disease risks on Potato enterprise performance

It is difficult to control plant pests and diseases, and they can have a substantial impact on potato output. By way of illustration, according to Yuliar *et al*. (2015), plant pests and diseases diminish crop productivity worldwide by 36 percent, with diseases alone having been proven to impact crop yields by 14 percent. As a result, the control of plant pests and diseases

may be able to contribute to higher crop output, consequently increasing the overall performance of crop enterprises.

In potato farming, the major problematic diseases that substantially reduce potato yield are bacterial wilt and late blight disease. Thus, it is important for potato smallholder farmers to protect themselves against the potato losses associated with these diseases. In terms of bacterial wilt disease, results show that, 73 per cent of potato smallholder farmers reported that it was very important. In comparison, 18.1 per cent of them said it was somewhat important to prevent the consequences of bacterial wilt disease on the potato enterprise performance. This implies that about 91.1 per cent of the surveyed potato farmers perceived that it was important for them to protect their potato farm against the negative effect of bacterial wilt disease, which might also negatively affect potato enterprise performance in Tanzania. This could be attributed to the fact that bacterial wilt disease is one of the potato soil-borne diseases that are considered to be more limiting in the production of potatoes than seed-borne or air-borne diseases, and it is responsible for some significant yield losses each year in the United States. As a result, it is critical to control the illness since it has the potential to cause a loss of potato income, so significantly impacting the performance of potato enterprises among smallholder farmers. Agricultural Research Service (USDA) (2003) stated that soil-borne diseases, such as bacterial wilt, account for 10–20 percent of crop losses annually.

Furthermore, it was found that 72.3 per cent of potato smallholder farmers believed it was very important to prevent the consequences of late blight disease on their potato enterprise performance. On the other hand, 19.1 per cent said it was somewhat important to protect their potato farms against the negative effect of the disease. In other words, 91.4 per cent of all the potato smallholder farmers surveyed believed it is important to control late blight disease and prevent its negative consequence on the potato enterprise's performance. The possible explanations for this could be that late blight of potato remains a challenging problem in the global agriculture system, causing enormous crop and monetary losses to potato growers. Hence, potato smallholder farmers perceived it was crucial to prevent the negative consequences in Tanzania. Majeed (2014) reported that late blight of potatoes is a major agricultural problem in most parts of the world where potatoes are grown; hence it is important for the disease to be effectively managed.

4.4.4 Importance of Preventing consequences of Market risks on Potato enterprise performance

Market risk exists as a result of the volatility of potato prices and the uncertainty of future market pricing that the potato smallholder farmer must contend with when determining whether or not to grow potatoes. A total of two market hazards, namely price volatility and post-harvest losses, were examined in this study as the most important determinants influencing the success of smallholder potato enterprises in Kenya. As a result, it is critical to avoid the consequences of their actions.

About price volatility, the findings demonstrate that 79.6 per cent of the interviewed potato smallholder farmers described that it was very important to preclude the negative consequence of price fluctuation on potato enterprise performance. Supplementary, it was further showed that about 13.3 per cent of the respondents stated that it was somewhat important for them to prevent the negative consequence resulting from the volatility of potato prices. This entails that 92.3 Per cent of the surveyed potato smallholder farmers thought that they should prevent the negative effect of potato price volatility on their potato revenue, thereby improving potato enterprise performance among smallholder farmers. Hence potato smallholder farmers believed that it was essential to manage price volatility and prevent its negative effect on potato revenues. This could be contributed by the fact that; potato is a highly commercialized crop in Tanzania. Hence, price volatility becomes an important factor that might negatively affect the performance of potato enterprises among smallholder farmers in Tanzania. The quantity of land allowed for round potato production and the commercialization index both indicate that the crop has become more commercially viable in recent years (Mpogole *et al.,* 2012). So Mpogole *et al.,* (2012) indicated that between 20 to 67 percent of the total cropland under cultivation was assigned to round potato production, with 88 percent of the total cropland sold. Additionally, FAO (2013) pointed out that farmers producing high-value produce such as potatoes may find price fluctuations to be their most significant risk than those producing low-value crops. OECD (2011) reported that prices for all crops demonstrate higher variability than yields, suggesting that price risks are more prominent than yield risks among Dutch farmers in the Netherlands.

Regarding potato post-harvest losses, results indicate that 55.4% of smallholder farmers believed that it was very important for them to protect their potato farms against the losses associated with poor post-harvest handling techniques. Moreover, about 11.5% of the respondents revealed that it was somewhat important for their potato revenues to be protected from the effect of potato post-harvest losses in the study area. This suggests that potato post-

harvest losses have a substantial contribution to potato revenues losses as almost 67per cent of potato stallholder farmers revealed that it was important to prevent the consequence of it to the potato enterprise performance. This could be attributed to the fact that potato smallholder farmers used poor post-harvest handling techniques such as hand hoe for harvesting potatoes, as a result, the losses contributed to the -reduced potato yield hence negatively affecting potato enterprise performance among potato smallholder farmers. According to Coker (2015) survey, almost all respondents in the study area recorded post-harvest losses. The survey further show that lack of harvesting equipment was a major challenge in reducing post-harvest losses as 92.50 per cent confirmed. The study also emphasized that post-harvest losses affected rice smallholder farmers' income in the study area and adversely farmers' income.

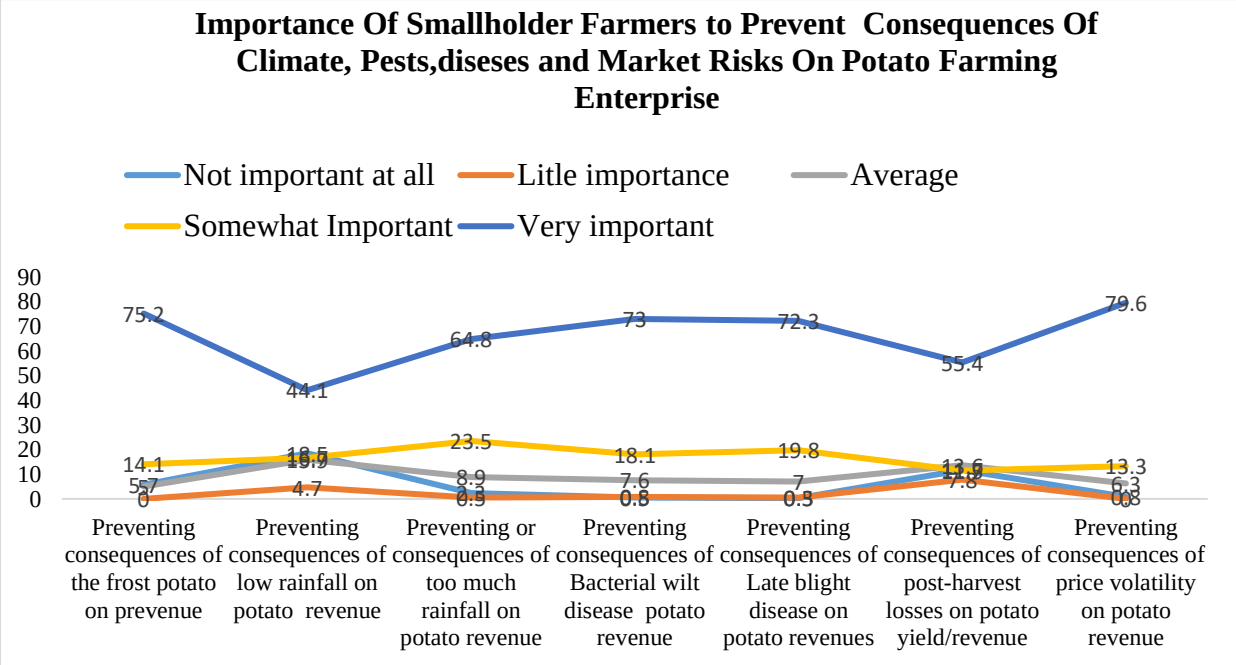


Figure 5: The importance of smallholder farmers preventing the consequence of climate, pests, diseases and market risk on potato enterprise performance

4.4.5 Ability of potato smallholder farmers to protect themselves against climate risks, market risks, pests and diseases risks

Smallholder farmers play a critical role in risk management because they make decisions about crop management that have a direct impact on the performance of the firms they work for (Pacilly *et al*., 2016). Smallholder farmers employ a variety of risk management measures to keep their businesses afloat. For these reasons, it is critical to assess the ability of smallholder farmers, when they utilize traditional risk management measures, to handle these risks effectively. The tactics are usually available in any farming community where they are

practiced. According to Hardaker *et al.* (2004), "the well-being of the farm family and the viability of the farm business may be dependent on how well agricultural hazards are mitigated." As an additional point of emphasis, Flaten *et al.* (2006) asserted that the assessment of farmers' perceptions of risk as well as their responses to risk are critical because they can be used to describe the decision-making behaviour of smallholder farmers when confronted with risky situations.

Smallholder farmers are one of the most vulnerable groups to climate risks, with no exception to potato smallholder farmers in Tanzania. Therefore, it is essential to assess the ability of potato smallholder farmers in managing these climate-related risks. The study considered too much rain fall and low rain fall as the prevailing risks among potato farmers. Concerning too much rainfall, the findings disclose that 41.8 per cent of potato smallholder farmers revealed that they could protect their potato farms from too much rain. On the other hand, 12.3 per cent of the surveyed potato farmers thought that they could protect themselves very well, whereas 15.9 per cent reported that they could somewhat protect themselves against the negative effect of too much rainfall on potato enterprise performance. This implies that about 70 per cent of all the interviewed potato smallholder farmers managed the negative effect of too much area on their potato farms. This could be true because, when potato smallholder farmers experience too much rainfall, there is a likelihood of being exposed to the high incidence of late blight disease. This is because Late blight outbreaks spread quickly under favourable conditions (cool, wet weather). After all, the pathogen can produce vast numbers of wind-dispersed spores. Most potato smallholder farmers can protect their farms from the consequences of too much rainfall due to the use of fungicides, infrequent fungicides application. Majeed *et al*. (2014) noted that late blight disease is primarily managed by rigorous application of fungicides with plausible results. Majeed *et al*. (2014) further pointed out that fungicides are more effective in controlling diseases severity and the disease progress hence increasing potato yield.

In terms of low rainfall, the results indicate that 32.4 per cent of the potato smallholder farmers can protect their potato farms against low rainfall. Furthermore, the findings reveal that about 17.2 per cent of the surveyed potato farmers can protect themselves very well, while 14.4 per cent can somewhat protect their potato farms from the negative effect of low rainfall. This means that 64.0 per cent of all the interviewed potato farmers could protect their potato farms against the negative effect of low rainfall, thereby improving potato enterprise performance. This is because, in the study area, most potato smallholder farmers employ irrigation systems as a strategy to manage the effect of low rainfall. Potato smallholder farmers

had also agreed that irrigating their potato farms during the dry season has become an effective strategy to improve their potato farm income. These results are in line with Beyan *et al.* (2014) that participation in irrigation scheme found to have a significant positive effect on smallholder farmers' income.

Moreover, the application of small–scale irrigation had improved the annual income of irrigator households from 98.90 USD to 504.95 USD before and after using irrigation in Ethiopia (Mengistie *et al*., 2016). Additionally, it was revealed that 32.1 per cent of irrigators increased their frequency of production due to irrigation. Daniel (2015) also highlighted that irrigation had a positive and statistically significant effect on gross potato margin at 5% among smallholder farmers. Daniel (2015) specifically noted that the gross margin of land under irrigation is higher by Tshs. 32 per kg. This implies that potato smallholder farmers who irrigated their land had higher chances of getting a more significant gross margin than those under rain-fed. As Osewe *et al* (2020) pointed out, the acceptance of farmer-led irrigation practices among smallholder farmers in Tanzania is influenced by the low rainfall experience of the farmers in the area. The findings of the study also revealed that irrigation practice had a favourable and statistically significant impact on the per capita net crop revenue of the adopters in the study area. Aside from that, according to Dawang *et al*. (2014), irrigated Irish potato cultivation in Nigeria is a profitable operation with strong economic viability, as evidenced by the values of Gross Margin (N655,637.88) and the Benefit-Cost Ratio (2.64) among smallholder farmers.

In the fields, a variety of pests and diseases are present that interfere with the growth of potato crops. Potato yields are reduced as a result of these pests and illnesses, which also boost production costs and reduce the marketability of potatoes. They also increase the risk of farming as a source of income or as a commercial enterprise. Pests and diseases can cause major crop failure if they are not identified and treated with in a timely manner. In this study, late blight and bacterial wilt were identified as the principal pests-diseases that negatively impact the performance of smallholder farmers' potato enterprises. In the opinion of Pacilly *et al*. (2016), smallholder potato farmers play a critical role in the control of late blight and the bacterial wilt disease because they make decisions on crop management that have a direct impact on the spread of pests and diseases. In order to measure the competence of potato smallholder farmers to control diseases such as late blight and bacterial wilt among themselves, it is necessary to conduct a survey.

In terms of late blight disease, the findings reveal that 53.3 per cent of potato smallholder farmers in the study area perceived that they could protect themselves well from late blight

disease. On the other hand, 23 per cent of the surveyed potato smallholder farmers reported that they could protect themselves very well against late blight, while 11 per cent thought that they could somewhat protect themselves. This indicates that majority (87.3 per cent) of the interviewed potato smallholder farmers in Tanzania can protect their potato farms from potato late blight disease. The fact could attribute this, most of these potato smallholder farmers employ fungicides such as FARMZEB, BLUE COPPER and increase the frequency of use of such fungicides to manage late blight disease. These results are consistent with Okello *et al.* (2015) that potato smallholder farmers in Tanzania used pesticides and fungicides to combat potato pests and diseases. In addition, it was revealed that majority of potato smallholder farmers have shown to follow a calendar-based spray system to control pests and diseases. Hence potato smallholder farmers effectively managed pests and diseases. Pacilly *et al.* (2016) reported that, when comparing the effect of management strategies on disease control, fungicide application on the susceptible fields reached relative high yield levels.

Regarding potato bacterial wilt, the results show that 31.3 per cent of smallholder farmers responded that they could protect themselves well from bacterial wilt, whereas 11.7 per cent of them thought that they could protect their farms very well from the disease. The findings further disclose that, of all the potato smallholder farmers interviewed, 21.1 per cent reported that they could somewhat protect themselves from bacterial wilt. This suggests that slightly over half (64.1 per cent) of the interviewed potato smallholder farmers in the study area can protect their potato farms against bacterial wilt disease. The possible explanations for this could be that some of the potato smallholder farmers in the study area managed bacterial wilt by employing strategies such as chemical, use of improved seed potatoes, uprooting and burning infected plants, crop rotation, fallowing. These methods are helpful in improving crop production through the suppression of bacterial wilt. These results are in line with Okello *et al.* (2015) that 33 percent of the potato smallholder farmers in Njombe still practice fallowing. It was further indicated that about 59 per cent of potato smallholder farmers uproot and burn infected plants, and 19 per cent used crop rotation to manage bacterial wilt (Okello *et al*., 2015). Moreover, CIP (1996) pointed out that crop rotation is a popular and straightforward method to control bacterial wilt as it aims at breaking pest and disease cycles.

On the other hand, about 36 percent of potato smallholder farmers cannot. This may be due to a decrease in land size in the study area. As a result, some potato smallholder farmers plant potatoes in the same plot each season. Okello *et al*. (2015) also highlighted land sizes in all study areas have declined significantly over the last ten years, so most potato smallholder farmers currently own an average of three compared to five hectares just ten years ago. The

study emphasized that, land shortage has resulted in a significant reduction in the continuous cultivation or fallow period of arable land, resulting a rapid increase in bacterial wilt (Okello *et al*., 2015).

4.4.6 Potato smallholder farmers' ability to protect themselves against market risks

In terms of market hazards, they refer to the likelihood that smallholder farmers would lose access to a market for their products or that the price they receive will fluctuate. The authors of Tatwangire and Nabukeera (2017) theorized that market risks create inefficiencies and variations in the production and income of households. The result is that smallholders are unable to engage in profitable activities that might otherwise aid in the reduction of poverty among smallholder farmers and their families.

For example, Aditto *et al.* (2012) noted that marketing risks associated with unexpected variability of product prices were significant concern of the smallholder farmers in the studies regions in Thailand. This is because price volatility hampers the development of many smallholder farmers in most of countries**.** Therefore, it is important to assess the ability of smallholder farmers to manage market risks to enhance their risk management capacity. This study considered potato price volatility and post-harvest losses as the market risk potato smallholder farmers face. Hence the ability them to protect their potato enterprise performance from potato price volatility and post-harvest losses was evaluated.

In terms of potato price volatility, the findings disclose that 48 per cent of the interviewed potato smallholder farmers in Tanzania cannot protect themselves at all, while 19.8 per cent can somewhat protect against the negative effect of price volatility on their potato enterprise performance. On the other hand, 12.5 per cent of the surveyed potato smallholder farmers perceived that they could protect themselves well, whereas 7.6 per cent reported that they could protect their potato enterprise performance very well against the negative potato price volatility. This implies that most (67.8 per cent) of the potato smallholder farmers in Tanzania could not fully protect their potato enterprise performance against the negative effect of the price volatility. This could be attributed to the fact that potato smallholder farmers in Tanzania are price takers. As a result, they are not able to control the price they receive from the market. In other words, potato farmers have minimal influence on the price. As a result, even the potato revenues are out of their control. Additionally, potato smallholder farmers usually have to accept established prices as fact, and it usually is not determined by the costs incurred during that year. Therefore, this reveals that potato smallholder farmers cannot protect their potato enterprise performance against the negative effects of price volatility.

Potato smallholder farmers, on the other hand, used market risk management tactics such as spreading sales over several months, leaving potatoes in the soil, getting market information, and moving potatoes to the major markets in Dar es Salaam and Dodoma. These techniques, however, were shown to be ineffective in mitigating the negative effects of price fluctuation, as demonstrated by potato growers' observations. This is due to the fact that the majority of smallholder potato growers interviewed believed they would be unable to get their produce to a market where prices were high. This demonstrates that price volatility impacts the majority of potato smallholder farmers in Tanzania, and that they are unable to protect themselves against it, resulting in a negative impact on their potato enterprise performance. The Common Agricultural Policy (CAP) in the United States, for example, is primarily concerned with compensating farmers for the unfavourable effects of price volatility and mitigating the effects of income volatility during the 2014–2020 timeframe (EPRS, 2016). A further finding of the study was that smallholder farmers are frequently faced with significant swings in the prices they receive for the sale of their agricultural products, causing them to experience financial insecurity about their income prospects. Aditto *et al.* (2012) also noted that among smallholder farmers in Thailand, marketing risks related with unanticipated variability in product prices were connected with the highest and second-highest mean ratings for sources risk, respectively, according to their findings. EPRS (2016), on the other hand, reported that high levels of price volatility could result in financial concerns for potato smallholder farmers, since their revenues would be less predictable and could be jeopardized by rapid price declines. Furthermore, price instability lowers the ability of farmers to make long-term investments, which is especially true for young farmers. Furthermore, it was pointed out that the uncertainty surrounding product prices has become increasingly concerning among smallholder farmers in Thailand's central and northeast regions, particularly in the agricultural sector (Aditto *et al.,* 2012). According to the findings of the study, this is most likely due to the fact that the sources of price volatility are outside the control of smallholder farmers, but have a direct impact on their farm revenues. Wasukira *et al*. (2014a) also discovered that when the price of ware potatoes is low and variable, market performance throughout the potato value chain is negatively impacted.

Furthermore, the study discovered that farm-gate prices for potato smallholder farmers' ware potatoes could decline dramatically, resulting in prices that are insufficient to pay production expenses (Wasukira *et al.,* 2014). Furthermore, Arisoy (2017) found that fluctuations in potato prices have a rapid impact on production, and that producer revenue changes substantially depending on annual potato prices, according to the study. However, according to the United Nations Food and Agriculture Organization, global price volatility has

increased significantly since 2005 and is expected to be a key source of concern for smallholder farmers over the next several decades (EPRS, 2016).

In terms of potato post-harvest losses, the findings indicate that 44.9 per cent of the assessed smallholder farmers are able to adequately protect themselves from losses. In contrast, 25.1 percent of them are able to safeguard their potato enterprise performance from the detrimental impact of post-harvest losses very well. On the other side, around 7.3 percent of those who answered the survey question were able to mitigate their losses to some extent. This shows that slightly more than three-quarters (77.3 percent) of all the interviewed potato smallholder farmers in Tanzania are able to mitigate the detrimental impact of post-harvest losses on their businesses' profitability. It is conceivable that this is due to the fact that the majority of smallholder farmers in the research area used tactics such as harvesting for the second time and using the potatoes as seed potatoes for the following season, as well as strict supervision during the harvesting process. In the study, potato smallholder farmers expressed satisfaction with their ability to reduce the negative impact of post-harvest losses on their income, believing that the measures they employed were effective. Because they will sell their potatoes during the off-season, when the supply of potatoes is low, smallholder farmers who use strategies such as leaving potatoes in the soil may be able to earn greater prices from their crops. The Food and Agriculture Organization of the United Nations (FAO) (2013) stated that spreading sales allow different parts of the crop to be sold at different periods throughout the year. The farmer can keep an eye on fluctuations in the market and sell when prices are at their most favorable levels.

Tatwangire and Nabukeera (2017), on the other hand, discovered that the introduction and utilization of enhanced locally-adapted storage facilities reduces the challenges of seasonality, variable market prices, and low earnings for value chain players.

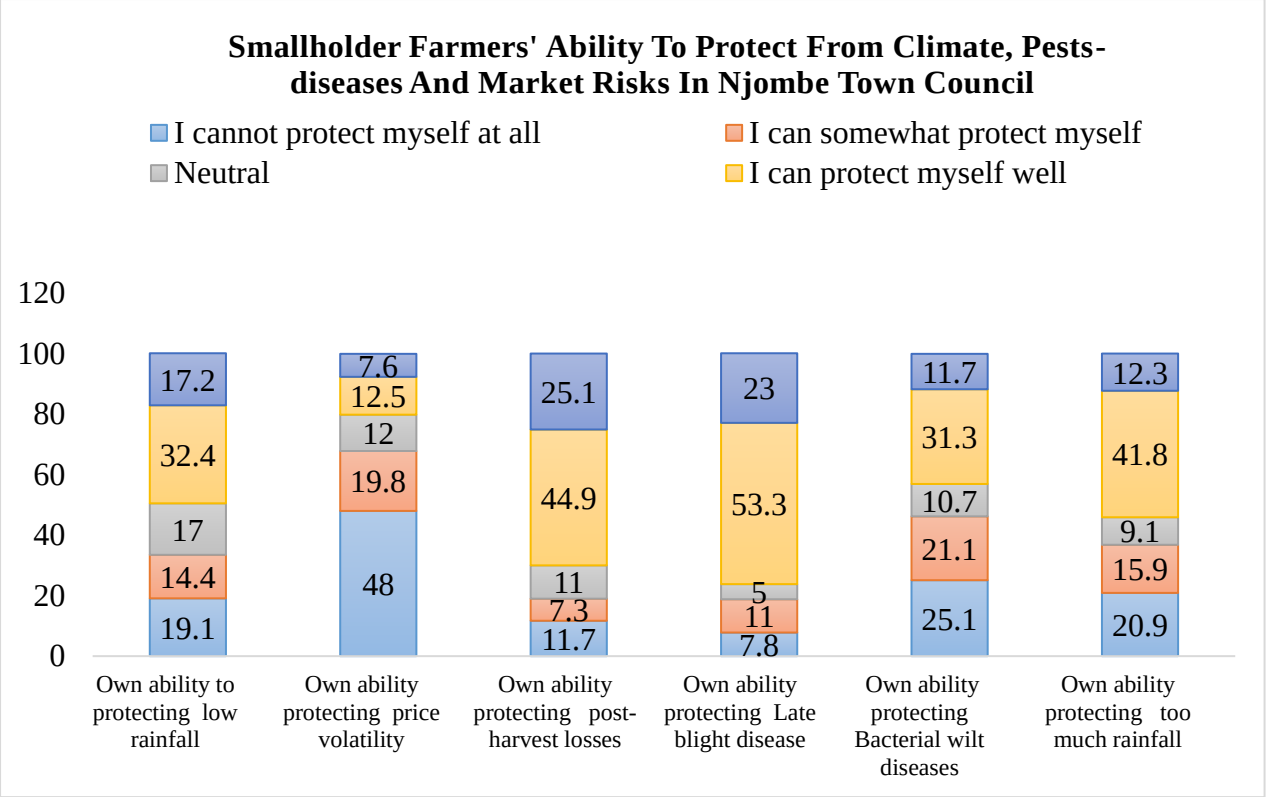


Figure 6: Ability of potato smallholder farmers to protect themselves from climate, pests, diseases and market risk

4.4.7 Risk Management Strategies Employed by Potato smallholder farmers

Risk management has become increasingly important among all actors in the potato value chain. Risk management strategies consist of responses that may reduce the probability of unfavourable events occurring or reduce the consequences if the event occurs. There are several strategies smallholder farmers can employ to reduce and mitigate farm exposure to risks. This survey indicates that potato smallholder farmers heavily use on-farm risk management strategies to manage climate, pests, diseases, and marketing risks. Findings further reveal that most potato smallholder farmers use more than one risk management strategy to manage these risks. Therefore, these on-farm risks management strategies can be grouped into climate-related risk management strategies, pests-diseases risk management strategies, and marketing risks management strategies. Climate hazards are becoming increasingly dangerous to food security, making it necessary to develop locally suitable risk management solutions to mitigate the threats to food security (Shikuku *et al.*, 2017).

In terms of frostbite management, the findings from this study reveal that potato smallholder farmers use chemical before planting to manage frostbite in their potato farms. Additionally, smallholder farmers employ irrigation systems such as over-plant sprinklers to

remove frost that covered potatoes. According to Alamerie *et al*. (2013) over sprinkler irrigation system is used to protect low plants. Even in the case of advection frostbite, if the amount of application is sufficient and spread evenly, application to plants provides excellent frost protection up to approximately - 7 ° However, this method can cause serious damage if the sprinkler fails, the water demand of the process is high and root disease can be a problem in poorly drained soil.

Furthermore, the findings indicate that potato smallholder farmers also employed over-plant sprinklers and furrow irrigation in managing low rainfall. The possible explanations for this could be that farmers found there was a probability of fetching higher prices of potatoes when irrigating their potatoes due to low rainfall.

Alamerie *et al.* (2013) noted that irrigating potato farms were the most common strategy employed by smallholder farmers to manage low rainfall in the study area. Similarly, Daniel (2015) reported that low rainfall made potato smallholder farmers in Njombe urban irrigate their farms, hence supplying potatoes in the market, thereby fetching higher prices and higher gross margins. In terms of too much rainfall, potato smallholder farmers applied fungicides, made furrows to drain excess water from the farms, increased the frequency of fungicide application, and planted potatoes during dry seasons to manage to late blight disease caused by the presence of too much rainfall. Obalola *et al*. (2017) pointed out that the incidence of late blight disease is high when there is too much rains and the disease is a major problem that limits potato farmers output. Alamerie *et al*. (2013) also pointed out that late blight is a common disease for potatoes and farmers often prefer to produce potatoes in the dry season where there is a lower incidence of late blight.

In terms of pests and diseases related risk management strategies, the findings pointed out that potato smallholder farmers use field sanitation practices, pesticides and fungicides to control potato pests and diseases. Okello *et al*. (2015) also noted that the majority of the focus group discussion participants used fungicides and pesticides to control potato pests and diseases. Kilimo Trust (2017), on the other hand, found that the vast majority of farmers interviewed (86 percent) used insecticides and fungicides to control pests and diseases in their fields. The usage of these chemicals as a result has been identified as one of the key determinants of potato production in Tanzania (Rahko, 2012). Late blight and bacterial wilt were the most problematic pests-diseases in the research area, and these were the measures that were primarily used to control them. According to the data, potato smallholder farmers used fungicides such as FARMZEB, COPPER, and RIDOMIL, among other things, to prevent late blight disease on their plants. Late blight is the most common disease in the study region, and

there are no late blight resistant types available in the area. Therefore, fungicides are used by the majority of them as a disease management technique to combat the disease. The findings are consistent with those published by Okello *et al.* (2015), who found that in Njombe, 80 percent of survey respondents used fungicides to combat late blight disease in cotton crops.

On the other hand, the results show that potato smallholder farmers employed strategies such as fungicides and pesticides, improved seed potatoes, uprooting and burning infected plants, crop rotation, and fallowing in controlling bacterial wilt disease in the study area. This implies that farmers in the study area were aware that bacterial wilt is a soil-borne disease and the disease does not have chemicals to manage it; therefore, the only method of controlling it is by soil fertility management. Similar findings were reported by Okello *et al.* (2015) that 59 per cent of potato farmers in Njombe uprooting and burning infected plants, and 19 per cent use crop rotation to manage bacterial wilt. CIP (1996) noted that crop rotation was a popular, simple and more effective method in controlling bacterial wilt disease in the study area. Okello *et al.* (2015) also noted that about 33 per cent of potato smallholder farmers practiced fallowing in the Njombe region. In the same line, Kagona (2008) revealed that the dominant method to control bacterial wilt in the study area by potato farmers was uprooting the infected plants and burying them. The study further indicated that this method is practiced by almost three-quarters of the sampled farmers in Malawi.

In subsistence agriculture, where farm household's production is hardly sufficient for own consumption, market risks are not significant. However, as smallholder farmers start producing for the markets, market risks such as price volatility, post-harvest losses become a significant peril in the farm business. Therefore, it becomes imperative for potato smallholder farmers to manage marketing risks. In terms of potato price volatility, the results show that smallholder farmers employ strategies such as looking for markets, transporting potatoes direct to the markets (Dar es Salaam), gathering market information from neighbours, brokers and traders. It was further revealed that potato stallholder farmers in Njombe leave their potatoes in the soil and sell them after some time. This enables smallholder farmers to fetch higher potato prices as they sold their potatoes in the offseason. This implies that potato is a highly commercialized crop in Njombe as a result, farmers used different strategies such as transporting potatoes direct to the market to manage price volatility risk. Similar findings were reported by Alamerie *et al.* (2013) that potato farmers in Ethiopia employed sequential marketing in managing price volatility. The sequential sale refers to the spreading sales and making several sales of potatoes during the year. This strategy is commonly used by potato smallholder farmers in the study area. Furthermore, it was noted that smallholder farmers

harvested potatoes in piecemeal over the harvesting time to manage price volatility risk (Alamerie *et al*., 2013). Additionally, Nyunza and Mwakaje (2012) pointed out that potato smallholder farmers in Tanzania, especially the rich ones, were selling potatoes to wholesalers in urban areas such as Mbeya and Arusha Dodoma and Dar es Salaam.

Regarding managing potato post-harvest losses, the findings show that smallholder farmers use strategies such as harvesting potatoes for the second time and use as seed potatoes for the next planting season, close supervision during harvesting and selling immediately after harvesting. This suggests that managing post-harvest losses among potato smallholder farmers is an essential aspect of potato farming. This is because, in the food-insecure regions, post-harvest losses at the farm level reduce available food for family consumption and directly affect smallholder farmers' income and livelihoods in general. Alamerie *et al.* (2013) also reported that selling immediately after harvesting was one strategy that potato smallholder farmers employed in managing potato post-harvest losses. In contrast to these findings, the citizen (27th August 2017) pointed out that selling immediately as possible following harvest as a solution employed by most farmers to minimize post-harvest losses provides quick money to pay school fees, repay debts among others partially. However, when everyone sells the same product simultaneously, prices are usually at their lowest. As a result, farmers get low potato farm incomes (The citizen, 27th August, 2017).

4.4.7 Effectiveness of On-farm risk Management strategies among smallholder farmers

Potato enterprise is a risky business. Therefore, understanding the perception of the effectiveness of various production and marketing practices among potato smallholder farmers is a principal factor in determining smallholder farmers' choice of risk management strategies. This study highlights that potato smallholder farmers in the study area employed both production and market risk management strategies in dealing with climate, pests-diseases and marketing risks.

Regarding the effectiveness of strategies employed in managing low rainfall, the results show that 34.2 per cent of potato smallholder farmers agreed that risk management strategies are effective. On the other hand, 20.1 per cent of the respondents mentioned strongly agreed that the strategy used to manage the incidence of low rainfall effectively. Additionally, descriptive statistics show that most potato smallholder farmers employed Furrow and Sprinkler irrigation systems to manage low rainfall risks. This implies that slightly over half (54.3 percent) of the potato smallholder farmers agreed that irrigating their farms in the period of low rainfall was an effective risk management strategy. This is because when potato

smallholder farmers in the study area employed irrigation systems, their potato farm income increased. As a result, they perceived irrigating potato farms as an effective strategy. Beyan (2014) also reported that participation in irrigation has a significant and positive effect on farm households' income among smallholder farmers in Ethiopia.

Moreover, the findings show that about 48 per cent of potato smallholder farmers in Njombe had agreed that the risk management strategies employed in managing the effect of excess rainfall are effective. In contrast to this, 11.3 per cent of the respondents had strongly agreed. In other words, 59.3 per cent of potato smallholder farmers agreed that the strategies such as the use of fungicides, making furrow to remove excess water in the farm, increasing the frequency of fungicide application, planting potatoes during dry seasons are effective in managing the effect of too much rainfall which include increased incidence of late blight disease in the study area. This may be due to the fact that most of the smallholder potato farmers who participated in the study used fungicides to control and manage late blight. As a result, smallholder farmers attest that the strategy is an effective one. For example, FAO (2006) revealed that about 93 per cent of the respondents used fungicide in potato production. This implies that potato smallholder farmers believed that fungicide application is an effective strategy in managing the incidence of late blight disease.

In terms of frost bite, the findings show that 21.1 per cent of potato smallholder farmers in Njombe had strongly disagreed on the effectiveness of the strategies employed in managing frosts while 15.1per cent had disagreed. This implies that about 36.2 per cent of potato smallholder farmers believed that the strategies (smallholder farmers use the chemical application before planting and irrigation system such as over-plant sprinklers and furrow irrigation to remove frost that covered potatoes) they employed in managing frost bite are not effective. This is because most of the potato smallholder farmers perceived the methods they used are passive; hence they not able to effectively protect their farms from frost damage. In other cases, potato smallholder farmers needed more proactive methods, such as predicting and monitoring night-time minimum possible temperature changes. This helps protect frost, as it helps potato smallholder farmers decide it protection is needed and when the system needs to start working.

Generally, when it comes to managing pests and diseases, potato smallholder farmers believe that, strategies employed are effectively. In terms of bacterial wilt management, potato smallholder farmers employ strategies such as clean seed potatoes, crop rotation, uprooting and burning infected plants fallowing, which are effective in managing the disease. As a result, 34.2 per cent of potato smallholder farmers had agreed that these strategies are effective,

whereas 12% had strongly agreed. This implies that about 46.2 per cent of potato smallholder farmers in the study believed in the effectiveness of the employed strategies in managing bacterial wilt. This is because the disease is soil-borne; therefore, there is no chemical in the market to control and manage the disease. As a result, farmers are advised to employ field sanitation practices that aim at breaking bacterial wilt cycles of which most of them followed. For example, Okello *et al*. (2015) reported that over half of potato smallholder farmers in Njombe used field hygiene measures such as uprooting and burning plants to control bacterial wilt

In the same line, Kagona (2008) revealed that strategies such as positive selection and crop rotation were employed by potato smallholder farmers in Malawi to manage bacterial wilt. Further, it was noted that positive selection for disease-free potato plants have shown to increase yields up to 34 per cent among smallholder farmers. In addition, the results show that about 58.2 per cent agreed that the strategies (fungicides such as FARMZEB, BLUE COPPER, RIDOMIL) in controlling late blight are effective, while 22.7 per cent had strongly agreed. This implies that majority of potato smallholder farmers (85.9 per cent) in Njombe perceived that the strategies used in managing late blight area effective. The use of fungicides in late blight management could be clearly explained because potato farmers believed that fungicide application is the most effective strategy. According to Kabungo (2008) potato smallholder farmers control potato blight by using fungicide in Tanzania. In the same line, it was easy revealed that about 93% of the respondents used fungicide in potato production while 7.0 per cent did not use fungicide (FAO, 2006). Okello *et al*. (2015) also pointed out that approximately 96.0 per cent of the survey respondents used pesticides to control late blight.

Additionally, Kilimo Trust (2017) noted that more than half of all farmers used fungicides, where the highest percentage was in Rungwe, with 100 per cent of the surveyed potato farmers used. Okello *et al*. (2015) further revealed that majority of the farmers who used fungicides followed the calendar spray regime; hence it is an effective strategy for managing late blight. Similarly, the Kilim Trust (2017) shows that Njombe district has the highest percentage of fungicides usears and spraying fungicides may help manage the risks associated with it and may thus improve potato smallholder farmers' productivity.

Further, Mantecon (2007) revealed that fungicides are the most effective technique in decreasing both late blight disease severity and boosting tuber yields. In the same line, Majeed *et al.* (2014) discovered that the application of fungicides such as (RIDOMIL GOLD, BLUE COPPER) was highly successful in reducing late blight severity level and progress. As a result, most potato smallholder farmers in managing late blight disease in Tanzania. Effective market

risk management solutions play a crucial role in minimizing revenue volatility by providing a predictable form of revenue for potato smallholder farmers.

Potato smallholder farmers in Njombe employ different and combinations of traditional strategies to manage marketing risk. Therefore, it is essential to assess the effectiveness of these risk management strategies. In terms of potato price volatility, the results show that 38.2 per cent of potato smallholder farmers had strongly disagreed on the effectiveness of the strategies such as looking for markets, transporting potatoes direct to the markets (Dar es Salaam), gathering market information from neighbours, brokers/traders and leaving potatoes in the soil to manage price volatility. The findings further pointed out that 10.7 per cent had disagreed that strategies are effective. This implies that over half (50 per cent) of respondents had agreed that the traditional strategy of potato smallholder farmers in Njombe are not effective in managing price volatility. The possible explanations for the potato smallholder farmers to perceive that these strategies were ineffective could be that most of them are not able to employ strategies such as looking for markets and transporting potatoes direct to the markets (Dar es Salaam). This is because of the high cost associated with this strategy, and it could be the best strategy for big and rich potato farmers. As a result, farmers concluded that this method was not effective as it favored more big and rich potato farmers in the study are. For example, Nyunza and Mwakaje (2012) pointed out that potato smallholder farmers in Tanzania, especially the rich ones, were selling potatoes to wholesalers in urban areas such as Mbeya, Arusha, Dodoma and Dar es Salaam. Nyunza and Mwakaje (2012) also noted that large potato producers and wealthy farmers were able to take potatoes to larger markets in urban areas where demand for potatoes was higher than in rural areas. This enabled them to sell potatoes at high price. Furthermore, according to Mwakaje (2010), a disproportionately tiny number of smallholder farmers were able to rent trucks to transport their products directly to the main markets in Mbeya or Dar es Salaam when they were ready to sell their crops. The vast majority of them, however, chose to sell their produce to small-town merchants. This is due to the fact that the poor could not afford to transport round potatoes to the larger marketplaces in the first place. They also produce spherical potatoes in tiny amounts, but only in limited quantities. Additionally, the findings reveal that about 56.2 per cent of potato smallholder farmers had agreed that the strategies (such as harvesting potatoes for the second time and use as seed potatoes for the next planting season, close supervision during harvesting and selling immediately after harvesting) used were adequate whereas 24.5 per cent had strongly agreed on the effectiveness these strategies. This indicates that 80.7 percent of the potato smallholder farmers who were interviewed were confident in the success of the techniques used to manage

post-harvest losses. This is because most of the potato post-harvest losses that happen at the farm level is at harvesting. Therefore, using strategies such as close supervision of labourers during harvesting is an effective strategy.

Raghuvanshi *et al*. (2018) reported that potato post-harvest losses were the highest at the harvest followed by sorting and packaging. The study further pointed out that, the perception of potato smallholder farmers about crop losses is that most products are damaged to the extent that it can completely waste or sold out at a low price. Regarding the factors affecting post-harvest losses of potatoes at the farm level the study also found that timely availability of labour and storage facilities was negative and statistically significant. This implies that, if workers are available at the required time, and closely monitored, the post-harvest losses of potatoes at the farm level among potato smallholder farmers would be significantly reduced (Raghuvanshi *et al*., 2018).

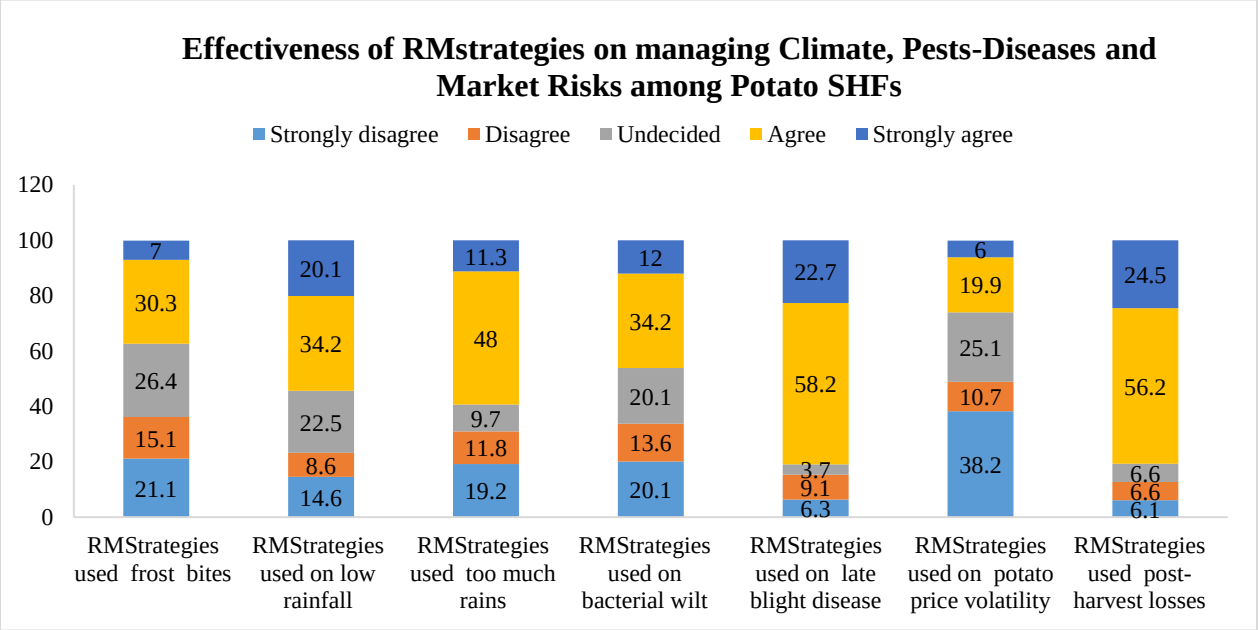


Figure 7: Effectiveness of traditional risk management strategies on managing climate, pests, diseases and market risks

4.4.8 Effect of risk management strategies attributes on potato enterprise performance among smallholder farmers

Table 12 shows the results of a multiple regression model of the risk management strategies' attributes on potato performance enterprise(PEP). The model has low goodness of fit coefficient of 0.27, which is common in cross-sectional data. This means that the coefficients of all the explanatory variables in the model accounted for about 27 percent of the variation in the dependent variable. However, the model was statistically significant at 1 percent. Results

further reveal that for every 1 per cent increase in the frequency of risk management strategies, potato revenues increased by 0.667 per cent among potato smallholder farmers at a 1 per cent statistical significance level. This implies that potato enterprise performance is improved by 0.667 per cent when smallholder farmers increase the frequency of risk management strategies by 1 per cent. In the same line, Okello *et al*. (2015) noted that potato smallholder farmers were found to be more likely attacked by potato pests and diseases. As a results, potato smallholder farmers increasingly using chemicals and non-chemical strategies to control pests and diseases. In addition, Schreinemachers *et al*. (2012) reported that the use of chemicals per hectare, especially fungicides and pesticides, generally increased disproportionately to yield per hectare. The study also found that improved yield performance per hectare was associated with increased use of chemical per hectare.

The effectiveness of the risk management strategies employed by potato smallholder farmers positively affected the potato enterprise performance. Specifically, the findings show for every 1per cent increase in the use of an effective risk management strategy, potato enterprise performance improved by 3.91 per cent. This implies that when the risk management strategies are more effective in managing risk, potato revenues increase, improving potato enterprise performance. To some extent, this is because an effective risk management strategy helps potato farmers manage climate risks, pests, diseases and market risks, increasing their potato yield and revenues. As a result, potato enterprise performance improved.

Moreover, an effective risk management strategy means controlling production and market risks better, therefore, fewer losses, lower operational costs, and more profit. In the same line, Chakraborty and Banerjee (2016) reported that the late blight of potato can effectively be managed by applying fungicides such as Fenamidone, Mancozeb among others. The study specifically pointed out that spraying potato farms with Fenamidone and Mancozeb had exhibited the best management of late blight of potato in terms of per cent reduction of disease over control.

Small-scale irrigation, on the other hand, according to Beyan *et al.* (2014), is one of the most effective irrigation systems for increasing agricultural output, reducing the risks related with rainfall flotations, and increasing the revenue of smallholder farmers. The findings also revealed that involvement in the irrigation system had a statistically significant and beneficial impact on the revenue of smallholder farmers (Beyan *et al*., 2014). Osewe *et al.* (2020) hypothesized that the usage of agricultural irrigation systems was successful and had a significant impact on the net farm income of smallholders in Tanzania's southern highlands, and that this effect was both positive and significant. In a similar vein, the Food and Agriculture

Organization of the United Nations (FAO) (2016) discovered that effective agricultural risk management techniques play an essential role in supporting profitable and sustainable investment across agricultural value chains. Food security is ensured, hunger is eliminated, and poverty is reduced as a result. Aside from that, good risk management methods assist developing countries to achieve their yearly agricultural gross domestic product growth targets (FAO, 2016). The effect, on the other hand, was not statistically significant.

Specifically, when it comes to the cost of risk management methods, the data show that for every one percent increase in the cost of risk management strategies, potato enterprise performance among smallholder farmers improved by 0.307 percent. The effect, on the other hand, was not statistically significant. This was in direct opposition to what was predicted. As the FAO (2013) pointed out, one crucial feature of risk management is the fact that all responses to risks are expensive in the long run. These costs are defined in terms of the quantity of resources that smallholder farmers will require in order to manage production and market risks more effectively in the future. For example, the Food and Agriculture Organization of the United Nations (FAO) (2013) discovered that smallholder farmers can produce drought-resistant crops rather than other drought-prone crops. Drought-resistant crops, on the other hand, may command a lower market price than crops susceptible to drought. This study further illustrates that every 1 per cent increase in risk management strategies improves potato enterprise performance by 0.048 per cent among smallholder farmers. This implies that increased risk management strategies control production and market risks, improving potato enterprise performance. This is in line with Namwata *et al*. (2010) findings that the increased household income was significantly and positively associated with the number of technologies adopted in the study area. Hence, employing more risk management strategies among potato smallholder farmers minimise the negative impact of production and market risks, improving potato enterprise performance. Rahuta and Alib (2017) also illustrated that smallholder farmers who have introduced more adaptive practices have a higher level of food security than smallholder farmers who have experienced lower level of poverty. This is due to the fact that farm-level climate change adaptation strategies have significant development benefits and can lower the exposure of smallholder farmers to climate risks, which is why they are encouraged. The study also found that household income levels are high on a monthly basis, indicating that those households that are implementing climate-risk management techniques have higher income levels. The effect, on the other hand, was not statistically significant. This was in directly opposed to what was predicted.

Table 9: Multiple regression results of the effect of risk management strategies attributes on potato enterprise performance among potato smallholder farmers

LogAVEAPOTREVENUE	Coef.	Std. Err.	P>t	[95% Confidence Interval]	
LogTOTALFREQSTRA	0.667***	0.254	0.009	0.167	1.167
LogTOTALNUSTRATEGIES	0.048	0.238	0.839	-0.420	0.516
logTOTALAVECOSTSRISK	0.307	0.580	0.846	-2.800	3.416
Logeffectiveness	3.915	9.792	0.843	-42.834	35.003
_cons	6.387	5.971	0.285	-5.354	18.130

Note: ***Significant at 1%

4.5 Results for objective three: Analysis of various crop-revenue insurance products that exist for smallholder farmers in Tanzania

4.5.1 Description of crop-revenue insurance products for potato smallholder farmers in Tanzania

In describing the crop-revenue insurance products for potato smallholder farmers in Tanzania, the thematic content analysis was employed. The analysis describes results from the key informant interview into the following themes;

- Program name
- Year the company started offering crop-revenue products
- Product type, i.e. Product portfolios
- Provider-Name of the Organization
- Location-Countries and regions of operations
- Risks covered diseases, drought, excess rains, prices, post-harvest losses
- Contract structure-area based/individual base/weather index
- Involvement of the company in agriculture insurance services, i.e.? Insurance provider, Awareness/education/Funding/financing
- Role, the organization, plays in creating awareness and publicity of agricultural insurance
- Product maturity (low –less than 1-2 years of experiences of experience, medium - minimum of 2 years' experience, high-refers to greater than three years Greater than three years)
- Description of the key distribution channels
- Targeted markets in terms of income, location, gender, economic activity, is the scheme is open to all or just members of organized groups

- Premium per hectare insured
- Number of farmers insured per yea

Table 10: Description of the selected crop-revenue insurance products in Tanzania

S/N	Theme	MGen Insurance	ACRE Africa	UAP
1	Program name	Crop insurance	Crop insurance	Crop insurance
2	Year started offering crop-products	Since 2007	2015	2016
3	Product type, i.e. Which agricultural insurance products do you offer to SHFs? Product portfolios	Multiperils and Named perils that covers-Drought, Floods, Disease and pests and post-harvest losses	Weather station-based index insurance Replanting Guarantee Product (RPG)	Multiperils Weather Index insurance
4	The provider (Name of the Organization)	MGen Insurance	Agriculture and Climate Risk Enterprise (ACRE Tanzania)	UAP-Insurance company
5	Countries of operations	Tanzania and Zamia Individual-premium based	Kenya, Rwanda and Tanzania	Tanzania, Uganda, Kenya, Rwanda South Sudan
6	Region of operations	Arusha, Dar es salaam, Mwanza, Mbeya, Iringa, Njombe, Singida	Mbeya, Iringa, Arusha, Manyara, Lake zone regions, Insured crops Maize and Paddy	Morogoro, Iringa, Arusha, Singida
7	Risks covered (diseases, drought, excess rains, prices, post-harvest losses	Drought, Floods, Disease and pests and post-harvest losses	Insured perils Drought, excess rain	Disease-pests, drought, excess rain

Table 11: Description of the selected crop-revenue insurance products in Tanzania-continuation

S/N	Theme	MGen Insurance Company	ACRE Africa Company	UAP Insurance Company
8	Contract structure (area-based/individual base/weather index)	Individual-premium based	Weather Index Insurance The product uses a proxy (or index) – such as the amount of rainfall, temperature, wind speed *Kilimo Salama* insurance in Kenya, Tanzania and Rwanda,	Weather Index Insurance -Individual
9	How are you involved in agriculture insurance? **Hints**: Insurance provider, Awareness/education Funding/financing, Other (specify)	Technical services offered -GAP -Post-harvest handling practices -Financial training-TADB -Planting calendar -Post-harvest handling techniques provided by MGen insurance to	Intermediary between insurance companies, reinsurers and distribution channels Link to the mobile money providers Training at cooperatives and farmer groups such as MVIWATA Workshops to train TOTs of stakeholders,	Insurance GAP training Improved seeds, fertilizer from inputs supplies such as SeedCO Bank loans Involved NHIF to offer Health insurance to SHFs

S/N	Theme	MGen Insurance Company	ACRE Africa Company	UAP Insurance Company
		farmers of Sunflower such as right harvesting time, --storage facilities, Transport, Insurance provider	audio and SMS messaging	
10	What important role can you or your organization play in the awareness and publicity of agricultural insurance? **Hints**: Advertise agricultural insurance, Discuss agriculture insurance with farmers when you interact, Handouts on agricultural insurance like brochures and pamphlets to farmers	Provided hand-outs in Swahili on; What is crop insurance? How does insurance work? Who are eligible for crop insurance?	Training target farmers, policymakers, implementing partners, input companies, aggregators on the customized topics to suit the audience and cover a range of topics regarding insurance, financial inclusion for rural populations, policy changes necessary to encourage more financial inclusion.	Provides brochures in Swahili

Table 11: Description of the selected crop-revenue insurance products in Tanzania-continuation

S/N	Theme	MGen Insurance	ACRE Africa	UAP
11	Product maturity (low, medium, high)	Since 2007 High –Greater than three years, has gone through at least 2 product reviews, the operational process has stabilized for at least one year, the product is maturing and delivering and has good long term potential	Since mid-2015 Medium-Minimum of two years' experience, has gone through one product review cycle, the operational process beginning to stabilize, low/moderate long term potential	Since 2016 Medium-Minimum of two years' experience, has gone through one product review cycle, the operational process beginning to stabilize, low/moderate long term potential
12	Short description about the program/product and key distribution channels	Insurance agents Banks Farmers group	Agribusinesses with contracted farmers Lending institutions and savings and credit cooperatives (SACCOs) providing input loans and medium-scale professional farmers. Mobile companies such as TIGO Input supplies-SeedCO	Insurance agent- SeedCO company Banks Farmers group-UAP goes and talk to SHFs

Table 11: Description of the selected crop-revenue insurance products in Tanzania-continuation

S/N	Theme	MGen Insurance Company	ACRE Africa Company	UAP Insurance Company
13	Targeted markets Who are the target markets for your agricultural insurance products (potato SHFs, maize)? Hints: Capture key characteristics of the target group i.e. income, location, gender, economic activity, etc. Discuss if the scheme is open to all or just members of organized groups	Smallholder farmers Mostly male 50 percent Their income 50000/month The scheme is only open to the members of the organized groups	Farmers - Both small holder and large scale farmers The scheme is only open to the members of the organized groups	Small and medium farmers of any crop except cotton Both male and female Income 100000/month The scheme is only open to the members of the organized groups and share premium
14	Premium per hectare insured	Premium per hectare insured 17700/acre	Selling the product in terms of the scratch card 5000/card	Premium per hectare insured 5000-12000/acre/season
15	Number of famers insured per year	Number of SHFs insured 2017/2018 4000 2018/2019 3500	Number of SHFs insured 42000	Number of farmers insured 2300

4.5.2 Comparison of the selected crop-revenue insurance products

In comparing the selected crop-revenue insurance products in Tanzania, PACE analysis was employed. The PACE framework consists of four aspects; product design, access, cost, and experience to assess the customer value of existing micro-insurance products. Therefore, in this study, three crop-revenue insurance products offered by MGen insurance company, ACRE Africa and UAP were compared. Figure 8 presents findings of PACE analysis for the existing crop-revenue insurance in Tanzania. In terms of product design, the results of a PACE analysis reveals that ACRE Africa had 4.00 out of 5 as a score for the appropriateness of the crop-revenue insurance product offered to smallholder farmers in Tanzania. On the other hand, MGen insurance company had scored 3.75out of 5 in crop-revenue insurance product design, whereas UAP insurance company scored 4.37 out of 5. This implies that UAP insurance company had the highest (4.37) score in the product design aspect of the crop-revenue insurance products. For lack of a better expression, this demonstrates that the UAP insurance firm was successful in many elements of product design including coverage, quality of service, exclusions, waiting periods, the ratio of total insured to risk, eligibility criteria, and value-added services. This could be attributed to the fact that, in the product design aspect, the UAP insurance company offered simple cover without many exclusions. The pay out to farmers was adequate with the premium that farmers were paying. Hence UAP scored above average in the product design aspect. On the other hand, UAP company had moderate room for improving the crop-revenue insurance product design since it had scored above average.

Micro-insurance businesses' crop-revenue insurance products are designed in such a way that they are attractive to smallholder farmers in Tanzania, making them the most important component of their operations. So, according to the findings of the study, the simplicity of the product, the perception of good client value, and the quality of the crop-revenue insurance product appear to be important in determining good client value, which increases demand among farmers in the study area, according to Barooah *et al*. (2017). Additionally, it was discovered that "smallholder farmers desired a different type of coverage than that provided by the insurance policy." The team used this knowledge to rebuild the product, ensuring that it was still structured effectively from an actuarial standpoint while also providing the protection that the farmers were seeking (Barooah *et al.,* 2017). According to the findings of the survey, several farmers ranked poor product quality and poorly drafted contracts as the most significant impediments to achieving

the anticipated results following the purchase of crop insurance. A further point of emphasis was made in relation to the absence of research on the welfare implications of crop insurance products as a hindrance to smallholder farmers taking advantage of the service. In addition, smallholder farmers expressed reservations regarding the viability and usefulness of these insurance products in their operations. More effort should be placed into building high-quality insurance products in order to assure sufficient demand and allow for the measurement of their welfare impact, as indicated by this finding (Barooah *et al.,* 2017).

Regarding the access of crop-revenue insurance products in Tanzania, the results demonstrate that ACRE Africa company had the highest scores of 4.30 out of 5. In contrast, MGen insurance and UAP insurance had scored 3.52 and 3.85 out of 5.00 respectively in the product aspect of PACE analysis. This shows that ACRE Africa had scored above an average score. This implies that, ACRE Africa company was effective in many aspects of product access such as choice, enrolment, information, education, premium payment method and proximity. This could be attributed to the fact that ACRE Africa made a choice and enrolment process voluntary, simple enrolment process, not many documents required during enrolment. Additionally, the company provided clear information about the product, benefits and its limitation. These brochures were in Swahili hence dramatically improving accessibility of the product by smallholder farmers in Tanzania.

Examples include the fact that the ACRE Africa supplied insurance to around 400,000 smallholder farmers in Kenya, Rwanda, and Tanzania in 2015, resulting in a significant increase in revenue (GIIF, 2016). According to Greatrex *et al.* (2015), the wide range of products offered by ACRE, its role as an intermediary between insurance companies, reinsurers, and distribution channels, and its link with mobile money providers such as MPESA and TIGO-PESA in Tanzania are all contributing factors to the positive trend in insurance uptake.

Additionally, mobile banking is an important part of the East African economy, with more than 19.3 million users of the MPES mobile banking system (Safaricom, 2014). Therefore, the ACRE-MPESA partnership enables immediate payment and withdraw of compensation via mobile banking system. The M-PESA system supports easy registration and tracking of individual customer. In addition, this partnership is built primarily on the linkage with financial institutions. Inputs providers, and the MPESA mobile banking community, facilitating payment and distribution. This link allowed ACRE to reach more remote smallholder farmers while maintaining

ow transactional and delivery costs. According to Barooah *et al.* (2017), 19 per cent of the families do not use the products correctly and have difficulty handling them. Furthermore, when questioned about the most important characteristics that are likely to influence the success of these crop insurance products, respondents primarily mentioned aspects that increase demand and customer value, such as trustworthy distribution channels in the research area.

Concerning cost aspect as the dimension of PACE analysis, the findings show that MGen insurance has a score of 4.00 out of 5.00 while both UAP insurance company and ACRE Africa had scored 3.50 out of 5.00. This suggests that MGen insurance company had the highest scores in terms of the cost of access crop-revenue insurance products. In other words, ACRE Africa had above-average score, which implies that the company was effective in any aspects of the cost, such as premium-benefit, premium-client income, other fees-costs and cost-structure and controls of the crop-revenue insurance product. The possible explanations for this could be that MGen insurance company offered good value for money coverage, premium concerning client income was less than 2 per cent. Additionally, MGen insurance company also limited other costs such as travel costs and additional costs apart from the premium amount.

Further, the company had a good cost structure and controls such as fair price, strong cost control, and a mechanism in place to control fraud, adverse selection, and moral hazard. All these efforts had made MGen insurance company have the highest score in the cost aspect of the PACE analysis. However, the company had moderate room for improvement on the crop-revenue insurance product offered to smallholder farmers in Tanzania. The cost aspect of the crop insurance product plays an essential role in making smallholder farmers adopt the product in question. Barooah *et al*. (2017), for example, found that 42 percent of the smallholder farmers interviewed said that the cost of crop insurance was a key element in determining good customer value, which might result in an increase in demand.

Regarding the experience aspect of the crop-revenue insurance product, PACE analysis reveals that MGen insurance company had the highest score of 4.50 out of 5.00. In contrast, UAP Insurance company and ACRE Africa had scored 3.53 and 3.40 out of 5.00 respectively. This shows that MGen insurance company was more effective in claim procedures and processing time, policy administration, product tangibility and customer services. In other words, the company had above average score in the experience of the crop-revenue insurance products offered to smallholder farmers in Tanzania. This could be attributed to the fact that MGen insurance started

offering crop insurance services in Tanzania in 2007. As result it had more experience in providing the products in the country that is why the company had above average score in terms of experience. On average, MGen insurance company had scored 3.94 while UAP and ACRE Africa insurance companies scored 3.81 and 3.8 out of 5.00 respectively. This suggests that all the three companies had an average score in all aspects of PACE analysis, i.e. product design, access, costs and experience. Therefore, these companies were broadly effective and relatively useful in general situations as 50 per cent of client situations were covered when smallholder farmers employed the crop-revenue insurance products as a risk management strategy.

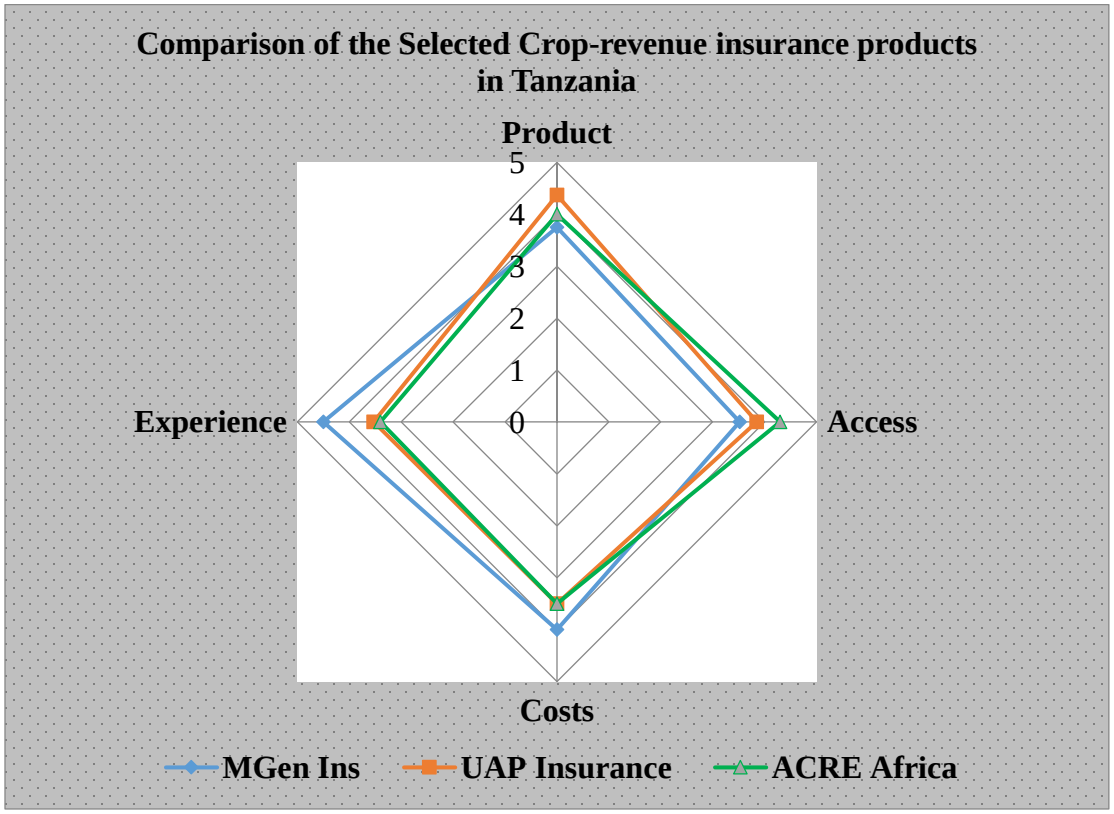


Figure 8: PACE analysis of the selected crop-revenue insurance products in Tanzania

4.5.3 Description of the business model for crop-revenue insurance products in Tanzania

Business models are defined as a plan for the successful running of a business that identifies revenue streams, target consumer bases, product offerings and finance specifics. The model also defines the justification for how an organization develops, delivers, and captures value in a variety of contexts, including but not limited to those of the economic, social, and cultural nature of the organization. Results revealed that crop-revenue insurance companies in Tanzania collaborated with other organizations such as banks, inputs suppliers, off-takers, mobile phone providers in

offering insurance services to smallholder farmers in the country. In terms of operation, premium from smallholder farmers was collected by micro-insurance companies through commercial banks such as Tanzania Agricultural Development Bank, Tanzania Postal Bank. Then these commercial banks transferred the funds to Micro-Insurance Company. During indemnity disbursement, the banks transferred the funds from the micro-insurance Company's account to smallholder farmers.

On the other hand, smallholder farmers are linked to the markets so that they sell their produces. Micro-insurance companies also provided training at cooperatives and farmer groups such as MVIWATA. Additionally, crop-revenue insurance companies cooperated with mobile phones and acted as the distribution channels. For example, the partnership between ACRE and MPESA has made it possible to pay both premiums and indemnity instantly via mobile banking. In addition, the MPESA system makes it easier to register and follow individual smallholder farmers throughout the country's agricultural sector. ACRE was able to contact thousands of smallholder farmers in rural places as a result of this connection.

Figure 9 and 10 describes how crop-revenue insurance model works in Tanzania.

- Micro-insurance Companies → Indemnity to Banks → Smallholder farmers
- Banks → Premium → Micro-insurance companies
- SHFs pay premium → Banks → Micro-insurance companies
- Micro-insurance companies → Insurance services → Smallholder farmers
- Smallholder farmers sell produces ↔ Markets provide revenues to SHFs
- Input suppliers → Inputs → Smallholder farmers
- Banks → Loans → Smallholder farmers

Figure 9:Description of the business model of crop-revenue insurance products

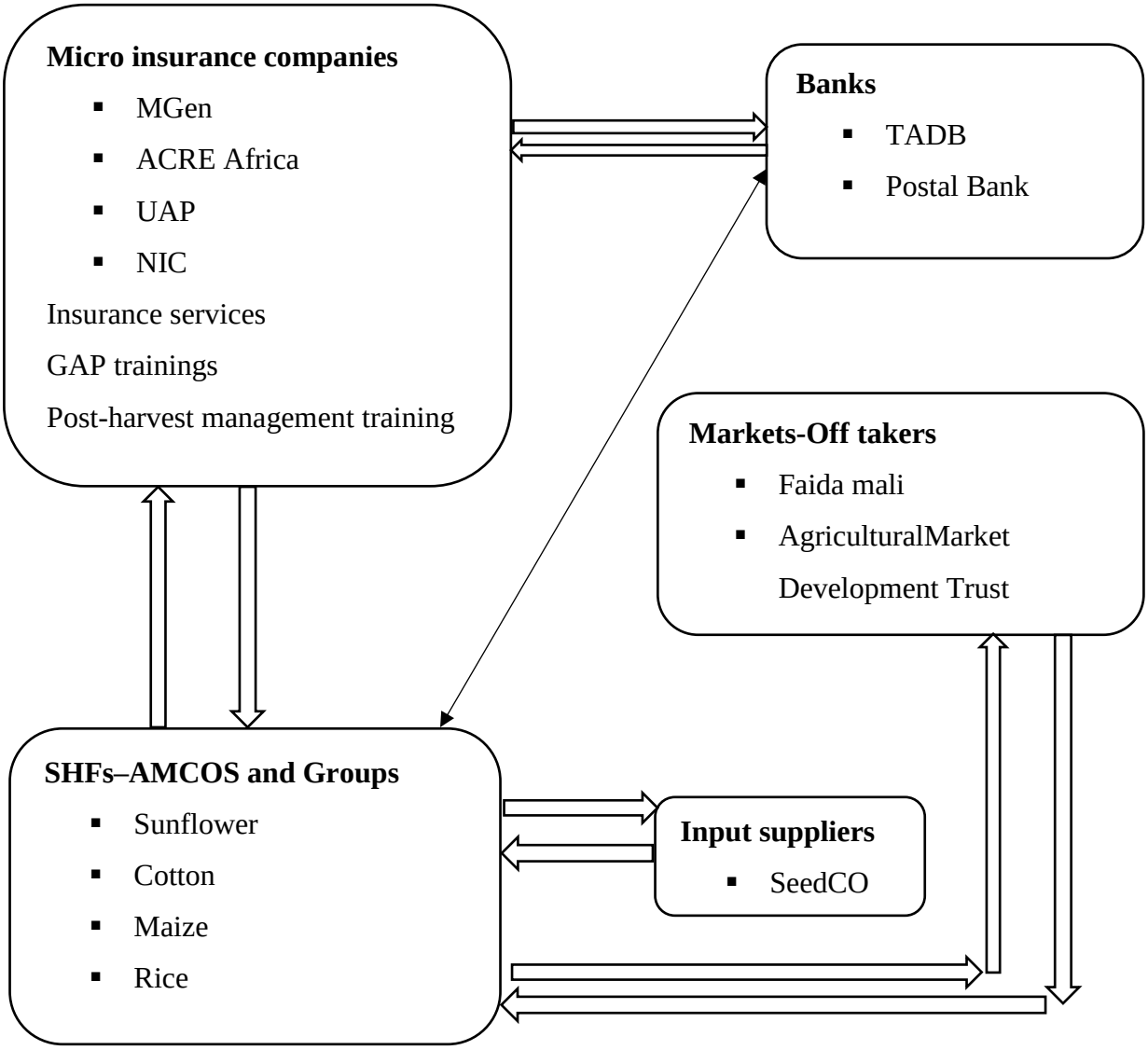


Figure 10: Business model for the crop-revenue insurance products in Tanzania

4.6 Results for objective four: Designing a Collaborative-based Revenue Insurance Scheme (CoBRIS) for Potato smallholder farmers

4.6.1 Stage one: Developing attributes and attribute levels for CoBRIS

The first stage in conducting a Discrete Choice Experiment (DCE) involved identifying CoBRIS attributes and the critical levels when potato smallholder farmers choose the CoBRIS contracts once they are presented under local settings. According to WHO (2012), identifying the attributes and their levels is critical in conducting the Discrete Choice Experiment because this

assists in the formulation of DCE options. This step included a literature review process as well as qualitative research methods such as key informant interviews and focus group talks with stakeholders and policymakers who were relevant to the topic (WHO, 2012). As a result, the study looked over relevant crop insurance literature to come up with the CoBRIS traits and levels. According to Blaauw *et al.* (2010), the selection of qualities and their levels should be based on the following criteria: Informed by the literature on the subject area –crop insurances, Policymakers and other stakeholders will find it realistic and actionable. Based on qualitative research in the field, such as a review of relevant literature, focus group discussions, or key informant interviews. As a result, eight attributes: impact of risk, the management structure of CoBRIS, indemnity amount, transparency, risk covered, premium, coverage level, contract content, and their associated levels were developed. Additionally, the study defined the identified attributes as continuous or categorical variables. Therefore, characteristics such as premium amount, indemnity rate and coverage level fell under the continuous group. Categorical attributes, on the other hand, refer to variables that are associated with certain sub-categories.These attributes include variables such as the impact of risk, management structure, transparency, risk covered and contract content. Table 11 shows the list of developed attributes and the associated levels.

Table 11: Developed attributes and attribute levels for the CoBRIS contract

Attributes	Description	Attribute levels
Impact of risk	The level of Impact of risk on potato yield/ income	High, Medium or low)
Management structure	The management structure of the CoBRIS contract	Insurance agents, Management by external NGO, management by a community committee, collaboratively
Indemnity	Expected payment in the case of yield loss, revenue loss	
Transparency	How easily explained and understood the products is	
Risk covered	Type of risks covered	Low rainfall, Excess rains, pests and disease, potato price and post-harvest losses
Premium	Premium (Cost of CoBRIS contract per acre)	
Coverage Level	Level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS contract. Indemnity will be paid for any revenue realization that is below the coverage level	
Contract content	Content of the CoBRIS contract	Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses

4.6.2 Stage two: Validation of the CoBRIS' Attributes and Levels

Following the initial identification of prospective qualities and levels, key informant interviews were undertaken to further investigate and validate these attributes and their levels for inclusion in the Discrete Choice Experiment (DCE). The amount of attributes to include in the

DCE has a considerable impact on how the Discrete Choice Experiment is carried out. This is because DCE's theoretical underpinning believes that once a person has completed DCE, they will evaluate all traits, levels, and trade-offs while making decisions. As a result, according to WHO (2012), it is critical to limit the number of features included in the final Discrete Choice Experiment. Also asserted was that attribute numbers in Discrete Choice Experiment applications in low- and middle-income countries have ranged from five to eight in the context of Discrete Choice Experiment applications (WHO, 2012).

Furthermore, when performing a Discrete Choice Experiment, it is recommended that the appropriate amount of qualities be investigated within the pilot work, as this is likely to be context-specific. However, eight is widely considered to be close to the maximum number (WHO, 2012). As a result, the predicted trade-offs will be incorrect. In order to validate and limit the number of features to a reasonable quantity, the study interviewed insurance companies in Tanzania. Interviews with key informants revealed the relative relevance of attributes, revealing how to reduce the number to a reasonable level by ranking the original attributes from 1 to 8 in order of priority. Table 12 presents the ranking of attributes by insurance companies in Tanzania.

Table 12: CoBRIS attributes according to their importance to the company and clients

Attribute	Description	Rank
Impact of risk	Whether the impact of production and marketing risk on-farm revenue is High, Medium or low	**8**
Management structure	(Insurance agents, Management by external NGO, management by community committee, collaboratively)	**7**
Premium	Premium (Cost of CoBRIS contract per acre)	**1**
Indemnity	Expected payment in the case of yield loss, revenue loss	**5**
Transparency	How easily explained and understood the products is	**6**
Risk covered	Include risks such as Low rainfall, Excess rains, pests and disease, potato price and post-harvest losses	**2**
Coverage Level	Percentage level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS contract. Indemnity will be paid for any revenue realization that is below the coverage level)	**4**
Contract content	Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses)	**3**

The research reveals that when it comes to the manageable number of qualities, the number of attributes should be between eight (at the higher end) and two (at the lower end) (de Bekker-Grob *et al.,* 2012). Sibuko *et al.* (2017) also noted that in order not to overwhelm participants in the experiment, the researchers chose to employ only five contract features. As a result, the initial attributes were reduced to five as they were both important to agricultural insurance companies and policy-relevant. These attributes were risk covered, premium amount, contract content, coverage level and indemnity rate. Table 13 presents the list of attributes that were finally included in the CoBRIS-Discrete Choice Experiment.

Table 13: Final attributes included in the CoBRIS contracts

Attribute	Description	Rank
Premium	Premium (Cost of CoBRIS contract per acre)	**1**
Indemnity	Expected payment in the case of yield loss, revenue loss	**5**
Risk covered	Include risks such as Low rainfall, Excess rains, pests and disease, potato price and post-harvest losses	**2**
Coverage Level	Percentage level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS contract. Indemnity is paid for any revenue realization that is below the coverage level)	**4**
Contract content	Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses)	**3**

4.6.3 Stage three: Experimental design and construction of CoBRIS choice sets

Once the attributes and levels were developed and validated, the study defined the CoBRIS choice sets, which are hypothetical ones resulting from combining the attributes and levels. These CoBRIS choice sets were presented to potato smallholder farmers. These approaches are typically used to decrease the number of choices to a manageable number while still allowing the researcher to infer preferences for all of the CoBRIS contract sets that have been designed.

Table 14: Designed CoBRIS choice sets

No/Attributes	Risk covered	Premium	Contract content	Cover level	Indemnity
A	Climate risk and Diseases	10,000	Potato yield	85% Medium	75% High
B	Climate risk, Diseases and Post-harvest losses	15,000	Potato yield and post-harvest losses	90% High	65% Medium
C	Climate risk, Diseases and Price volatility	12,000	Potato yield and price volatility	80% Low	55% Low
D	Climate risk, Diseases and Post-harvest losses	10,000	Potato yield and post-harvest losses	85% Medium	75% High
E	Climate risk and Diseases	10,000	Potato yield	85% Medium	65% Medium

4.6.4 Orthogonality of the developed CoBRIS attributes

It is usual to examine the correlation between the two properties and describe them as orthogonal if the correlation is zero or low. As a result, orthogonality can be thought of as the polar opposite of multicolliearity in nature. When the characteristics move together and the separate impacts of each attribute are unable to be determined, this is referred to be a cluster. When there is a large degree of multicollinearity between variables, it is impossible to discern which traits are responsible for the preferences of the participants. In the worst-case scenario, neither the regression model nor the results are obtained from the data. Table 15 shows the complete factorial design correlation. These correlation coefficients were estimated using several tests, including Pearson (Pearson's Product of Moments, or PPM) and Spearman's Rho number of relationships. All CoBRIS attributes showed no Correlation-Perfect orthogonality.

Table 15: Correlation Matrix for the developed and validated CoBRIS attributes

	Risk covered	Premium	Contract content	Coverage level	Indemnity
Risk covered	1	0	0	0	0
Premium	0	1	0	0	0
Contract content	0	0	1	0	0
Coverage level	0	0	0	1	0
Indemnity	0	0	0	0	1

4.6.5 Stage four: Determining willingness to participate and pay for the developed CoBRIS' attributes

Table 16 presents results for the willingness to participate in the CoBRIS contracts among potato smallholder farmers. Following the outcomes of the study, it was discovered that 85 percent of the potato smallholder farmers were willing to participate in the CoBRIS contracts, while only 15 percent were not willing to participate in the CoBRIS contracts. The majority (85 percent) of potato smallholder farmers in Tanzania were willing to participate in the CoBRIS contract, indicating that the contract was a good fit for them. This could be explained by the fact that the majority of potato smallholder farmers stated that their farms were heavily affected by production and market risks, and that it was thus vital for them to engage in a crop insurance program such as CoBRIS to manage risks.

For example, descriptive results show that potato smallholder farmers faced production and market risks such as pests-disease, climate risks and price volatility which might have triggered them to participate in the CoBRIS contract. For example, from the key informant interview, it was revealed that farmers cannot manage the frost that affects potato farms. Frostbite is not frequently happening, but when it happens it destroys all the crops in the farm. For example, in the 2019/2020 dry season, potatoes in Luponde and Miva village experienced complete crop failure due to frostbites in June and July 2019. Smallholder farmers were not able to harvest even one bag of potatoes. This implies that potato smallholder farmers cannot control and manage it. As a result, most of them decided to participate in the CoBRIS contracts. Moreover, potato smallholder farmers in Njombe believed that crop insurance is, theoretically, an effective risk management

strategy that can assist farmers in their efforts to protect themselves against the loss of their crops or farm income as a result of natural disasters such climate change, pests-disease or drop in potato prices.

These findings align with Ellis (2016) that in Ghana, a high percentage of maize and paddy smallholder farmers were willing to purchase insurance products. According to the findings of the survey, the vast majority of smallholder farmers were interested in protecting their crops against production risks and uncertainties (Ellis, 2016). Additionally, the possible explanation could be that most potato smallholder farmers were members of a group in the study area, possibly making them willingly participate in the CoBRIS contract. It has been demonstrated in several research that higher levels of social capital in the form of social links at the community level have positive and significant impacts on a smallholder farmer's decision to participate in a community-based insurance scheme (Donfouet & Mahieu, 2012). Donfouet *et al.* (2011a) found that communities with sufficient stocks of social capital were more likely to pay for and seek community-based insurance services than communities with insufficient stocks of social capital.

Further, slightly over half (54 per cent) of potato smallholder farmers willing to participate in the CoBRIS contract opted out of contract C. This could be attributed to the fact that CoBRIS contract C had also covered price volatility risks that potato smallholder farmers had reported as the risk that they could not manage and control it in the study area effectively. As a result, most of potato smallholder farmers opted for contract C.

On the other hand, none of the potato smallholder farmers in the study chooses CoBRIS contract E. The possible explanations for this could be that the contract had only covered climate risk, pests and diseases of which potato smallholder farmers had reported that they effectively managed these types of risks; hence they assumed there was no need for them to opt CoBRIS contract E. Of the total number of potato smallholder farmers in the study area who were willing to participate in the CoBRIS contract because they wanted to improve potato revenues, household food security, household income and credit access from financial institutions.

Further, potato smallholder farmers who were not willing to participate in the CoBRIS contracts provided a number of motives for their decision. Some of the reasons were that there was no seller available, that I did not have enough information and was still in doubt, that I did not understand how insurance works, that I did not trust insurance companies, that the premium was too high, that I did not believe the production and marketing risks covered by the scheme affected

my potato revenue, that the scope of the production and marketing risks covered by the scheme was limited, that I was able to handle everything on my own, and that I was extremely fearful of bureaucratic system.

Ellis (2016) reported similar findings, stating that a large number of smallholder farmers stated that they did not have enough information about the insurance program, while others stated that they were concerned about high premium rates, the possibility of delayed compensation, and the need for more time to make a decision. Nimoh *et al*. (2011), on the other hand, found that a number of these reasons were comparable to those discovered by Nimoh *et al*. (2011), who found that some of the sampled smallholder farmers were unable to insure because of a lack of income or poor expertise, respectively.

Table 16: Willingness to participate in CoBRIS contracts in Tanzania

Variable	Frequency	Per cent
WTPYes	324	85
WTPNo	59	15
Willingness to Pay by CoBRIS contracts		
CoBRIS contract A	50	15
CoBRIS contract B	74	23
CoBRIS contract C	174	54
CoBRIS contract D	26	8
CoBRIS contract E	0	0

Specifically, in terms of farmer willingness to pay for CoBRIS attributes and potato enterprise-related factors, the results show that some of the mean parameters have statistically significant expected signs, whereas others do not, indicating that the contract attributes selected are not relevant for farmers in this context. There are two main applications for the coefficients (ßs) generated by the logit: determining whether or not the attributes are important, as indicated by the significance level of the coefficients ß and the direction of importance (as indicated by the sign of the estimated ß), and determining the relative importance of the attributes (size of the estimated parameter). In addition, the direction of the coefficient signs serves as a check on the theoretical/internal validity of the choice experiment model, which is important. That is, if the coefficients move in the direction predicted by economics or priori anticipation. A positive result

suggests that there is a higher likelihood of making a purchase. A negative number indicates that the probability of purchasing the CoBRIS contracts among potato smallholder farmers in the study area is decreasing as a result of the study. In the findings, it was discovered that all of the mean coefficients for CoBRIS traits, potato enterprise, and trust-related components were critical variables to include in the conditional logit model, which was used to test this hypothesis. At the 5% confidence level, this was shown by the probability value of 0.01, which indicates that there was a statistically significant among smallholder farmers.

Regarding the willingness to pay for the CoBRIS' attributes, the findings from Table 17 shows that the coefficient associated with CoBRIS premium is negative. This implies that the premium amount decreases the probability of potato smallholder farmers paying for the CoBRIS contracts. The presence of a premium has a detrimental impact on the likelihood of CoBRIS being purchased since potato smallholder farmers, by their nature, prefer to spend less money. The coefficient for the premium attribute, on the other hand, does not reach statistical significance. A positive sign was found in the model coefficient associated with the variable CoBRIS coverage level, suggesting that potato smallholder farmers prefer CoBRIS contracts with higher levels of coverage on average, as opposed to those with lower levels of coverage.

This suggests that a higher CoBRIS coverage level increased the probability of a potato smallholder farmer paying for the CoBRIS contracts. This is because coverage level represents percentage level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS contract, and the indemnity amount will be paid for any revenue realization that is below the coverage level. However, there was no statistical significance. In terms of indemnity amount for the CoBRIS contracts, results postulate that the coefficient had a positive sign. This suggests that a higher CoBRIS indemnity rate would increase the probability of potato smallholder farmers participating and paying for the CoBRIS contracts. However, the effect was not statistically significant. This could be contributed by the fact that; potato smallholder farmers would like to have higher compensation if they encounter potato yield loss or revenue loss. This was contrary to the expected results.

Table 17: Regression results of Conditional Logit Model for CoBRIS contract attributes

Variables	Coefficient SE	Std. errors	P-value
Premium	-0.38	1.90	0.84
CoBRIS coverage level	0.01	0.02	0.61
CoBRIS Indemnity	0.01	0.01	0.48
_cons	-1.93	1.45	0.18

Table 18 presents the results of potato enterprise and trust-related factors on potato smallholder farmers' willingness to pay. The results reveal that there is a negative effect of potato enterprise-related factors (Potato Post-harvest loss) on potato smallholder farmers' willingness to pay for the CoBRIS contract. This implies that potato post-harvest losses are not an essential factor that might influence potato smallholder farmers to pay for the CoBRIS contracts willingly. This could be contributed by the fact that most potato smallholder farmers in Tanzania do not consider post-harvest losses as a significant factor that might affect their potato yield/income. Results from the descriptive statistics also reveal that over three quarters (77.3 per cent) of all the potato smallholder farmers can protect the negative effect of the post-harvest losses on potato enterprise performance in Tanzania. This could be explained by the fact that most of the smallholder farmers in the study area employed strategies such as harvesting for the second time and use as seed potatoes for the next season and close supervision during harvesting. Additionally, potato smallholder farmers perceived that their strategies effectively managed the negative effect of post-harvest losses on their revenues. However, the effect was not statistically significant. Smallholder farmers' willingness to pay for the CoBRIS contracts, on the other hand, appears to be influenced by horizontal trust in a positive and statistically significant way, according to the data. This clearly shows that building trust among potato smallholder farmers in the study area is critical to boosting the likelihood of them paying for CoBRIS contracts in the first place. Similar findings were reported by Tundui and Macha (2014), who found that the amount of trust among community members appears to be a strong predictor of their willingness to pay. In addition, Zhang *et al.* (2006) reported a favorable relationship between trust among community members and their likelihood of being willing to participate in community-based insurance in rural China.

Furthermore, the findings reveal that the vertical trust positively increased the likelihood of potato smallholder farmers to pay for the CoBRIS contracts. This suggests that when potato

smallholder farmers trust micro-insurance companies and financial institutions, then they become more willing to pay for the CoBRIS contracts than when they do not trust them. However, the effect was not statistically significant. This was contrary to the expected results. Generally, trust-related factors (0.10 for horizontal trust and 0.06 for vertical trust) are more important in increasing the probability of potato smallholder farmers to pay for CoBRIS contracts than potato post-harvest losses (0.03).

Table 18: Results of Conditional Logit Model for Potato enterprise and Trust related factors

Variables	Coefficient	Std. Err.	P-value
Potato Post-harvest loss	-0.03	0.004	0.40
Horizontal trust	0.10*	0.06	0.09
Vertical trust	0.06	0.01	0.60
_cons	-1.93	1.45	0.18

Note: *Significant at 10%, respectively

Results of the marginal WTP for the CoBRIS qualities among potato smallholder farmers are presented in Table 19 of this study. This is accomplished by dividing the attribute coefficient by the premium coefficient. The mean willingness to pay (WTP) for the CoBRIS qualities is determined by this method. According to the findings, potato smallholder farmers were only willing to pay for two CoBRIS attributes: reliability and availability (CoBRIS coverage level and Indemnity). In terms of CoBRIS contract B, potato smallholder farmers in the study were willing to pay on average of TZS 15,035 for the high (90 percent) level of coverage. This implies that potato smallholder farmers in the study area were willing to pay a TZS 35 above the market price (TZS 15,000) for the CoBRIS contract B for the high coverage level. This could be attributed to the fact the coverage level was high as CoBRIS contract B was able to cover up to 90 per cent of the potato yield and post-harvest losses. Therefore, smallholder potato farmers were inspired and willing to pay 35 TSZ more than the market price of TZS 15000 for their produce as a result of the initiative. Specifically, it was hypothesized that potato smallholder farmers would be prepared to pay TZS 12,035 for the low coverage level of 80 percent under the CoBRIS contract C. This implies that potato smallholder farmers paid 35 Tshs more above the market price of TZS 12000 for the same CoBRIS contract. According to the results of CoBRIS contract D, potato smallholder

farmers in Tanzania were willing to pay TZS 10,035 for a medium coverage level of 85 percent, according to the results. This suggests that smallholder farmers in the study region were willing to spend 35 Tshs more than the market price of TZS 10,000 for the CoBRIS contract, which is more than the market price of TZS 10,000. Generally, the findings show that potato smallholder farmers were willing to pay more (TZS 15,035) for the coverage level of CoBRIS contract B than contract C (12,035 TZS) and D (TZS 10,035). This could be attributed to the fact that CoBRIS contract B (90%) had the highest coverage level compared to contract C (80 per cent b) and D (85 per cent). Therefore, this made potato smallholders farmers to willingly pay more the percentage level purchased of CoBRIS contract B in the study area. These findings are in line with Olila *et al*. (2015) that Maize smallholder farmers in Kenya preferred higher levels of coverage hence were willing to pay for it. This was represented by a positive coefficient, which indicates that as coverage increases, the willingness to pay swings upward. It was especially pointed out by Olila *et al.* (2015) that on average, maize-growing smallholder farmers in the research area were ready to pay an average of KES 86 for a low level of coverage and KES 158 for a medium level of coverage. The predicted indemnity is the amount of indemnification payment that a potato smallholder farmer will get if the potato farm yield/revenue falls below the trigger yield/index level in the year in question. The findings of this study, potato smallholder farmers in the research area were willing to pay 15,038 TSZ for a medium level of indemnity (65 percent) for the medium level of indemnity. To put it another way, the medium level of indemnification required by CoBRIS contract B was worth TZS 38 more to potato smallholder farmers than the market price of 15000 Tshs demanded by the CoBRIS contract B. Furthermore, it was discovered that smallholder farmers were willing to pay TZS 12,038 for the CoBRIS contract C, potato, which was awarded to them. Thus, smallholder farmers were willing to pay TZS 38 per unit of indemnity for the low (55 percent) level of indemnity rather than the market price of TZS 12000 per unit of indemnity for the CoBRIS contract B. Also revealed by the findings is that, for the CoBRIS contract D, potato smallholder farmers were willing to pay TZS 10,038 in exchange for a high degree of indemnification and protection (75 percent). This shows that smallholder potato farmers are willing to pay an additional TZS 38 over the market price of TZS 10,000 for their potatoes. In general, the data indicate that potato smallholder farmers were willing to pay more for the indemnification provided by the CoBRIS contract than they were willing to pay for the coverage level. This could be explained by the fact that potato smallholder farmers placed a higher

importance on the projected pay-outs in the event that they experienced a loss in potato output or a decrease in revenue. Also consistent with prior studies, the data show that maize smallholder farmers in Kenya were willing to pay extra for medium level coverage as compared to low level coverage (Olila *et al.*, 2015).

Table 19: Marginal willingness to pay for CoBRIS attributes Contract

CoBRIS attribute	**Marginal willingness to pay for CoBRIS contracts**		
	CoBRIS B	**CoBRIS C**	**CoBRIS D**
CoBRIS coverage level	TZS 15,035	TZS 12,035	TZS 10,035
CoBRIS Indemnity	TZS 15,038	TZS 12,038	TZS 10,038

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the findings

The findings of this study reveal that price volatility (72.6 per cent), bacterial wilt (67.6 per cent), frostbites (66.1 per cent), excess rainfall (63.5 per cent), and late blight (60.6 per cent), are very likely to affect potato farming enterprise among smallholder farmers. Moreover, the results show that the majority (66.1 per cent) of smallholder farmers perceived that potato price volatility is the most risk that has very high effect on potato farming enterprises compared to 46.2% for bacterial wilt, 44.0 per cent for late blight, 41.5 per cent for frostbite and 40.5 per cent excess rainfall.

The results further reveal that for every 1% increase in the frequency, effectiveness, costs and number of risk management strategies, potato enterprise performance improved by 0.667%, 3.91%, 0.307% and 0.048%, respectively, among potato smallholder farmers.

The results furthers show that the existing crop-revenue insurance products can be described in terms of the program name, the year the company started offering crop-revenue products, product type, name of the company, area of operations, risks covered (diseases, drought, excess rains, prices, post-harvest losses), involvement of the company in agricultural insurance services, product maturity, description of the key distribution channels and target markets, the premium per hectare insured and the number of smallholder farmers insured per year. Findings further reveal that MGen insurance company, UAP and ACRE Africa insurance companies had an average score in all aspects of product design, access, costs and experience. This implies that these companies are broadly effective and relatively useful in general situations as 50 per cent of client situations were covered when smallholder farmers employed the crop-revenue insurance products as a risk management strategy. Additionally, results reveal that crop-revenue insurance companies in Tanzania collaborate with other value chain actors (such as banks, inputs suppliers, off-takers, mobile phone providers and off-takers) in offering insurance services to smallholder farmers. The eight attributes (impact of risk, the management structure of CoBRIS, indemnity amount, transparency, risk covered, premium, coverage level, contract content and their associated levels were identified). Additionally, five CoBRIS attributes (risk covered, premium amount, contract content, coverage level and indemnity rate) were validated and included in the CoBRIS contracts. They were both critical to insurance companies and policy-relevant. Results show that the majority

(85 per cent) of potato smallholder farmers were willing to participate in the CoBRIS contracts. Findings reveal that the coefficient associated with CoBRIS premium is negative, implying that, the premium amount decreases the probability of potato smallholder farmers to pay for the CoBRIS contracts.

On the other hand, the coefficient of CoBRIS coverage level and indemnity have a positive signs indicating that potato smallholder farmers prefer CoBRIS contracts with higher coverage levels and indemnity amounts. Findings of the study reveal that there is the negative effect of potato post-harvest loss on potato smallholder farmers' willingness to pay for the CoBRIS contracts. Trust-related factors have a positive coefficient, implying that it increases the probability of potato smallholder farmers' willingness to pay for the CoBRIS contracts. Findings further reveal that potato smallholder farmers were willing to pay for only CoBRIS coverage level and Indemnity.

5.2 Conclusions

i. Potato price volatility and bacterial wilt are the major risks that are very likely to affect smallholder farmers. They have a very high effect on potato farming enterprises in the study area.

ii. The frequency of risk management strategies used improves potato enterprise performance among potato smallholder farmers.

iii. Micro-insurance companies (MGen, UAP and ACRE Africa) are broadly effective and relatively useful in general situations as 50 per cent of client situations were covered when smallholder farmers employed the crop-revenue insurance products as a risk management strategy. Moreover, the micro-insurance companies collaborate with banks, inputs suppliers, off-takers, mobile phone providers in offering insurance services to smallholder farmers in Tanzania.

iv. Eight attributes (impact of risk, management structure, indemnity amount, transparency, risk covered, premium, coverage level, contract content) and their associated levels were developed and validated among micro-insurance companies in Tanzania. Most of potato smallholder farmers are willing to pay for the collaborative-based revenue insurance scheme. On the other hand, the trust-related factors (horizontal and vertical trust) increases potato smallholder farmers' willingness to pay for the CoBRIS contracts.

5.3 Recommendations

i. This study recommends that potato smallholder farmers to observe price fluctuations that follow a pattern of high at pre-harvest, low at harvest and raising again towards the end of the season. This information will help them to plan when to grow and harvest their potatoes so that they can sell when prices get better. In the same line, public policies should aim at helping smallholder farmers develop resilience mechanisms to manage the risks posed by potato price volatility. This could be through developing Information Communications Technologies (ICT) related platforms such as (M-Kilimo) to improve the content and speed of market information such as price volatility. On the other hand, potato smallholder farmers should employ effective risk management strategies such as improved seed potatoes, crop rotation, and fallowing to manage the effect of bacterial wilt.

ii. This study recommends that potato smallholder farmers should increase the frequency of use of the on-farm risk management strategies to manage both production and market risks as this improves potato enterprise performance.

iii. This study recommends that micro-insurance companies in Tanzania continue collaborating with banks, inputs suppliers, off-takers, and mobile phone service providers to offer insurance services to smallholder farmers in the country. This model should be extended and include potato smallholder farmers.

iv. The study recommends encouraging and facilitating potato smallholder's membership to groups as this builds more trust among them, thereby increasing the probability of becoming willing to participate and pay for the CoBRIS contracts.

5.4 Areas for further research

i. The study considered the perceived effect of production and marketing risks on potato farm income and not the quantitative effects of these risks. A quantitative study on the effect of climate-related, pests-diseases and marketing risks on-farm income should be done.

ii. The study was limited to the effects of the on-farm risk management strategies' attributes on the potato enterprise performance. Research on the impact of off-farm risk management strategies' attributes among potato smallholder farmers would be fascinating. It could help to figure out how risk management strategies such as crop insurance' coverage level and indemnity affect the performance of potato enterprise in Tanzania.

iii. The present study only looked at micro-insurance companies as the only actor in the insurance value chain in Tanzania. This was done in terms of analysing how crop-revenue insurance companies perform in the aspect of product design, access, costs and experience. The study, therefore, recommends the inclusion of smallholder farmers through the use of the "3-D" Client Value Assessment tool for a crop insurance product that provides a multi-dimensional measure of crop-revenue insurance contract's total value proposition for smallholder farmers. The results of the 3-D analysis typically highlight gaps and strengths in product design, distribution and delivery, each of which can be used to improve the overall value of the crop-revenue insurance product.

iv. The collaborative-based insurance scheme was developed in terms of qualities and attribute levels, according to the findings of the study. It also evaluated whether or not people were willing to pay for the newly formed CoBRIS. As a result of this, additional research is needed because the costs and benefits of implementing the collaborative-based revenue insurance plan are not well understood. As a consequence, this information may be useful to any stakeholder who is eager to put the scheme into effect.

REFERENCES

Abbas, Q., Han, J., Adeel, A., & Ullah, R. (2019). Dairy Production under Climatic Risks: Perception, Perceived Impacts and Adaptations in Punjab, Pakistan. *International Journal of Environmental Research and Public Health,* 16, (40),1-21.

Abdullah, A. M., Auwa, A. G., & Darham, S. (2014). Farmers' Willingness to Pay for the Crop insurance in North West Selangor Integrated Development Area in Malaysia. *International Society for Southeast Asian Agricultural Science;* 20 (2), 19-30.

Adane, K., Measho, G., & Mezgebu, Y. (2014). Willingness to pay for community-based health insurance among households in the rural community of Fogera District, North West Ethiopia. *International Journal of Economics, Finance and Management Sciences,* 2(4), 263-269.

Aditto, S., Gan, C., & Nartea, G.V. (2012). *Risk Management-Current Issues and Challenges Sources of Risk and Risk Management Strategies: The Case of Smallholder Farmers in a Developing Economy.* Intech.

Afroz, R., Akhtar, R., & Puteri-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*; 7(4), 1-9.

Ahasan, D.A. (2011). Farmers' Motivation, Risk Perception and Risk Management Strategies in a Developing Economy: Bangladesh Experience. *Journal of Risk Research,* 14 (3), 325-349.

Aidoo, R., Mensah, J.O., Wie, P., & Awunyo-Vitor, D. (2014). Prospects of Crop Insurance as a Risk Management Tool among Arable Crop Farmers in Ghana. *Journal of Asian Economic and Financial Review,* 4(3), 341-354.

Akyoo, A.M., Temu, A.E., & Hella, J.P. (2013). Agricultural production risks, Coping mechanisms and Potential for crop insurance in Tanzania. *Time Journal of Agriculture and Veterinary Science* 1(1),11-22.

Alaerie, K., Ketema, M., & Gelaw, F. (2013). Risk Management Strategies and Pesticides Use in Vegetable Production; The case of Smallholder farmers in Kombolcha, Woreda, East Harare Zone, Oromia National Regional State, Ethiopia. *Journal of Economics and Sustainable Development*.4, (7), 108-115.

Ali L., Mangheni N., Sanginga P., Delve R., Mastiko F., & Miiro R. (2007). Social capital and adoption of soil fertility management technologies in Tororo district, Uganda. In: Bationo A., Waswa B., Kihara J., & Kimetu J. (eds) *Advances in Integrated Soil Fertility Management in sub-Saharan Africa: Challenges and Opportunities* (pp.947-954). Springer, Dordrecht.

Anderson, J.R., & Dillon, J.L. (1992). *Risk Analysis in Dryland Farming Systems*. Food and Agriculture Organization of the United Nations.

Apostolakis, G, van Dijk, G., & Drakos, P. (2015). Micro-insurance performance: A systematic narrative literature review. *Journal of Corporate Governance,* 15(1),146-7

Arısoy, H., & Bayramoğlu, Z. (2017). Determination of the Effect of Price Fluctuations on Producer Income – the Case of Potatoes. *Turkish Journal of Agriculture - Food Science and Technology*, 5(11),1342-1349.

Asseldonk, M.V., Porgo, I., Hamusimbi, C., Mumba, G., & Banda, J. (2015). Is there evidence of linking crop insurance and rural credit and its potential benefits? Policy Brief of the Farm Risk Management for Africa Project.

Babbie, E., & Mouton, J. (2006). *The practice of social research.*: Oxford University Press.

Bhullar, K.S. (2012). Effect of Polypropylene Covers on Frost Protection and Yield of Potato Crop in Punjab, India. *Journal of Krishi Vigyan* (1),18-20.

Balew, S., Agwata, J., & Anyango, S. (2014). Determinants of Adoption Choices of Climate Change Adaptation Strategies in Crop Production by Small Scale Farmers in Some Regions of Central Ethiopia. *Journal of Natural Sciences Research* 4(5), 78–93

Banterle, A. and Vandone, D. (2013, April*). Price Volatility and Risk Management: The Case of Rice.* (Working Paper No.2013- 8).

Barnett, B.J., Black, J.R., Hu, Y., & Skees, J.R. (2005). Is area yield insurance competitive with farm yield insurance? *Journal of Agricultural Resource Economics* 30(2),285–301.

Bartolini, F., Andreoli, M., & Brunor, G. (2014). Explaining determinants of the on-farm diversification: empirical evidence from Tuscany region. *Bio-based and Applied Economics* 3(2), 137-157.

Barooah, B., Bharat, K., & Puri, J. (2017*). Understanding Financial Risks for Smallholder farmers in low and middle-income countries; What we know and not know*. International Initiative for Impact Evaluation.

Barrett, C.B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. *Journal of Food Policy* 33 (4), 299-317.

Bateman, I.J., Carson, R.T., Day, B., Hanemann, M., Hanley,N., Hett,T., Jones-Lee,M., Loomes, G., Mourato, S.,Özdemiroglu, E., Pearce, D., Sugden, R., & Swanson,J.(2002). *Economic valuation with stated preference techniques*:*A manual*. Edward Elgar.

Bauer, L., & Bushe, D. (2003*). Managing the Modern Farm Business: Designing the Management Strategies*. Edmonton.

Bernard, T., Spielman, D.J., Taffesse, A.S., & Gabre-Madhin, E.Z. (2010). *Cooperatives for Staple Crop Marketing: Evidence from Ethiopia*. International Food Policy Research Institute.

Beyan, A., Jema, H., & Adem, K. (2014). "Effect of Small-scale Irrigation on the Farm Households' Income of Rural Farmers: The Case of Girawa District, East Hararghe, Oromia, Ethiopia. *Asian Journal of Agriculture and Rural Development*, 4(03),1-10.

Bhattamishra, R., & Barrett, C.B. (2008). *Community-based Risk Management Arrangements: An Overview and Implications for Social Fund Programs*. (Working Paper No. 0830).

Bidarali, A.H. (2016). The Role of Off-farm Investments in Risk management of Agricultural households in Bhubaneswar, India. *International Journal of Management and Information Technology*, 3(2),39-45.

Binswanger-Mkhize, H. (2012). Is there too much hype about index-based agricultural insurance? *Journal of Development Studies*, 48(2), 187–200.

Borges, J.A.R., & Machado, J.A.D. (2012). Risk and Risk Management Mechanisms: An Analysis of Perceptions of Producers of Agricultural Commodities. *Interdisciplinary Journal of Research in Business*, 2 (5), 27-39.

Budhathokia, N.K., Lassa, J.A., Pun.S., & Zandera, K.K. (2019), Farmers' interest and willingness-to-pay for index-based crop insurance in the lowlands of Nepal. *Journal of Land Use Policy*, 85(1), 1-10.

Burger, K., Hotel, E.M., Asseldonk, M.V., & Soubeyran, R. (2017). *Impact assessment of risk management tools* [Policy brief]. The Farm Risk Management for Africa.

Bradshaw, J. E. & Ramsay G. (2009). Potato Origin and Production. In: Singh, J. & Kaur L. (eds) *Advances in Potato Chemistry and Technology*. (pp.1-26). Academic Press.

CCAFS (Climate Change, Agriculture and Food security). (2014). *A community-based approach to climate risk management: making insurance work for smallholders in India*. Climate Change, Agriculture and Food security.

Cervantes-Godoy, D., Kimura, S., & Antón, J. (2013, June). *Smallholders' risk Management in Developing Countries* (Working Paper 61).

Chakraborty, A., & Banerjee, H. (2016) Effective Management Strategies against Late Blight disease of Potatoes, *Journal of Agriculture* 14(1),111-117.

Chandhok, G. A. (2009). Insurance; A Tool to Eradicate and a Vehicle to Economic Development. *International Research Journal of Finance and Economics*, (24), 71- 76.

Churchill, C. & Matul, M. (2012). *Protecting the Poor: A micro-insurance compendium*. The Micro-Insurance Network.

Churchill, C. (2006). *What is Insurance for the Poor? Protecting the Poor: A micro-insurance Compendium,*'(Ed). International Labor Organization.

Climate Resilient Agribusiness for Tomorrow (CRAFT). (2019*). Potatoes in Tanzania: Climate Change Risks and Opportunities*. Climate Resilient Agribusiness for Tomorrow.

Cohen, M., & Sebstad, J. (2006). *The importance of understanding the demand for micro insurance. Protecting the poor: A micro-insurance Compendium*. International Labor Organization.

Coker, A.A., & Ninalowo, S.O. (2016). Effect of post-harvest losses on rice farmers' income in Subsaharan Africa: a case of Niger state, Nigeria. *Journal of Agricultural Science and Food Technology*,2 (3),27-34.

Cole, J.B., & Gibson, R. (2010). Analysis and Feasibility of Crop revenue insurance in China. *Agriculture and Agricultural Science Procedia* 1 (2010),136-145.

Cole, S., Gautam, B., Sangita, V., Carina, W., & Stein, D. (2012) '*The effectiveness of index-based micro-insurance in helping smallholders manage weather-related risks.* Social Science Research Unit.

Collier, B., Barnette, B., & Skees, J. (2010*). Data Requirement for the Design of Weather Index Insurance globally. Innovation in Catastrophic Weather Insurance to Improve the Livelihoods of Rural Households*. Forum for Agricultural Risks Management and Development

Cooper, D. R., & Schindler, P. S. (2010). *Business Research Methods*. Sage Publications.

Crimp, D., Gobbett, D., Thomas, S., Bakar, G., Hopwood, U., Nidumolu, P., & Hayman, M. (2013). *Understanding Frost Risk in a Variable and Changing Climate in* Aouthern Australia

Daniel, B. (2015). *Economic Analysis of Irish potato value chain in Njombe urban and Wanging'ombe districts, Tanzania*. (Unpublished Master's thesis). Sokoine University of Agriculture.

Daninga, P.D., & Qiao, Z. (2015). Drought Insurance Pilot Program in Tanzania: an understanding from Cotton Growers Focus Groups. *Journal of Agricultural Economics, Extension and Rural Development*: 3(1), 244-253.

Danso-Abbeam, G., Addai, K.N., & Ehiakpor, D. (2014). Willingness to pay for farm insurance by smallholder cocoa farmers in Ghana. *Journal of Social Science for Policy Implications*, 2(1), 163-183.

David L., Gobbetta U., & Crimp, N.S. (2018). Modelling frost generates insights for managing risk of minimum temperature extremes. *Journal of Weather and climate Extremes.27(3) 1-9.*

DeSarbo, W.S., Hausman, R, E., & Kukitz, J.M. (2007). Restricted principal components analysis for marketing research. *Journal of Modeling in Management*, 2 (3), 305-328.

Dick, W., & Wang, W. (2010*). Government interventions in Agricultural insurance: Agricultural Risk and Food Security*. *Agriculture and Agricultural Science Procedia*, 1, (1), 4-12.

Ellis, E. (2017). Farmers Willingness to Pay for Crop Insurance: Evidence from Eastern Ghana. *International Journal of Agricultural Management and Development*, 7 (4), 447-463.

Ethan, L. (2009). Risk Management in the Cooperative Contract. *American Journal of Agricultural Economics*, 91 (5), 1211–1217.

FAO (Food and Agricultural Organization of the United Nations). (2016). *Agriculture and Food Insecurity Risk Management in Africa; Concepts, lessons learned and review guideline*. United Nations.

FAO (Food and Agricultural Organization of the United Nations). (2015). *Agricultural cooperatives: paving the way for food security and rural development*. United Nations.

FAO (Food and Agricultural Organization of the United Nations). (2007). *Approaches to linking producers to markets*. United Nations.

FAO (Food and Agricultural Organization of the United Nations). (2013*). Farm management extension guide*, MANAGING RISK in farming. United Nations.

Farrin, K., Miranda, M.J., & O'Donoghue, E. (2016). *How Do Time and Money Affect Agricultural Insurance Uptake? A New Approach to Farm Risk Management Analysis*. Department of Agriculture, Economic Research Service.

Feyisa, A., D. (2016). The Role of Agricultural Cooperatives in Risk Management and Impact on Farm Income: Evidence from Southern Ethiopia. *International Journal of Economic Behavior and Organization*; 4(4), 28-39.

Fraga, H., Malheiro, A.C., Moutinho-Pereira, J., & Santos, J.A. (2013). Future scenarios for viticultural zoning in Europe: Ensemble projections and uncertainties. *International Journal of Biometeorol*, 57 (2013), 909-925.

FSDT (Financial Sector Deepening Trust Tanzania). (2013). *Measuring the state of financial services in Tanzania*. Financial Sector Deepening Trust Tanzania.

Ghazanfar, S., Abdullah. A., & Ahmad, J. (2015). Farmers' Willingness to Pay for Crop insurance in Pakistan. *Journal of Business, Economics and Finance*, 4, (2), 166-179.

Guenthner, J.F., MichaeL, K.C., & Nolte, P. (2001). The economic impact of potato late blight on US growers. *Potato Research* 44 (44), 121 - 125

Greg, E., Anam, B.E., William, M.F., & Duru, E.J.C. (2011). Climate change, food security and agricultural productivity in Africa: issues and policy directions. *International Journal of Humanities and Social Science*, 1(21), 205-223.

Groebner, F. D., Shannon, W. P., Fry, C. P., & Smith, D.K. (2011). *Business Statistics: A Decision Making Approach*". Faculty Authored Books.

Hardaker, J. B., Huirne, R. B.M., Anderson, J.R., & Lien, G. (2004). *Coping with Risk in Agricultur*e (2nd ed). CABI Publishing.

Harvey, C.A., Rakotobe, Z.L., Rao, N.S., & Dave, R. (2014). Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philosophical Transactions of the Royal Society of Biological Sciences* 369 (1639), 1-13.

Hazell, P. (1992). The appropriate role of agricultural insurance in developing countries. *Journal of International Development*, 4(6), 567–581.

Tanzania Insurance Regulatory Authority (2016). Development and Implementation of Agricultural Insurance Methodology in Tanzania. [PowerPoint slides]. Tanzania Insurance Regulatory Authority.

IPSARD (Institute for Policy and Strategy for Agriculture and Rural Development). (2009). *Policy vision for Agricultural insurance in Vietnam*. Institute for Policy and Strategy for Agriculture and Rural Development.

Jaffee, S., Siegel, P., & Andrews, C. (2010*). Rapid agricultural supply chain risk assessment: A Conceptual Framework.*Agriskmanagementforum.org.

Jeffrey, R. (1992). *Probability and the Art of Judgment*. Cambridge University Press

Jain, R.C.A. (2004). Challenges in Implementing Agriculture Insurance and Re-insurance in Developing Countries. *The Journal of Insurance and Re-insurance,* 3 (3),14 -23.

Janowicz-lott, M., Lyskawa, K., & Rozumek, P. (2015). Farm Income Insurance as an Alternative for Traditional Crop Insurance. *Proceedia Economics and Finance*,33(2015), 439 – 449.

JesúsAntón, S.K. (2012). *A Comparative study of Risk Management in Agriculture under Climate Change.* Food, Agriculture and Fisheries.

Jwanya, B. A., Dawang, N. C., Zarmai, D. U., & Mashat, I.M. (2014). Economic Analysis of Irrigated Irish Potato Production in Plateau State. *Developing Country Studies*,4 (12), 80-86.

Kabungo C.V.D. (2008). *Evaluation of Irish Potato production and marketing performance in Mbeya rural District, Tanzania* (Unpublished Master's thesis) Sokoine University of Agriculture.

Kachulu, M. (2018). Climate change effects on crop productivity and welfare sensitivity analysis for smallholder farmers in Malawi. *African Journal of Agricultural and Resource Economics*13 (1), 58-77.

Kagona, J.D.Z. (2008). *The incidence of Bacterial wilt (Ralstonia solanacearum) in informal potato planting material used by farmers in Dedza and Ntcheu districts of Malawi* (Unpublished Master's thesis) Norwegian University of Life Sciences.

Kammar, S.K., & Bhagat, R. (2009). Constraints experienced by farmers in adopting risk and uncertainty management strategies in Rain fed agriculture. *PusaAgri Science,* 5 (32),70–74.

Kvale, S. (2007). *Doing interviews. Thousand Oaks*, CA-Sage.

Kerer, J. (2013). *Background paper on the Situation of Agricultural Insurance in Kenya with reference to International Best Practices*. Adaptation to Climate Change and Insurance.

Key, N., Prager, D., & Burns, C. (2017). *Farm income variability: An Analysis Using Panel Data from a National Survey*. Economic Research Service.

Kilimo Trust. (2016). *Calories and Household Incomes from Potatoes Sub-sector (CHIPS) Project*. Kilimo Trust.

Kilimo Trust. (2012). *Sustainable Food Security in the EAC Region: putting the "EAC food security action plan" into practice – Scoping of strategic food commodities*. Kilimo Trust.

Kim, Y., Pendel, D., &Yu, J. (2017, August 17-18). *How Crop Insurance Affects Farm Business Survivability: Case of Kansas Farm Management Association*. [Paper presentation] A Risk and Profit 2017 Conference, Kansas, USA.

Kisaka-Lwayo, M., & Obi, A. (2012). Risk Perceptions and Management Strategies by Smallholder famers in Kwa Zulu-Natal Province, South Africa. *International Journal of Agricultural Management*, 1(3), 28-39.

Kouame, E., & Komenan, A. N. (2012). Risk preference and demand for insurance underprice uncertainty: an experimental approach for cocoa farmers in Côte D'Ivoire. (Working Paper No. 13).

Korir, L. K. (2011*). Risk management among Agricultural households and the Role of OFF-farm investments in Uasin-Gishucounty, Kenya* (Unpublished Master's thesis) Egerton University.

Korir, L.K. (2011). Risks Management among Agricultural Households and the Role of Off-farm Investments in Uasin-Gishu County in Kenya. *Current Journal of Economics Theory*, 3(2), 62-68.

Kwadzo, T-M. G., Kuwornu, J.K.M., & Amadu, I.S.B. (2013). Food Crop Farmers' Willingness to Participate in Market-Based Crop Insurance Scheme: Evidence from Ghana. *Journal of research in Applied Economics*, 5(1), 1-21.

Liesvaara, P., & Myyra, S. (2014). Willingness to pay for agricultural crop insurance in the northern EU. *Agricultural Finance Review*, 74(4), 9-554 ·

Liu, B. (2013). Toward uncertain finance theory. *Journal of Uncertainty Analysis and Applications*, 1(1), 1-15.

Lubungu, M., Chapoto, A., & Tembo, G. (2012, August). *Smallholder Farmers Participation in Livestock Markets: The Case of Zambian Farmers* (Working Paper 66).

Louviere, J.J., Hensher, D.A., & Swait, J.D. (2000). *Stated choice methods: Analysis and Applications*. Cambridge University Press.

Madre, Y., & Devuys, P. (2016). *How to tackle price and income volatility for farmers? An overview of international agricultural policies and instruments, Price volatility in agricultural markets Risk management and other tools.* Briefing European Parliament Research Services.

Maguire, L.A., & Albright, E.D. (2005). Can Behavioral decision theory explain risk-averse fire management decisions*? Journal of Forest Ecology and Management,* 2(11), 47-58.

Mahul, O., & Wright, B. (2003). Designing optimal crop revenue insurance. *American Journal of Agricultural Economics*, 85 (3), 580-589.

Majeed, A. Ahmad, H., Ali, M.A., & Khan, H. (2014). Effect of systemic and contact fungicides on late blight disease and tuber yield of potatoes. *Journal of Agricultural* Technology 10(1),209-217.

Makate, C., Wang, R., Makate, M., & Mango, N. (2016). Crop diversification and livelihoods of smallholder farmers in Zimbabwe. *Adaptive management for environmental change, Springer plus*, 5(1), 1135.

Mamo, E., & Bekele, G. (2017). Households' Willingness to Pay for the Community Based Health Insurance Scheme in Kwiot and Efratana Gedem Districts of Ahmhara Region Ethiopia. *Journal of Business and Economic Research*, 7(2), 212-231.

Manfredo, M.R., & Richards, T.R. (2007). Cooperative risk management, Rationale, and Effectiveness: the case of dairy cooperatives. *Agricultural Finance Review*, 67 (2), 311-339.

Mantecon, J.D. (2007). Potato yield increases due to fungicide treatment in Argentinian early blight (Alternariasolani) and late blight (Phytophthorainfestans) field trials during the 1996-2005 seasons. *Plant Health Progress*, 8 (1),1-7.

Melyukhina, O. (2011). "*Risk Management in Agriculture in the Netherlands*". Food, Agriculture and Fisheries.

Mende, D. H., Mwatawala, M.W., & Kim A. Kayunze, K. A. (2014). Contribution of Potato Production to Household Income in Mbeya and Makete Districts of Tanzania. *Journal of Biology, Agriculture and Healthcare*, 4 (18), 1-10.

Mengistie, D., & Kidane, D. (2016). Assessment of the Impact of Small-Scale Irrigation on Household Livelihood Improvement at Gubalafto District, North Wollo, Ethiopia. *Journal of Agriculture*, 6(27), 1-22.

Mesfin, W. (2014). Crop Mix and Resource use patterns and Risk: The case of smallholder farmers in Eastern Ethiopia. *International Journal of Agriculture and Crop Science*; 7(5), 251-261.

Meuwissen, M.P., Hurine, R.B.M., & Hardakar, J.B. (2001). Risk and Risk management: An Empirical Analysis of Dutch Livestock Farmers. *Journal of Livestock production science*, 69(1),43-53.

Mohan, S. (2007). Market-based price-risk management for Coffee producers. *Journal of Development Policy Review*, 25 (3), 333-354.

Mugenda, O.M., & Mugenda, A.G. (2003). *Research Methods; Quantitative and Qualitative Approaches.* African Centre for Technology Studies.

Munasib, A., & Jordan, J.L. (2011). The Effect of Social Capital on the Choice to Use Sustainable Agricultural Practices. *Journal of Agricultural and Applied Economics* 43(2), 213-227.

Muthoni, J., & Nyamongo, D.O.A. (2009). Review of constraints to Irish potatoes production in Kenya. *Journal of Horticulture*, 1(7), 98–102.

Mpogole, H. Mlambiti, M.E., & Kadigi, R.M.E. (2012). Round potato (Solanum tuberosum) production in southern highlands of Tanzania: Are smallholder farmers becoming commercial? *Journal of Agricultural Extension and Rural Development*, 4(14), 385-391.

Mpogole, H. (2013). *Round potato production in southern highlands of Tanzania; Market preferences, Farmers' variety selection and Profitability* (Unpublished Doctoral dissertation): Sokoine University of Agriculture.

McConnell, C.R., Brue, S.L., & Flynn, S.M. (2009). *Economics: principles, problems, and policies*. McGraw-Hill Education.

Mwambi, M.M., Oduol, J., Mshenga, P., & Saidi, M. (2016). "Does contract farming improve smallholder income? The case of avocado farmers in Kenya", *Journal of Agribusiness in Developing and Emerging Economies*, 6(1), 2-20.

Nahvi, A., Kohansal, M. R., Ghorbani, M., &Shahnoushi, N. (2014). Factors Affecting Rice Farmers to Participate in Agricultural Insurance. *Journal of Applied Science and Agriculture*, 9(4), 1525-1529.

Namwata B.M. L, Lwelamira, J., & Mzirai, O.B. (2010). Adoption of improved agricultural technologies for Irish potatoes (Solanum tuberosum) among farmers in Mbeya Rural district, Tanzania: A case of Ilungu ward. *Journal of Animal and Plant Sciences*, 8, (1), 927- 935.

Nasir, S. (2016). Review on major potato disease and their management in Ethiopia. *International Journal of Horticulture and Floriculture.* 4 (5),239-246.

Nath, T.K., Inoue, M., & Pretty, J. (2010). Formation and function of social capital for forest resource management and the improved livelihoods of indigenous people in Bangladesh. *Journal of Rural and Community Development* 5 (3), 104–122.

NEA (Netherlands Enterprise Agency). (2017). *Seed potatoes in Tanzania*. Netherlands Enterprise Agency.

Nesamvuni, M.E., & Maponya, P. (2015). Adapting to the Impacts of Drought by Smallholder Farmers in Sekhukhune District in Limpopo Province South Africa. *Journal of Agricultural Science*; 7, (2). 115-124.

Nganje, W., Hearne, R., Orth, M., & Gustafson, C. (2004, August 1-2). *Using Choice Experiment to elicit Framers' Preferences for Crop and Health Insurance* [Paper presentation]. Agricultural and Applied Economics Association Annual Meeting 2004, Denver, Colorado.

Ng'elenge, H.S. (2008). *Demand Assessment for Crop Insurance in Tanzania*. (Unpublished Master's thesis) Sokoine University of Agriculture.

Nkere, D.P. N. (2016). *The Effects of Crop Insurance and Financing on Productivity of Wheat Farmers in Narok County*. (Unpublished Master's thesis). University of Nairobi.

Nnadi, F. N., Chikaire, J., Echetama, A.J., Ihenacho, A.R., Umunnakwe, C.P., & Utazi, O.C. (2013). Agricultural insurance: A strategic tool for climate change adaptation in the agricultural sector. *Journal of Agricultural Science*, 1(1), 1-9.

Ntow, W.J. (2008). *The Use and Fate of Pesticides in Vegetable-Based Agroecosystem in Ghana.* (Unpublished Doctoral dissertation). Wageningen University.

Nyunza, G., & Mwakaje, A. (2012). Analysis of Round potato marketing in Tanzania: The case of Rungwe district, Tanzania. *International Journal of Business and Social science,* 3 (23),86-96.

Obalola, T. O., Agboola, B. O., & Odum, E. B. E. (2017). Profitability and Constraints to Irrigated Onion Production in Wamakko and Kware Local Government Areas Sokoto State, Nigeria**.** *Journal of Global Agriculture and Ecology*, 7(3), 106-110.

OECD (Organization for Economics, Co-operation and Development). (2009). *Managing Risk in Agriculture, a Holistic Approach: A Holistic Approach.* Organization for Economics, Co-operation and Development

Okello, J.J., Kwikiriza, N., Kakuhenzire, R., Parker, M, SchulteGeldermann, E., & Pambo, K. (2015, July 26-28). *Micro and Meso-level issues affecting Potato production and marketing in the Tropical highlands of Sub-Saharan Africa: The Known and the Unknowns* [Paper presentation]. The American Applied Economics Association meetings 2015, San Francisco, California, United States of America.

Okonya, J.S., Ocimati, W., Nduwayezu, A., Kantungeko, D., Niko, N., Blomme, G., Legg, J.P., & Kroschel, J. (2019). Farmer Reported Pest and Disease Impacts on Root, Tuber, and Banana Crops and Livelihoods in Rwanda and Burundi. *Journal of Sustainability,*11, (1592),1-20.

Olila, D.O., Nyikal, R., & Otieno, D. (2015, August 8-14). *What Do Farmers Want from Crop Insurance Schemes: A Stated Preference Approach*. [Paper presentation]. International Conference of Agricultural Economist 2015, Milan, Italy.

Oriakhi, H. O., & Onemolease, E. A. (2012). Determinants of Rural Household's Willingness to Participate in Community Based Health Insurance Scheme in Edo State, *Nigeria. Journal of Ethno-Medicines*, 6(2), 95-102.

Osewe, M., Liu, A., & Njagi, T. (2020). Farmer-Led Irrigation and Its Impacts on Smallholder Farmers' Crop Income: Evidence from Southern Tanzania. *International Journal of Environmental Research and Public Health,* 17(5),1-13.

Parmigiani, G., Johns-Hopkins, J., & Lurdes Y. T. (2010). *Decision Theory Principles and Approaches*. John Wiley and Sons.

Pasaribu, S. (2010). Developing Rice from Insurance in Indonesia. *Agriculture and Agricultural Science Procedia*, 1, 33-41.

Raghuvanshi, A., Gauraha, A.K., & Chandrakar, M.R. (2018). Post-harvest losses in potato and factors affecting post-harvest losses at farm level in Chhattisgarh.*Journal of Pharmacognosy and Phytochemistry*; 7(3), 3122-3124.

Rahuta, B.D., & Alib, A. (2017). Coping with climate change and its impact on productivity, income, and poverty: Evidence from the Himalayan region of Pakistan. *International Journal of Disaster Risk Reduction*, 24 (1), 515-525.

Raymundo, R., Asseng, S., Robertson, R., Petsakos, A., Hoogenboom, G., Quiroz, R., Hareau, G., & Wolf, J. (2018). Climate change impact on global potato production. *European Journal of Agronomy*, 100 (1), 87-98.

Sadati, S. A., Ghobadi, F.R., Sadati, S. A., Mohamadi, Y., Sharifi, O., & Asakereh, A. (2010). Survey of Effective Factors on Adoption of Crop Insurance among Farmers. *African Journal of Agricultural Research*, 5(16), 2237-2242.

Sadoulet, E., De Janvry, A., & Benjamin, C. (1996, November*). Households' Behavior with Imperfect Labor Markets* (Working Paper No. 786*).*

Schreinemachers, P., & Tipraqsa, P. (2012). Agricultural pesticides and land use intensification in high, middle and low-income countries. *Journal of Food Policy* 37(6),616–626.

Shaaban, H. and Kisetu, E. (2014). Response of Potato to NPK fertilizer application and its economic return when grown on a Ultisol of Morogoro, Tanzania. *Journal of Agricultural and Crop Research* 2(9), 188-196.

Senkondo, E.M.M. (2000). *Risk Attitude and Risk perception in Agroforestry Decisions in Babati, Tanzania* (Unpublished Doctoral dissertation) Wageningen University.

Sherman, Z. (2010). *Micro-insurance: An effective Risk Management Tool for the Poor?* (Unpublished Bachelor's thesis) University of Puget Sound.

Shumetie, A., & Yismaw, M.A. (2017) "Effect of climate variability on crop income and indigenous adaptation strategies of households", *International Journal of Climate Change Strategies and Management*, 10 (4). 580-595.

Sibiko, W., Veettil, P. C., & Qaim, M. (2018). Small farmers' preferences for weather index insurance: insights from Kenya. *Journal of Agriculture and Food Security*,7 (3), 1-14.

Silici, L. (2016). *The Role of Social Capital in the Adoption and the Performance of Conservation Agriculture*: *The Practice of Likoti in Lesotho*. Food and Agriculture Organization.

Singh, G. (2010). *Crop Insurance in India*. Indian Institute of Management.

SIDA (Swedish International Development Cooperation Agency). (2012). *Review of Core Support under Joint Financial Agreement to Zambia National Farmers Union in Zambia*. Swedish International Development Cooperation Agency.

Sproule, R.S. & Valsan, C. (2009). A simple test for the Violation of Non-stiation axiom under uncertainty: The theory. *Economics Bulletin*, 29(4), 2656-2664.

Sundar, J., & Ramakrishnan, L. (2013). A Study on Farmers' Awareness, Perception and Willing to Join and Pay for Crop Insurance. *International Journal of Business and Management Invention*, 2 (1), 48-54.

Tadesse, B., Bakala, F., & Lamirot W. M. (2018). Assessment of postharvest loss along Potato Value Chain: the case of Sheka Zone, southwest Ethiopia. *Journal of Agriculture and Food security* 7 (18),1-14.

Tanzania National Financial Inclusion Framework. (2018-2022). (2017). *Tanzania at a Glance; Public-Private Stakeholder Initiative* Financial Sector Deepening Trust Tanzania.

Tatwangire, A., & Nabukeera, C. (2017). *Technical report Market and Value Chain Analysis of Ware Potato from Eastern Uganda with a focus on postharvest management practices and losses; Expanding Utilization of Roots, Tubers, and Bananas and Reducing their Postharvest Losses*. The Consultative Group for International Agricultural Research.

Tesfaye, A, B., Lemaga, J. A., & Mwakasendo, Z. (2010). *Markets for fresh and frozen potato chips in the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) region and the potential for regional trade: Ethiopia, Tanzania, Rwanda, Kenya, Burundi and Uganda*. International Potato Center (CIP).

The Actuary Magazine. (2015). Agricultural Insurance: More room to grow? *Society of Actuaries*, 12(2), 36-40.

Torero, M. (2011, January 17-18). *A framework for linking small farmers to markets*. [Paper presentation] International Funds for Agricultural Development (IFAD), conference 2011, Rome, Italy.

Tundui, C., & Macha, R. (2014). Social Capital and Willingness to Pay for Community Based Health Insurance: Empirical Evidence from Rural Tanzania. *Journal of Finance and Economics*, 2(4), 50-67.

Train, K.E. (2003). *Discrete choice methods with Simulation*. Cambridge University Press.

Trang, N.M. (2013). *Willingness to Pay for Area Yield Index Insurance of Rice Farmers in the Mekong Delta, Vietnam* (Unpublished Master's thesis) Wageningen University and Research Center.

Twine, E.E., Omore, A., & Githinji, J. (2017, April 24-26). *Risk and Uncertainty in Milk Production by Smallholders in Tanzania: Implications for Inclusiveness and Investmen*t

[Paper presentation]. Annual Conference of the Agricultural Economics Society 2017, Dublin, Ireland.

Unterschultz, J.R. (2000). Managing market risk in Western Canadian agriculture. *Canadian Journal of Agricultural Economics* 48(4): 527–537.

URT (United Republic of Tanzania). (2013). *Njombe Town Council; Socio-Economic Profile*. The United Republic of Tanzania

USDA (The United States Department of Agriculture). (2018). *Economic Research Service-Farm Income and Wealth Statistics and Risk Management Agency in the United States of America*.

Wairimu, E. W. (2013). *Evaluation of Smallholder Farmers' Response to Kilimo Salama Insurance Scheme and its contribution to Food security in Laikipia-East district, Kenya* (Unpublished Master's thesis) Egerton University.

Wang, E., Yua, Y., Bertis B., Little, B.B., & Zuozhi-Li, Z. (2010). Crop Insurance Premium Design Based on Survival Analysis Model. *The International Conference on Agricultural Risk and Food Security Agriculture and Agricultural Science Procedia*, 67–75pp.

Waweru, C.W. (2017). *Analysis of Risk Attitude and Management Strategies among Dairy farmers in Murang'a County, Kenya* (Unpublished Master's thesis) University of Nairobi.

Whittington, D. (2010). What Have We Learned from 20 Years of Stated Preference Research in Less Developed Countries? *Annual Review of Resource Economics*, 2(1), 209-236.

WHO (World Health Organization of the United Nations). (2012). *How to conduct a discrete choice experiment for health workforce recruitment and retention in remote and rural areas: a user guide with case studies.* World Health Organization, United States.

Wolf, C. (2012). Dairy farmers' use of price risk management tools in the United State of America. *Journal of Dairy Sciences*, 95(7), 4176-4183.

Woolcock, M., & Narayan, D. (2000). Social capital: Implications for development theory, research, and policy. *World Bank Research Observer*, 15(2),225–249.

Xiua, F., Xiu, F., & Bauer, S. (2012). Farmers' Willingness to Pay for Cow Insurance in Shaanxi Province, China. International Conference on Applied Economics (ICOAE). *Procedia Economics and Finance*, 1, 431–440.

Yang, Y., & Wang, Y. (2013). Tail behaviour of the product of two dependent random variables with applications to risk theory. *Journal of Extremes*, 16(1), 55-74.

Zhang, L., Wang, H., Wang, L., & Hsiao, W. (2006). Social capital and farmer's willingness to join a newly established community-based health insurance in rural China. *Journal of Health Policy*, 76(2), 233–242.

Zhao, Y., Chai, Z., Delgado, M.S., & Preckel, P.V. (2016) "An empirical analysis of the effect of crop insurance on farmers' income: Results from Inner Mongolia in China", *China Agricultural Economic Review*, 8(2), 299-313.

APPENDICES

Appendix I: A questionnaire for potato smallholder farmers

ANALYSIS OF REVENUE RISK MANAGEMENT STRATEGIEAMONG POTATO SMALLHOLDER FARMERS IN NJOMBE TOWN COUNCIL; TANZANIA

INTRODUCTION

My name is Semeni Ngozi, a scholar at Egerton University, Kenya. This questionnaire has been evolved to accumulate information for the purpose of designing a collaborative-based revenue scheme with a view of managing production and market risks among potato smallholder farmers.

We would like to assure you that any information you display in this questionnaire will merely be used for this research. In this research, there is no going to be a right or wrong answers. We collect theses data for us to find out your honest opinion on this issue. We would like to request the head of the household to respond to these questions. You may also discuss with other members of your family when responding to questions if you desire. We also request that; you don not discuss the questions with your neighbours or other people who are not part of your family. The data collected from this research will only be used for this study with the utmost confidentiality.

Thank you!

Enumerator:

1. **Before beginning the interview, read the consent form on the last page to the respondent. Sign that they have been read the form, and give them a copy of the information sheet.**
2. **Only the household head should be interviewed, or in his/her absence, the spouse should be interviewed or another adult income earner.**
3. **Instruction: Please fill in the Pre-Interview information at the beginning of the interview**
4. **Please, check-in (Tick) the appropriate box representative the answer given in the spaces provided**
5. **All boxes MUST be filled**

Pre-Interview Information

1. Questionnaire number: _____
2. Name of the interviewer: _____
3. Name of the Supervisor _____
4. Date of the interview _____/_____/_____
5. What time did the interview start: _____

SECTION 1: SOCIO-ECONOMIC CHARACTERISTICS

Enumerator read: This section is designed to help us learn about you and your household.

Please take a few minutes to answer the following questions.

SECTION 1A: HOUSEHOLD CHARACTERISTICS

Q	QUESTION	RESPONSE CODE (CHECK THE APPROPRIATE OPTION)
1	What is the name of the household head?	Name: Phone number:
2	What is the sex of the household head?	1. Male [ ] 2. Female [ ]
3	What is the age of the Household head/respondent?	Age in years [ ]
4	What is the relation of the respondent to the household head?	1. Household head [ ] 2. Spouse [ ] 3. Child [ ] 4. Others (Parents, Siblings, Child in law) [ ]
5	What is your status in this household?	1. Female head of household [ ] 2. The male head of household [ ]
6	What is the educational level of the household head?	1. Informal education [ ] 2. Primary education [ ] 3. O'level secondary [ ] 4. A'level Secondary [ ] 5. College education [ ] 6. University education [ ]
7	Total number of years that you spent schooling	Number of years : [ ]
8	Are you the main income earner in your household?	1. Yes [ ] 2. No [ ]
9	What is main occupation of the respondent /Household head	1. Farmer [ ] 2. Petty trading [ ] 3. Government worker [ ] 4. Employed in private sector [ ]

		5. Big business person [ ] 6. Others [ ] specify_____
10	Household size	Number
11	Do you participate in membership-based groups?	1. Yes [ ] 2. No [ ]
12	Which groups are you a member of	1. Name group 1 _____ 2. Name group 2 _____ 3. Name group 3 4. _____ 5. Name group 4 _____

SECTION 1B: Household Assets and Income

No	**QUESTION**	**RESPONSE CODE (CHECK THE APPROPRIATE OPTION)**
13	How many of these animals do this household own?	1. Milk cows, oxen or bulls [ ] 2. Goats [ ] 3. Sheep [ ] 4. Chickens [ ] 5. Beehives [ ] 6. Donkey [ ] 7. Other(specify) [ ]
14	Does your household have following assets?	
	Functioning radio	1. Yes [ ] 2. No [ ]
	Television	1. Yes [ ] 2. No [ ]
	Bicycle	1. Yes [ ] 2. No [ ]
	Motorcycle	1. Yes [ ] 2. No [ ]
	Car	1. Yes [ ] 2. No [ ]
	Fridge	1. Yes [ ] 2. No [ ]
	Generator	1. Yes [ ] 2. No [ ]
15	What is the total farm size holding of the household in acres?	Land size in acres [ ]

No	QUESTION	RESPONSE CODE (CHECK THE APPROPRIATE OPTION)
16	Land rented in by the household	Land size in acres [ ]
17	Total land allocated for potato production (Own and rented in)	Land size in acres [ ]
18	What is the average annual income of your family?	Annual income in Tshs [ ]
19	How much income of your family comes from potato production per year?	Income from Potato in per cent [ ]

SECTION 1C: Production and Marketing costs for one acre of potato

NO	ACTIVITY	UNITY COSTS (TSH)	TOTAL COSTS (TSH)
	LAND PREPARATION		
20	land clearing		
21	Land ploughing		
22	Harrowing		
	SUB-TOTAL (A)		
	INPUTS		
23	Seed potato		
24	Chemicals –Fungicides (Kg/Packets)		
25	Chemicals – insecticides (L)		
26	Fertilizers –TSP (Basal)		
27	Fertilizer- CAN (Top dressing)		
	SUB-TOTAL (B)		
	LABOURER		
28	Spraying-Fungicides		
29	Spraying-Pesticides		
30	1st Weeding		
31	Ridging		
32	Basal fertilizer application		
33	Topdressing fertilizer application		
	SUB-TOTAL (C)		
	MARKETING COSTS		
34	Harvesting		
35	Transportation		
	SUB-TOTAL (D)		
	GRAND TOTAL= (A+B+C+D)		

36. Give information about potato yield in the past year (2017) **for season one**

Area (acres)	Expect yield (Bags)	Actual yield (Bags)	Expected Price per bag	Actual price per bag	Total expected revenue	Total actual revenue

37. On average, how many 100 Kg Bags are lost from one-acre harvest before sell? (Number of bags) _____

38. Give information about potato yield in the past year (2017) **for season two**

Area (acres)	Expect yield (Bags)	Actual yield (Bags)	Expected Price per bag	Actual price per bag	Total expected revenue	Total actual revenue

39. On average, how many 100 Kg Bags are lost from one-acre harvest before sell? (Number of bags) _____

SECTION 2: SOCIAL CAPITAL QUESTIONS

SECTION 2A: **Questions to assess Horizontal and Vertical 'trust'**

S/N	PERCEPTION STATEMENT	1	2	3	4	5
40	Most famers of this community can be trusted					
41	Most farmers of the rural community would try to take advantage of you to achieve their own goals if they got a chance					
42	Most farmers would return what they pick up to the original owner					
43	Most of your neighbours can be trusted					
44	;Leaders in the village can be trusted					
45	I trust leaders of Lusitu Agribusiness Group					
46	I trust micro-insurance companies					
47	I trust financial institutions					

Codes for the responses

1. = Strongly disagree
2. =Disagree
3. =Undecided
4. =Agree
5. =Strongly agree

SECTION 2B: Questions to assess Reciprocity

S/N	PERCEPTION STATEMENT	1	2	3	4	5
48	People in the village are concerned about issues that not only relate to themselves but also relate to others					
49	Villagers will provide help if someone really needs it					
50	I will lend money to your neighbour if they need it to see a doctor					
51	If your village was a large family, you would be a member of this family					
52	I would like to support a project that might not benefit you most but benefit other villagers					

Codes for the responses

1. = Strongly disagree
2. =Disagree
3. =Undecided
4. =Agree
5. =Strongly agree

SECTION 3: PERCEIVED EFFECT OF THE SELECTED PRODUCTION AND MARKETING RISK ON POTATO REVENUE AMONG SMALLHOLDER FARMERS

SECTION 3A: Likelihood occurrence of selected Production and Market risk on Potato enterprise

S/N	PERCEPTION STATEMENT	1	2	3	4	5
53	How likely may frost/cold weather affect your potato farm/revenue?					
54	How likely is low rainfall that may affect your potato farm/revenue?					
55	How likely is too much rainfall that may affect your potato farm/revenue?					
56	How likely is Bacterial wilt disease that may affect your potato farm/revenue?					
57	How likely may Late blight disease affect your potato farm/revenue?					
58	How likely is potato price fluctuation that may affect your potato farm/revenue?					
59	How likely is potato post-harvest losses due to the use of hand hoe in harvesting potatoes may affect your potato yield /revenue?					

Codes for the responses

1. =Very unlikely
2. =Unlikely
3. =Average
4. =Likely
5. =Very likely

SECTION 3B: Perceived affect levels of the selected Production and Market risk on-farm potato revenue

S/N	PERCEPTION STATEMENT	1	2	3	4	5
60	What is the effect of frost damage on your potato income?					
61	What is the effect of low rainfall/drought damage on your potato income?					
62	What is the effect of too much rainfall damage on your potato income?					
63	What is the effect of Bacterial wilt disease damage on your potato income?					
64	What is the effect of Late blight disease damage on your potato income?					
65	What is the effect of potato price volatility on your potato income?					

Codes for the responses

1. =Very Low
2. = Low
3. = Average
4. = High
5. = Very high

SECTION 4: RISK MANAGEMENT STRATEGIES AND THEIR EFFECTS ON MANAGING POTATO REVENUE RISKS AMONG SMALLHOLDER FARMERS

SECTION4A: Importance of managing Production and Market risks

S/N	PERCEPTION STATEMENT	1	2	3	4	5
66	How significant is it for you to prevent or reduce the adverse effects of the **frost/cold weather** causing damage to potato production and revenue					
67	How important is it for you to prevent or reduce the adverse effects of the **low rainfall** causing damage to potato production and revenue?					
68	How important is it for you to prevent or reduce the adverse effects of **too much rainfall** causing damage to potato production and revenue?					
69	How important is it for you to prevent or reduce the adverse effects of the **Bacterial wilt disease** causing damage to potato production and revenue?					
70	How important is it for you to prevent or reduce the adverse effects of the **Late blight disease** causing damage to potato production?					
71	How important is it for you to prevent or reduce the adverse effects of the **potato price volatility** on potato revenue					
72	How important is it for you to prevent or reduce the adverse effects of the **potato post-harvest losses** on potato revenue					

Codes for the responses

1. =Not important at all
2. =Little importance
3. =Average
4. =Somewhat important
5. =Very important

SECTION4B: Smallholder farmer's own Ability to manage Production and Market risks

S/N	PERCEPTION STATEMENT	1	2	3	4	5
73	How do you evaluate your ability to protect yourself from **low rainfall** causing damage to potato production and revenue?					
74	How do you evaluate your ability to protect yourself from **too much rainfall** causing damage to potato production and revenues?					
75	How do you evaluate your ability to protect yourself from **Bacterial wilt** disease causing damage to potato production and revenues?					
76	How do you evaluate your ability to protect yourself from **Late blight** disease causing damage to potato production and revenues?					
77	How do you evaluate your ability to protect yourself from **potato price volatility** causing a reduction in potato revenue?					
78	How do you evaluate your own ability to protect yourself from **potato post-harvest losses** causing a reduction in potato revenue?					

Codes for the responses

1. =I cannot protect myself at all
2. =I can somewhat protect myself
3. = Neutral
4. = I can protect myself well
5. = can protect myself very well

SECTION 4C: Risk management strategies used by smallholder farmers on managing Potato revenue risks

79. What risk management strategies do you use to manage frost/cold weather on your potato farm? Kindly mention them

1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

80. How frequently do you employ these risk management strategies mentioned above? Number of Times----------

1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

81. What risk management strategies do you employ to manage **low rainfall/drought** causing damage on your potato farm? Kindly **mention** them
1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

82. How frequently do you employ these risk management strategies mentioned above? Number of Times----------
1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

83. What risk management strategies do you employ to manage **too much rainfall** causing damage on your potato farm? Kindly **mention** them
1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

84.How frequently do you employ these risk management strategies mentioned above? Number of Times----------
1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

85. What risk management strategies do you employ to manage **Bacterial wilt disease** causing damage on your potato farm? Kindly **mention** them
1. ----------
2. ----------

3. ----------
4.----------
5. ----------

86. How frequently do you employ these risk management strategies mentioned above? Number of Times----------

1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

87. What risk management strategies do you employ to manage **Late blight disease**-causing damage on your potato farm? Kindly **mention** them
1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

88. How frequently do you employ these risk management strategies mentioned above? Number of Times----------

1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

89. What risk management strategies do you employ to manage **potato price volatility** causing loss on your potato revenue? Kindly mention them
1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

90. How frequently do you employ these risk management strategies mentioned above? Number of Times----------
1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

91. What risk management strategies do you employ to manage **potato post-harvest losses** causing loss on your potato revenue? Kindly mention them

1. ----------
2. ----------
3. ----------
4. ----------
5. ----------

92. How frequently do you employ these risk management strategies mentioned above? Number of Times----------

1= Sometimes [ ]
2=Often [ ]
3=Always [ ]

Commonly risk management strategies used by smallholder farmers

a. Buy agricultural insurance
b. Obtaining marketing information
c. Sign the interlinked contract with local potato procession company
d. Marketing contracts
e. Production contracts
f. Use of crop rotation
g. Use of pesticides and Fungicides
h. Crop diversification
i. Enterprise diversification
j. Use of Irrigation system
k. Seeking support from relatives, friends and neighbours
l. Use of lean seed potatoes per acre
m. Use of positive seed potato selection
n. Immediate sale of potatoes after harvest
o. Sorting and grading potatoes
p. Potato deholming process
q. Leaving potatoes in the soil

SECTION 3C: Cost incurred by potato smallholder farmers in employing the self-insurance strategies

No	Risks Management strategy	The average cost of RM strategy	Tshs
93	Frost		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	
94	Low rainfall/drought		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	
95	Bacterial wilt		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	
96	Too much rainfall		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	
97	Late blight		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	
98	Potato price volatility		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	

No	Risks Management strategy	The average cost of RM strategy	Tshs
99	Potato post-harvest losses		
A		Average costs per acre in a season	
B		Average costs per acre in a season	
C		Average costs per acre in a season	
D		Average costs per acre in a season	
E		Average costs per acre in a season	

SECTION 4D: **Effectiveness of various risks management strategies used by smallholder farmers on managing potato revenue risks**

No	Perception Statement	1	2	3	4	5
100	Risk management strategies I use to manage frost on my potato farm are effective					
101	Risk management strategies I use to manage extreme drought frost on my potato farm are effective					
102	Risk management strategies I use to manage the effect of too much rains frost on my potato farm is effective					
103	Risk management strategies I use to manage bacterial wilt on my potato farm is effective					
104	Risk management strategies I use to manage late blight disease on my potato farm is effective					
105	Risk management strategies I use to manage potato price volatility are effective					
106	Risks management strategies I use to manage post-harvest losses on my potato farm is effective					

Codes for the responses

1. = Strongly disagree
2. =Disagree
3. =Undecided
4. =Agree
5. =Strongly agree

SECTION5: DISCRETE CHOICE EXPERIMENT SCENARIOS FOR CoBRIS

SECTION 5A: Scenarios of CoBRIS contract attributes

107. Now we would like to know your willingness to participate and pay for the designed CoBRIS contracts.

DCE scenarios of CoBRIS contract to be presented to a respondent

Attributes	Risk covered	Premium amount	Coverage level	Contract content	Which contract do you prefer?
Contract A	Low rainfall, Frosts, Excess rainfall and Diseases	10,000	85% Medium	Potato yield	Contract A [ ]
Contract B	Low rainfall, Frosts, Excess rainfall, Diseases and Post-harvest losses	15,000	90% High	Potato yield	Contract B [ ]
Contract C	Low rainfall, Frosts, Excess rainfall, Diseases and Price volatility	12,000	80% Low	Potato revenue	Contract C [ ]
Contract D	Low rainfall/drought, Frosts, Excess rainfall, Diseases and Post-harvest losses	10,000	85% Medium	Potato yield	Contract D [ ]
NONE					None of them [ ]

108. If contract A, B, C or D is chosen, kindly ask the respondent why they would like to participate in the selected contract?

1. Improve potato revenue [ ]
2. Food security [ ]
3. Improve household income [ ]
4. Improve access to credit access from financial institutions [ ]
5. To help other farmers [ ]

109. If none of the contracts is chosen, kindly ask the respondent why they do not like participating in the CoBRIS contract?

1. No seller is available [ ]
2. I don't have enough information and am still in doubt [ ]
3. I don't understand insurance works [ ]
4. I don't trust insurance companies [ ]
5. I don't trust the management of Lusitu Agribusiness Group [ ]
6. The premium is too high [ ]
7. I don't think the production and market risks covered in the scheme affects my potato income [ ]
8. Scopes of production and market risks covered by the scheme is limited [ ]
9. I cope with everything on my own [ ]
10. I'm afraid of bureaucracy [ ]

Time the interview ends: _____

THANK YOU

Appendix II: Key informant interview

Interview Schedule for companies, agencies and personnel dealing with agriculture insurance in Tanzania

Date: ----------

Introduction

1. Thank you for agreeing to do this interview. My name is Semeni Ngozi, a student at Egerton University. This questionnaire has been developed to gather data for the purpose of analyzing various crop-revenue insurance products that exist in Tanzania. Today's purpose of this interview is to learn more about the products you offer to the market, your customers, and your experiences with agricultural insurance services in Tanzania. You are among the key informants who have been selected for the study

2. . We would like to assure you that anything you display on this questionnaire will simplest be used for this research. There is not any right or incorrect answer to the questions. We handiest want to get your sincere opinion on the issues at hand. We request that the head of the department participate in this key informant interview. However, you are at liberty to seek to consult from other workers of your company whilst answering the questionnaire in case you would wish to do so. Data accumulated will only be used for this study. The data will be treated with maximum confidentiality.

3. The interview will last about 1 hour.

4. (Start at _____ End at _____)

Section 1: Analyzing various crop-revenue insurance products exist for smallholder farmers in Tanzania

Section 1A: Background information on a crop-revenue insurance provider, market served, product and its performance

S/N	Information required	Response
1	Name of the participant	
2	Gender of the participant	
3	Age of the participant	
4	Phone number of the participant	
5	Program name	
6	The year the company started offering crop-revenue products	
7	Which agricultural insurance products do you offer to smallholder farmers? Product portfolios	
8	Name of the Organization	
9	Countries of operations	
10	Region of operations	
11	Area covered (Districts, villages)	
12	The risks covered among smallholder farmers(diseases, drought, excess rains, prices, post-harvest losses	
13	Contract structure (area based/individual base/weather index)	
14	How does your company participate in agricultural insurance? Providing insurance services, creating awareness to smallholder farmers /capacity building/ financing/, Other (please specify)	
15	What essential role is your company play in creating awareness and publicity of agricultural insurance?	

16	**Product maturity level (low, medium, high)** Low: Involves agricultural insurance product with less than 1-2 years of practice or pilot stage The agricultural insurance product is undeveloped, operational process unsteady, and vague long term potential of the product Medium-The product has a minimum of two years' experience in the market. It has further gone through one product review cycle, the operational process is beginning to stabilize, has low-moderate long term potential High –The agricultural insurance product has greater than three years. It has also gone through at least two product review cycles, the product a stable operational process , the product is maturing and delivering and has a good long term potential to grow in the market	
17	Short description about the program, product and key distribution channels of those products	
18	**Targeted markets** Who are the target markets for your agricultural insurance products (potato smallholder farmers, maize smallholder farmers)? **Hints**: The enumerator need to capture key features of the target group such as income, location, gender, economic activity among other variables Discourse if the program is open to all or just smallholder farmers who are members of organized groups	
19	Premium per hectare insured	
20	Number of smallholder farmers insured per year	

Section 1B: PACET Framework for conducting PACET analysis

The PACE is a client value evaluation tool that aims at the value-added for clients from the agricultural insurance products through comparing the products to other insurance products. Customer value in the context of PACE is intending at reducing vulnerability among the customers through the improved risk management practices that ultimately lead to the improvement of the customers'' welfare. In this tool, value is created when customers use agricultural insurance products and are satisfied enough to renew their policies. Specifically, the PACE tool looks at four aspects of agricultural insurance products: product design, access, costs, and experience, hence the abbreviation PACE. The tool generally aims to identify the strengths, weaknesses and chances to increase customers value proposition of agricultural insurance products.

21. PACE scoring criteria and sub-dimension weights

I. PRODUCT DESIGN ASPECT

a. Coverage, quality of service, exclusions and waiting periods

	Statement	**1**	**2**	**3**	**4**	**5**
1	The product covers appropriate risks from a customer's perspective					
2	The product assimilates appropriate riders (requirements) to the main cover					
3	The product offers modest insurance cover without many eliminations					
4	The product provides limited waiting period for the customers					

1=Poor
2=below average
3=Average
4= above average
5= Strong

b. Sum insured concerning cost of risk

	Statement	**1**	**2**	**3**	**4**	**5**
1	The product pays out the adequate amount concerning cost of risk insured					
2	The product does not have many sub-limits on a particular covers					

1=Poor
2=below average
3=Average
4= above average
5= Strong

c. Eligibility criteria

	Statement	1	2	3	4	5
1	Is the program inclusive or does not exclude groups of people					

1=Poor
2=below average
3=Normal
4= above average
5= Strong

d. Value-added services

	Statement	1	2	3	4	5
1	The products offers non-insurance benefits such as access to credit, better inputs					
2	The product offers value-added agriculture services, e.g. processing crops, post-harvest handling					
3	The products triggers positive behaviour changes					
4	The product has some linkages to basic social security, e.g. health services, band any potential externalities					

1=Poor
2=below average
3=Normal
4= above average
5= Strong

II. ACCESS

a. Choice and enrolment

	Statement	1	2	3	4	5
1	The product is voluntary					
2	The product provides wides choices in benefit levels or additional riders					
3	The product provides options for farmers to opt-out					
4	The product has simple enrolment process					
5	The product does not need a number of documents					
6	The product provides enrolment inconvenient times					
7	The product has an efficient way to remind clients to renew policies					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

b. Information and understanding about complexity

	Statement	1	2	3	4	5
1	The product provides clear information about the product, associated benefits and limitations					
2	The product provide clients with Swahili based brochures and leaflets					
3	The organization has an effective channel to update the information					
4	The product checks if customers clearly understand the product					
5	The organization train customers on broader agricultural insurance matters					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

c. Premium payment method

	Statement	**1**	**2**	**3**	**4**	**5**
1	The company makes it possible for the customer to make payment in small instalments					
2	The organization normally offers premium funding options at an affordable price					
3	The company offers premium subsidisations					
4	The company offers an option to deduct payments automatically					
5	The organization proposes a way to pay from savings accounts					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

d. Proximity

	Statement	**1**	**2**	**3**	**4**	**5**
1	The organization offers a close point of sales					
2	It does not require frequent travel to the point of sale					
3	The organization offers a close network of agricultural insurance agents					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

III. **COST**

a. Premium concerning benefit

	Statement	**1**	**2**	**3**	**4**	**5**
1	The product offers good value for money coverage					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

b. Premium in relation to client income

	Statement	**1**	**2**	**3**	**4**	**5**
1	Less than 2 percent of the client income as it calculated as a ratio of the monthly premium divided by average monthly household income					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

c. Other costs

	Statement	**1**	**2**	**3**	**4**	**5**
1	The product limits travel costs					
2	The product reduces opportunity costs					
3	The product confines co-payments					
4	The company does not charge any extra charges					

1=Poor
2=below average
3=Average
4= above average
5= Strong

d. Cost structure and controls

	Statement	1	2	3	4	5
1	Prices fairly					
2	The claim ratio of product has claims ratio in a range of ranges from 40 percent to 90 percent					
3	The organization has strong cost control system in place					
4	The organization has a mechanisms in place for managing t deception, adverse selection and moral hazard among customer					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

IV. **EXPERIENCE**

a. Claim processing procedures

	Statement	1	2	3	4	5
1	The company has modest claims processing procedures					
2	The company needs a limited documents to process a claim					
3	The organization offers cashless access to agricultural insurance services with a clear approval procedures					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

b. Claim processing time and service quality

	Statement	1	2	3	4	5
1	The organization does not reject claims					
2	The organization offers a quick claim payments in a less than seven days					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

c. Policy administration and tangibility

	Statement	**1**	**2**	**3**	**4**	**5**
1	The company issues guidelines on the spot or within 2 weeks					
2	The organization offers a clear policy documentation					
3	The organization offers a physical agricultural insurance card					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

d. Customer care

	Statement	**1**	**2**	**3**	**4**	**5**
1	The company has in place a procedures to collect feedback from customers					
2	The company has a clear first contact information					
3	The organization offers an easy access to the call centre					
	The product is offered by capable insurance agents					
	The company has a customer Relation Administration System in place					
	The company presents gratuities to loyal customers					
	The company has an organised system for building customers' trust					
	The company has a clear complaint procedures in place					

1=Poor
2=below normal
3=Normal
4= above normal
5= Strong

Section 1C: Importance of crop revenue insurance attributes for the development of CoBRIS scenarios

22. Perception of CoBRIS' attributes

S/N	Attribute	PERCEPTION STATEMENT	SD	D	UD	A	SA
1	Impact of risk (High, Medium or low)	The level of impact of risk on potato yield/ income is an essential factor to be considered when developing CoBRIS					
2	Management structure (Insurance agents, Management by external NGO, management by community committee, collaboratively)	The management structure is an essential factor to be considered when developing CoBRIS					
3	Premium (Cost of CoBRIS contract per acre)	Premium is an essential factor to be considered when developing CoBRIS					
4	Indemnity (Expected payment in the case of yield loss, revenue loss)	Indemnity is an essential factor to be considered when developing CoBRIS					
5	Transparency (How easily explained and understood the products is)	Transparency is an essential factor to be considered when developing CoBRIS					
6	Risk covered (Low rainfall, Excess rains, pests and disease, potato price and post-harvest losses)	Different type of risk covered is an essential factor to be considered when developing CoBRIS					
7	Coverage level (Level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS	Coverage level is an essential factor to be considered when developing CoBRIS					

S/N	Attribute	PERCEPTION STATEMENT	SD	D	UD	A	SA
	contract. Indemnity amount will be paid for any revenue realization that is below the coverage level)						
8	Contract content (Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses)	Contract content is an essential factor to be considered when developing CoBRIS					

Codes for the responses

6. SD= Strongly disagree
7. D=Disagree
8. UD=Undecided
9. A=Agree
10. SA=Strongly agree

23. Ranking of CoBRIS attributes according to its importance to your company and clients (1-5)

S/N	Attribute	Description	Rank
1	Impact of risk	Whether the impact of production and marketing risk on-farm revenue is High, Medium or low	
2	Management structure	(Insurance agents, Management by external NGO, management by community committee, collaboratively)	
3	Premium	Premium (Cost of CoBRIS contract per acre)	
4	Indemnity	Expected payment in the case of yield loss, revenue loss	
5	Transparency	How easily explained and understood the products is	
6	Risk covered	Include risks such as Low rainfall, Excess rains, pests and disease, potato price and post-harvest losses	
7	Coverage Level	Percentage level purchased as a percentage of the total yield, revenue per acre covered by CoBRIS contract.	
8	Contract content	Whether the contract is for Potato Yield only, Yield-Potato price or Yield-Post-harvest losses)	

1=Very significant
2= Significant
3= moderately important
4= slightly significant
5= Not significant

Thanks for your time and cooperation

<u>Appendix III</u>: Candidate's publications related to this study

Boosting Potato Enterprise Performance among Smallholder Farmers in Tanzania through Risks Management

Semeni Ngozi[1, 2], Patience Mshenga[1], Isaac Maina Kariuki[1], Aloyce Shaban Hepelwa[2]

[1]Department of Agricultural Economics and Agribusiness Management, Faculty of Agriculture, Egerton University, Egerton Njoro, Kenya

[2]Department of Agricultural Economics and Business, College of Agricultural Sciences and Food Technologies, University of Dar Es Salaam, Dar es Salaam, Tanzania

ABSTRACT

Smallholder potato farmers in Tanzania use different on-farm risk management strategies to boost potato enterprise performance. However, knowledge on how on-farm risk management strategies boost potato enterprise performance remains undocumented and scarce. Therefore, this study uses cross-sectional data collected from 384 potato smallholder farmers in 2019, to first identify various on-farm risk management strategies and then to determine the effect of risk management strategies on potato enterprise performance. Data is analysed by use of content analysis and descriptive statistics. Further, a multiple regression model is used to determine the effect of risk management strategies' attributes on potato enterprise performance. The findings of content analysis and descriptive statistics indicate that potato smallholder farmers use various strategies to boost potato enterprise performance. The strategies include application of chemicals, irrigation, furrowing, increased frequency of fungicide application, field sanitation practices, searching for markets, transporting potatoes direct to the markets, use of market information and delaying harvesting of potatoes by leaving them in the soil. Empirical results from multiple regression model reveal that, frequent use, perceived effectiveness, costs and the number of on-farm risk management strategies boost potato enterprise performance in Tanzania. The findings of this paper have several policy implications. First, more and effective risk management strategies such as the use of irrigation system, fungicides, accessing marketing information should be employed to boost potato enterprise performance in Tanzania. Second, since, the cost of risk management strategies had improved potato enterprise performance among smallholder farmers in Tanzania. However, the cost of employing risk management strategies is higher than the benefit potato smallholders get as a result of the strategies employed. The high costs had resulted from employing risk management strategies such as the purchase of irrigation systems during low rainfall and frost bites. Hence, potato smallholder farmers through public-private partnerships between Lusitu Agribusiness Group and Tanzania Agricultural Development Bank (TADB) should establish a village hiring irrigation to dramatically reduce the costs associated with risk management strategies such as irrigation.

How to cite this paper: Semeni Ngozi | Patience Mshenga | Isaac Maina Kariuki | Aloyce Shaban Hepelwa "Boosting Potato Enterprise Performance among Smallholder Farmers in Tanzania through Risks Management" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-1, December 2020, pp.1557-1565, URL: www.ijtsrd.com/papers/ijtsrd38189.pdf

IJTSRD38189

Potential Implications of Production and Market Risks on Potato Farming Enterprise among Smallholder Farmers in Tanzania

Semeni Ngozi[1,2], Patience Mshenga[1], Isaac Maina Kariuki[1]

[1]Department of Agricultural Economics and Agribusiness Management, Faculty of Agriculture, Egerton University, Egerton Njoro, Kenya

[2]Department of Agricultural Economics and Business, College of Agricultural Sciences and Food Technologies, University of Dar es Salaam, Dar es Salaam, Tanzania

ABSTRACT

Despite the risks that potato smallholder farmers face that are thought to affect the profitability and viability of the enterprise, little is known on the implications of the production and market risks on potato farming enterprise in Tanzania. Therefore, this study aims at determining the effects of production and market risks on potato farming enterprise among smallholder farmers in the study area. Therefore, this study uses cross-sectional data collected from 384 potato smallholder farmers in 2019, to first the likelihood of the selected production and market risks affect potato farming enterprise and how they affect the potato farm income among smallholder farmers. Data is analysed by use of descriptive statistics and, a multiple regression model is used to determine the effect of the selected production and market risks on potato farming enterprise. Empirical results from multiple regression model reveal that, climate risks (low rainfall and frost bite) and market risks (price volatility) have a positive and significant effect on potato farming enterprise among smallholder farmers in Tanzania. The findings of this paper have several policy implications. First, potato smallholder farmers to invest/ hire irrigation facilities especially during low rainfall and frost bites incidences so that they able to take advantages of the low supply of potato in the market hence fetching higher potato market prices. Second, potato smallholder farmers to observe price movement which follows a pattern of being high before the harvest, dropping at harvest time and rising again towards the end of the season. This information, could help potato smallholder farmers to plan when to plant and harvest potatoes and be able to have potatoes ready to sell when prices are good. Third, the government should come up with policies that help potato smallholder farmers to develop resilience mechanisms to manage potato price volatility. The polices should focus on developing Information Communications Technologies (ICT) related platforms such as (M-Kilimo) with the

How to cite this paper: Semeni Ngozi | Patience Mshenga | Isaac Maina Kariuki "Potential Implications of Production and Market Risks on Potato Farming Enterprise among Smallholder Farmers in Tanzania" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-6, October 2021, pp.494-504, URL: www.ijtsrd.com/papers/ijtsrd46378.pdf

IJTSRD46378

Appendix IV: Key Data Analysis Outputs

LogAVEAPOTREVENUE	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
LogTOTALFREQSTRA	.6684901	.25431	2.63	0.009	.1684025	1.168578
LogTOTALNUSTRATEGIES	.0410775	.2382633	0.17	0.863	-.4274552	.5096102
logTOTALAVECOSTSRISK	.2450501	1.622006	0.15	0.880	-2.944542	3.434642
Logeffectiveness	-3.07587	20.33268	-0.15	0.880	-43.05905	36.90731
logTOTALAVECOSTSRISK	0	(omitted)				
_cons	6.115059	6.145252	1.00	0.320	-5.969264	18.19938

Case ID variable: id — Number of cases = 197

Alternatives variable: CoBRISchoice — Alts per case: min = 4, avg = 4.0, max = 4

Wald chi2(12) = 24.48

Log likelihood = -219.25091 — Prob > chi2 = 0.0175

WTPYESNO	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
CoBRISchoice						
logprem1	-.3809221	1.909274	-0.20	0.842	-4.12303	3.361186
CoBRIScoveragelevel	.0108408	.0216369	0.50	0.616	-.0315667	.0532482
CoBRISIndemnity	.0099055	.0141729	0.70	0.485	-.0178729	.0376838
A	(base alternative)					
B						
PotPostharvestloss2	.0082337	.0424175	0.19	0.846	-.0749031	.0913705
Horizontatrust	.0523695	.0679445	0.77	0.441	-.0807993	.1855384
Verticaltrust	-.0136972	.1368704	-0.10	0.920	-.2819582	.2545638
_cons	-.9519016	1.497858	-0.64	0.525	-3.887649	1.983846
C						
PotPostharvestloss2	-.0338042	.0405844	-0.83	0.405	-.1133481	.0457396
Horizontatrust	.1051215	.0637352	1.65	0.099	-.0197972	.2300401
Verticaltrust	.0669608	.1297497	0.52	0.606	-.187344	.3212655
_cons	-1.934031	1.455352	-1.33	0.184	-4.786469	.9184071
D						
PotPostharvestloss2	-.0536814	.0743089	-0.72	0.470	-.1993241	.0919613
Horizontatrust	.1787285	.0949937	1.88	0.060	-.0074558	.3649128
Verticaltrust	-.5669118	.1773509	-3.20	0.001	-.9145131	-.2193105
_cons	-.7812037	2.02719	-0.39	0.700	-4.754422	3.192015

```
Iteration 0:   log likelihood = -226.04686
Iteration 1:   log likelihood = -219.31123
Iteration 2:   log likelihood = -219.25096
Iteration 3:   log likelihood = -219.25091
Iteration 4:   log likelihood = -219.25091

Conditional logit choice model                  Number of obs      =         788
Case ID variable: id                            Number of cases    =         197

Alternatives variable: CoBRISchoice             Alts per case: min =           4
                                                               avg =         4.0
                                                               max =           4

                                                   Wald chi2(12)   =       24.48
Log likelihood = -219.25091                        Prob > chi2     =      0.0175
```

WTPYESNO	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
CoBRISchoice						
logprem1	-.3809221	1.909274	-0.20	0.842	-4.12303	3.361186
CoBRIScoveragelevel	.0108408	.0216369	0.50	0.616	-.0315667	.0532482
CoBRISIndemnity	.0099055	.0141729	0.70	0.485	-.0178729	.0376838
A						
PotPostharvestloss2	.0338042	.0405844	0.83	0.405	-.0457396	.1133481
Horizontatrust	-.1051215	.0637352	-1.65	0.099	-.2300401	.0197972
Verticaltrust	-.0669608	.1297497	-0.52	0.606	-.3212655	.187344
_cons	1.934031	1.455352	1.33	0.184	-.9184071	4.786469
B						
PotPostharvestloss2	.0420379	.0326029	1.29	0.197	-.0218625	.1059384
Horizontatrust	-.0527519	.053359	-0.99	0.323	-.1573337	.0518298
Verticaltrust	-.080658	.1075629	-0.75	0.453	-.2914774	.1301614
_cons	.9821295	1.192892	0.82	0.410	-1.355897	3.320155
C	(base alternative)					
D						
PotPostharvestloss2	-.0198772	.0690683	-0.29	0.774	-.1552486	.1154942
Horizontatrust	.073607	.0861191	0.85	0.393	-.0951832	.2423973
Verticaltrust	-.6338726	.1555381	-4.08	0.000	-.9387216	-.3290236
_cons	1.152827	1.940175	0.59	0.552	-2.649847	4.955502

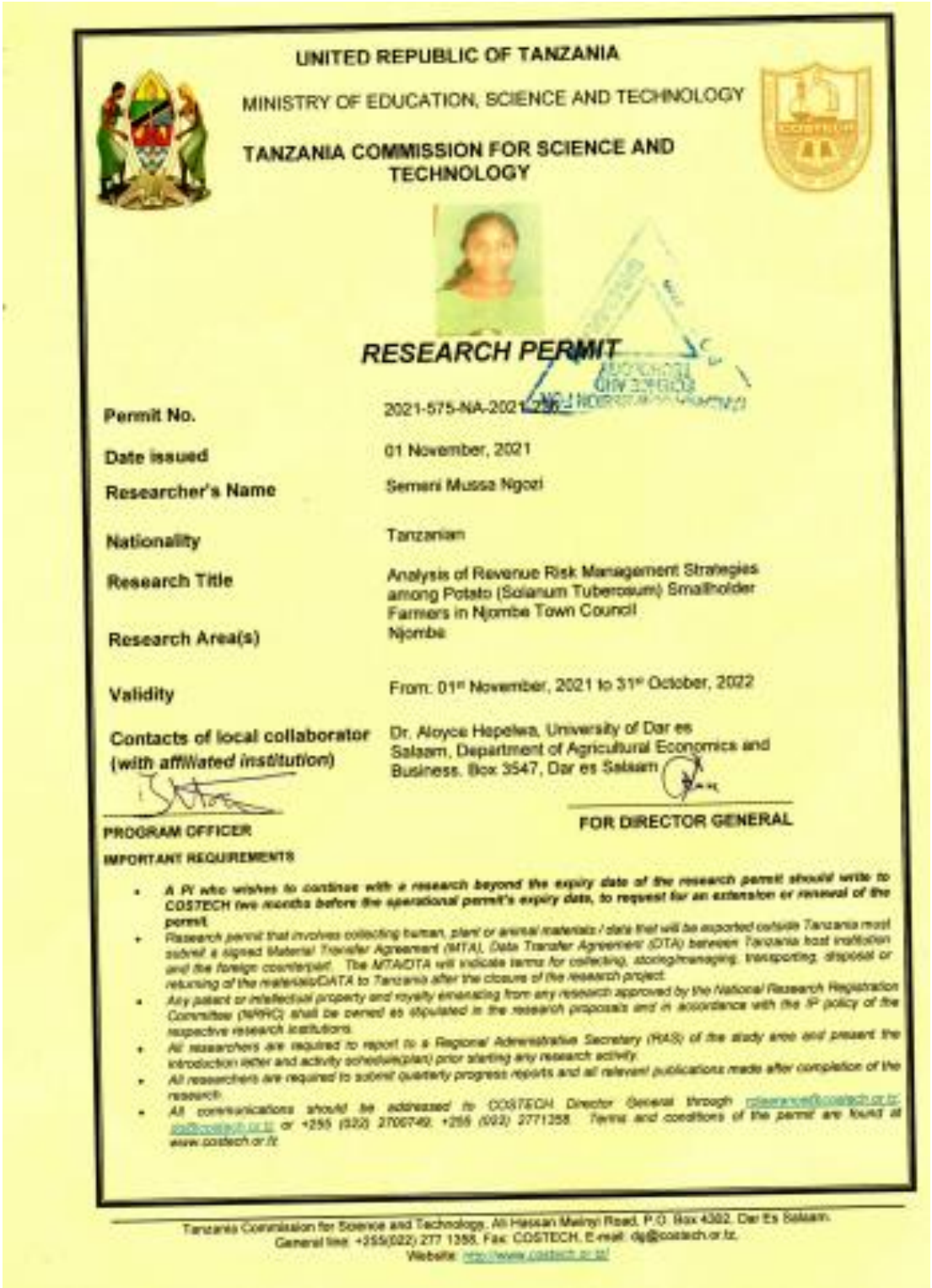
Conditional logit choice model — Number of obs = 788
Case ID variable: id — Number of cases = 197

Alternatives variable: CoBRISchoice — Alts per case: min = 4
avg = 4.0
max = 4

Wald chi2(12) = 24.48
Log likelihood = -219.25091 — Prob > chi2 = 0.0175

WTPYESNO	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
CoBRISchoice						
logprem1	-.3809221	1.909274	-0.20	0.842	-4.12303	3.361186
CoBRIScoveragelevel	.0108408	.0216369	0.50	0.616	-.0315667	.0532482
CoBRISIndemnity	.0099055	.0141729	0.70	0.485	-.0178729	.0376838
A						
PotPostharvestloss2	-.0082337	.0424175	-0.19	0.846	-.0913705	.0749031
Horizontatrust	-.0523695	.0679445	-0.77	0.441	-.1855384	.0807993
Verticaltrust	.0136972	.1368704	0.10	0.920	-.2545638	.2819582
_cons	.9519016	1.497858	0.64	0.525	-1.983846	3.887649
B	(base alternative)					
C						
PotPostharvestloss2	-.0420379	.0326029	-1.29	0.197	-.1059384	.0218625
Horizontatrust	.0527519	.053359	0.99	0.323	-.0518298	.1573337
Verticaltrust	.080658	.1075629	0.75	0.453	-.1301614	.2914774
_cons	-.9821295	1.192892	-0.82	0.410	-3.320155	1.355897
D						
PotPostharvestloss2	-.0619151	.0702944	-0.88	0.378	-.1996896	.0758594
Horizontatrust	.126359	.0889359	1.42	0.155	-.0479521	.3006701
Verticaltrust	-.5532146	.1618628	-3.42	0.001	-.8704598	-.2359693
_cons	.1706979	1.964297	0.09	0.931	-3.679253	4.020649

Appendix V: Research permit



UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY

RESEARCH PERMIT

Permit No.	2021-575-NA-2021-256
Date issued	01 November, 2021
Researcher's Name	Semeni Mussa Ngozi
Nationality	Tanzanian
Research Title	Analysis of Revenue Risk Management Strategies among Potato (Solanum Tuberosum) Smallholder Farmers in Njombe Town Council
Research Area(s)	Njombe
Validity	From: 01st November, 2021 to 31st October, 2022
Contacts of local collaborator (with affiliated institution)	Dr. Aloyce Hepelwa, University of Dar es Salaam, Department of Agricultural Economics and Business. Box 3547, Dar es Salaam

PROGRAM OFFICER

FOR DIRECTOR GENERAL

IMPORTANT REQUIREMENTS

- ***A PI who wishes to continue with a research beyond the expiry date of the research permit should write to COSTECH two months before the operational permit's expiry date, to request for an extension or renewal of the permit.***
- *Research permit that involves collecting human, plant or animal materials / data that will be exported outside Tanzania must submit a signed Material Transfer Agreement (MTA), Data Transfer Agreement (DTA) between Tanzania host institution and the foreign counterpart. The MTA/DTA will indicate terms for collecting, storing/managing, transporting, disposal or returning of the materials/DATA to Tanzania after the closure of the research project.*
- *Any patent or intellectual property and royalty emanating from any research approved by the National Research Registration Committee (NRRC) shall be owned as stipulated in the research proposals and in accordance with the IP policy of the respective research institutions.*
- *All researchers are required to report to a Regional Administrative Secretary (RAS) of the study area and present the introduction letter and activity schedule(plan) prior starting any research activity.*
- *All researchers are required to submit quarterly progress reports and all relevant publications made after completion of the research.*
- *All communications should be addressed to COSTECH Director General through [illegible] or +255 (022) 2700749, +255 (022) 2771358. Terms and conditions of the permit are found at www.costech.or.tz*

Tanzania Commission for Science and Technology, Ali Hassan Mwinyi Road, P.O. Box 4302, Dar Es Salaam.
General line: +255(022) 277 1358, Fax: COSTECH, E-mail: dg@costech.or.tz,
Website: http://www.costech.or.tz/