UNIVERSITY OF GHANA

AGRICULTURAL RISK MANAGEMENT OPTIONS, WILLINGNESS TO ADOPT AGRICULTURAL INSURANCE AND PRICING OF RAINFALL-INDEXED INSURANCE

BY

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DECLARATION

I, Richard Owiredu Amankwah, do hereby declare that this thesis is the result of my own original research and has not been presented in this or any other university for any academic award. I also bear responsibility for any shortcomings.

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CERTIFICATION

I hereby certify that this thesis was supervised in accordance with the laid down procedures laid down by the University of Ghana.

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DEDICATION

I dedicate this work to my family for their support in my academic pursuit.

ABSTRACT

This study examines the risks facing crop farmers and the strategies they employ to mitigate those risks. It further sets out to determine whether crop farmers are willing to adopt agricultural insurance as a means of mitigating farm income variability, formulate a derivative measure to determine pure premium of a rainfall-indexed insurance contract and to investigate how much farmers are willing to pay for such a contract. Using a questionnaire, data on farmers' demographics and farm characteristics were collected from 300 randomly selected farmers and used to examine the risks they face, the strategies they employ, and to determine farmers' willingness to adopt agricultural insurance using a binary logistic regression model. Annual rainfall and yield data for the period of 2000 to 2015 were also used to formulate a derivative pricing measure for rainfall-indexed insurance. The study found drought, storm and pests as the most pervasive risks that affect farmers' yield and farm income stability. Also, mixed cropping, use of improved seeds, timing planting, mixed farming, farmer cooperatives, engagement in other off-farm economic activities and seasonal migration were found as the means by which farmers mitigate the agricultural risks they face. Again, the study found that coefficient of variation of farm income positively and significantly affects willingness to adopt agricultural insurance. Female farmers and married farmers were also found more willing to adopt agricultural insurance. Farm size, land occupancy status, off-farm engagement and level of education positively impact on willingness whereas years of farming experience also negatively impact on willingness but were all statistically significant. Furthermore, 90% of the farmers are willing to adopt agricultural insurance and savour premium rate of 10% or below. The findings suggest that there is an available market for Ghanaian insurers to utilize and should therefore take advantage of the opportunity. Also, variation in farm incomes, gender and marital status of farmers be considered in designing

insurance contracts and in targeting clients for their uptake. Moreover, the premium rate should also be considered since a rate higher than 10% could affect farmers' willingness to adopt agricultural insurance.

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LIST OF ABBREVIATIONS

GDP	-	Gross Domestic Product
GLSS	-	Ghana Living Standards Survey
IPA	-	Innovations for Poverty Action
GIZ	-	German Development Cooperation
NIC	-	National Insurance Commission
MoFA	-	Ministry of Food and Agriculture
ISO	-	International Organization for Standardization
IIPACC	-	Innovative Insurance Products for the Adaptation to Climate Change
GAIP	-	Ghana Agricultural Insurance Programme
GIA	-	Ghana Insurers Association
ADB	-	Agricultural Development Bank
MoFEP	-	Ministry of Finance and Economic Planning
GMet	-	Ghana Meteorological Agency
SRID	-	Statistics, Research and Information Directorate
NPV	-	Net Present Value
USAID	-	United States Agency for International Development
JHS	-	Junior High School
SHS	-	Senior High School
BoG	-	Bank of Ghana

CHAPTER ONE

INTRODUCTION

1.0 Research Background

One of the main objectives of every business, except non-profit making organizations, is to maximize profit. En route to achieving their set targets are risks and uncertainties. Financial institutions for example face default risk, export-import businesses are embattled with exchange rate volatility, general merchandising firms who borrow to facilitate their transaction are also beset by interest rate volatility, etc. The agricultural sector like any other business sector is not free from risks. Agricultural operations are susceptible to sporadic changes in the weather (Kahan, 2008; Shannon and Motha, 2015). In effect, every business strives to manage risks associated with its operations to achieve its objectives and more importantly to relieve itself from the risk of being put out of business (Turvey, Bogan and Yu, 2012).

Agriculture is an important sector of every economy as it serves as a source of food production which is necessary for survival. In Africa, agriculture forms a significant part of Gross Domestic Product (GDP), contributing about 15% and therefore seen as a key means of driving economic growth (Kanu, Salamani and Numasawa, 2014). Moreover, Africa is noted for its high level of rural population (64%) for which agriculture is the main economic activity which provides about 70% of people living in such areas with income (Katie School of Insurance, 2011). In Ghana, the sector employs about 60% of the population (Choudhury, Jones, Okine & Choudhury, 2015). The agricultural sector in Ghana is predominantly characterized by smallholder farms which are mainly subsistence, growing food crops such as cereals, tubers, legumes and vegetables.

One key issue facing the activities of this crucial sector is its vulnerability to some peculiar production related risks like flood, drought, hailstorms, bush fires, pests and diseases. Ghanaian farmers have been severely affected by a significant number of such catastrophic weather events over the past three decades, notably in 1983, 1997, 2002, 2007 and 2009 (Bekoe and Logah, 2013). Research has also shown a continuous increase in Ghana's mean annual temperature of 1 °C per decade and a decrease in monthly rainfall of about 2.4% per decade since 1960 (De Pinto, Demirag, Haruna, Koo and Asamoah, 2012). Moreover, agricultural firms are also exposed to price fluctuations, financial risk, human resource risk and legal risk. However, the largest cause of uncertainty in Ghana and Africa, as identified by Etwire, Al-Hassan, Kuwornu and Osei-Owusu (2013) is the variation in rainfall of which Nunoo and Acheampong (2014) confirmed as being highly variable in Ghana. These risk factors put together affect the stability in farmers' yield and income, production decision making as well as economic growth and development.

Extant literature has shown that most farmers are risk averse and therefore seek avenues to reduce their risks as much as possible (Khuu and Weber, 2013). Mishra and Lence (2005) enumerated some "within-farm" strategies such as growing resistant varieties, irrigation, timing planting and avoiding the use of risky farming technologies as some of the risk management techniques that farmers can use to mitigate agricultural risk. Assa (2015) and Daron and Stainforth (2014) among others have also identified other off-farm strategies such as formation of co-operatives, setting aside funds from farm incomes, hedging, derivative contracts and especially insurance as effective means by which farmers can protect themselves against the adverse effects of such risks. With the availability of these risk management options, farmers are opened to an array of methods to choose from to match these exposures.

1.1 Research Problem

Agriculture in Ghana is heavily reliant on rainfall and irrigation is nearly non-existent (Tambo, 2016). Rainfall variability deprives crop farmers of assured yield and income levels and robs the agricultural sector of the needed investment. This poses a threat to GDP growth, potential widening of the inequality gap and food insecurity (Smart, Nel and Binns, 2015). The Intergovernmental Panel on Climate Change, IPCC's Fourth Assessment Report (AR4), released in 2007, predicted that by 2050, yields from rain-fed agriculture in some Sub-Sahara African countries could fall by up to 50%. This is seemingly evident in the fall of agriculture's contribution to Ghana's GDP from 42% to 22% from 2005 to 2013 although Ghana's GDP grew at an average of 7.8% over the same period according to the Ghana Living Standards Survey (GLSS6) (2014). With this in mind, crop farmers face an uphill task of stabilizing their farm yields and incomes.

Farmers in developed counties have used agricultural insurance to mitigate such risk and hence, there has been a passionate furtherance of agricultural insurance especially in less developed countries as a means to cater for such weather related risks by way of forming a protection base for farmers, indemnifying insured farmers in events of drought and flood as well as serving as collateral for farmers to access credit to expand their agricultural pursuits (United Nations, 2012; USAID, 2006). However, insurance patronage in Ghana is generally low with a penetration rate below 2% according to the 2013 National Insurance Commission (NIC) annual report. Agricultural insurance in Ghana is still in its development stage although awareness of the existence of agricultural insurance products is being created and a pilot project was done in 2009 (Nunoo and Acheampong, 2014). In case these insurance products do not come at the "right price", their patronage could be hampered, especially when they are not subsidized by government as is done in the advanced countries (Goodwin, 2015). Moreover, Ghanaian farmers are used to using on-farm and personal mitigating strategies although there is little evidence of effectiveness with the use of their risk management methods over the years. The coming of agricultural insurance products can save the situation but are Ghanaian farmers willing to adopt it as an option?

Amidst the growing interest in the study of insurance in general, there has been little empirical contributions in the uptake and pricing of agricultural insurance, a budding aspect of the developing insurance sector in Ghana. This study seeks to bridge that gap.

The study therefore seeks to explore the Ghanaian agricultural risk management case paying particular attention to examining the risk management options used by Ghanaian crop farmers and their willingness to adopt agricultural insurance as a risk management strategy. The study further seeks to measure pure premium of a weather index insurance contract for crops and also to investigate how much farmers will be willing to pay for a weather index insurance contract.

1.2 Research Objectives

The objectives of this study are:

- To investigate the agricultural risks faced by farmers and the risk management strategies employed to mitigate those risks.
- To examine farmers' willingness to adopt agricultural insurance as a means of mitigating yield and farm income variability.
- To measure pure premium of a rainfall-indexed insurance for food crops.

- To investigate how much farmers are willing to pay for a rainfall-indexed insurance for food crops.

1.3 Research Questions

The study intends to answer the following research questions:

- What are the prevalent agricultural risks farmers face and how do they manage them?
- What are the determinants of farmers' willingness to adopt agricultural insurance?
- How much should the pure premium of a rainfall-indexed insurance contract for food crops be?
- How much are farmers willing to pay for a rainfall-indexed insurance contract for food crops be?

1.4 Significance of the Research

Due to the persistence of risks in agriculture, every effort in helping to reduce or curtail their negative consequences is of great value to the entities being affected and more so in Ghana's case where agriculture's contribution is fallen from 42% to 22% between 2005 and 2013. The significance of this study can be viewed along three strands: research, practice and policy.

This study will contribute to the body of knowledge of research on agricultural risk management particularly in the area of determinants of willingness to adopt or pay for agricultural insurance and variables to consider when pricing weather indexed insurance especially in Ghana and Africa. This study will help farmers by bringing to bear some effective strategies being used by some farmers in other parts of the world to mitigate agricultural risk so that other farmers who are unaware of such strategies can adopt them to cope with agricultural risks. It will also provide insurers with information on the availability of a market base for agricultural insurance, some factors to consider before developing insurance products for farmers as well as a measure for price (premium) determination for weather indexed insurance contracts, particularly for rainfall-indexed insurance.

The study will inform policy makers in the Ministry of Food and Agriculture (MoFA) in formulating policies and programmes that will educate farmers on how to better manage their risks to stabilize their yield and farm income. This will in turn reduce the amount of money that government spend to put farmers back in business in events of catastrophes caused by the weather since they would have themselves put in place better risk management systems to deal with potential risks.

1.5 Research Scope and Limitation

This research will look at the agricultural risks farmers face and the risk management strategies being used by farmers. Agricultural insurance adoption as a risk management technique for Ghanaian farmers will be the focal point of the discussion. A review of relevant topical themes will be covered making references to some theoretical predictions and empirical studies conducted in the area under discussion. The research will focus only on small scale farmers, who will be looked at from the perspective of individuals instead of farm households.

Time and financial resource are the main constraints to this study. Due to limited time span available for the completion of this study as well as financial challenges, the study is confined to the Upper West Region of Ghana. The area is characterized by high variability in rainfall and will therefore be a good study area from which the research objectives can be achieved and a good representation for the other two northern regions which have variable rainfall patterns but would not be covered in this study. Moreover, there is a possibility that some of the respondents may not return their questionnaires.

1.6 Chapter Outline

The study is broken into five chapters. Chapter One focuses on the introduction- research background; research problem and purpose; research objectives; research questions; significance of the study; the scope and limitation of the study on the means by which Ghanaian crop farmers manage weather related risk.

Chapter Two is devoted to the literature review of the study. It will examine the theoretical perspective and contemporary practices related to the research questions. It will review documented cases and pieces of evidence, the methods and variables which have been empirically tested, the gaps left to be filled and also make used of both converging and diverging findings to establish constructive arguments to buttress the course of this research.

Chapter Three explains the methodology that will be used for the study. The chapter also covers the study design, study population, sample, method of collecting data from respondents, tools, techniques and procedures that will be used in analyzing and interpreting the results from the data collected.

Chapter Four presents the results from the data collected from the field, analysis and discussion of findings. It is the point of ideation where attention will be drawn to points of convergence and divergence with extant literature discussed in the Chapter Two.

Chapter Five presents the summary of the findings and conclusion of the study. This chapter will review the research objectives to ascertain whether due diligence has been done on them. It also presents recommendations per the findings and direction for future research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews literature critically examining the concepts of agricultural risk, agricultural risk management and agricultural insurance. It aims at putting the study in perspective by espousing understanding of the issues, theories and contemporary arguments on agricultural risk and its management as existent in literature and as well as eliciting the existing gaps. The review of literature will be done thematically organized under the following themes: explanation of concept of risk and risks in agriculture, agricultural risk management, agricultural insurance in Ghana, review of the theories, willingness to adopt agricultural insurance, pricing weather index insurance and a conceptual framework.

2.1 Concept of Risk

The concept of risk has been explained in several ways by different authors. Willis (2007) equates risk to expected loss whereas Campbell (2005) equates it to expected loss in utility. Weiner and Graham (1995) and ISO (2002) both see risk as a measure of the probability of an event and its consequences which is usually adverse. Studies in Finance have classified risk into systematic and unsystematic and the traditional approaches to risk are based on a mean-variance framework of portfolio theory (Markowitz, 1952).

Risk is defined in this study as the probability that a decision or an action taken, or an event occurring will adversely affect an individual or an organization's ability to achieve its objectives. Risk has become almost inseparable from all walks of life including health, investment, technology and politics among others. The agricultural sector is no different.

2.2 Risks in Agriculture

The agricultural sector is a primary source of food production for humanity without which survival will be critical, a key source of raw materials to the manufacturing sector and a source of employment to many. In pursuit of higher yields and profit, agricultural units are faced with some peculiar kinds of risk. Mishra and Lence (2005) categorized agricultural risk into two- production risk and business risk whereas Khuu and Weber (2013) classified them into yield/production risk and price risk. Ullah, Jourdain, Shivakoti, and Dhakal (2015) sub-divided them into production risk, marketing risk, human resource risk, financial risk, legal risk and social-political risk. However, the baseline for classification of agricultural risks has generally been on the risks factors farmers may have or have control and those they do not have control over which affect the production and sale of of their agricultural produce. This study classifies risks faced in agriculture into production/yield risk, price/marketing risk and institutional risks.

2.2.1 Production or Yield Risk

Production or yield risk refers to perils that affect the stability of yield from crop production year on year. Kahan (2008) outlined weather related risk such as flood, drought, frost, hailstorm, cyclone, extreme heat, hurricanes, blizzards, and other natural disasters in the form of wildfires, pests, plant diseases, etc as the main causes of yield variability in farming all over the world. In Ghana, the main risk factors are flood, drought, storms, bush fires, pests and plant diseases although the type of soil and its quality play a part in output level. Late start of rainy season, very low levels of rainfall and unpredictable period/span of rainfall in Ghana, and seasonal harmattan bush fires and spillages from Burkina Faso's Bagre dam in the Northern Regions of Ghana are the most critical agricultural issues of concern. These were evident in the years 1983, 1997, 2002, 2007 and 2009 (Bekoe and Logah, 2013). These weather events which are beyond the farmers' control can negatively impact the amount of yield farmers expected in a particular season.

2.2.2 Price or Marketing Risk

Quite apart from the weather variability which greatly affects farm yields, Khuu and Weber (2013) observed that farmers are also faced with fluctuation in input and output prices. Developing countries are also characterized by poor infrastructure, small markets and high transportation cost due to isolated rural markets from national and international markets, contributing to price risk (Korir, 2011). Moreover, the integration of developing countries into the global market has further opened up small scale farmers who are less able to influence prices in the market. Price risk driven by the free market conditions has increased growing competition and exposed agricultural units to exchange rate volatility (Louhichi and y Paloma, 2013). This also affects the stability of the incomes farmers get from the sale of their outputs.

2.2.3 Institutional Risks

The last of the classifications of agricultural risks under consideration is institutional risks. Farmers also face institutional risks like human resource risk, financial risk, legal risk and social-political risk as described by Ullah et al., (2015). Decisions of financial and state institutions as well as that of the farmers themselves pose risks on farmers' agriculture output and incomes. For instance, increase in tax on agricultural produce, increase in interest rate on credit by financial institutions, a complete removal of government subsidies on agricultural inputs and wrong timing of planting by farmers can all affect agricultural outputs (Bodin, Olin, Pugh and Arneth, 2016; and Akudugu, 2016). Such risks resulting from policies and decisions making by state institutions and farmers can also affects the stability of the incomes farmers get from the sale of their yields.

2.2.4 Effects of Agricultural Risk

Agricultural risk whether in the form of production/yield risk, market/price risk or institutional risks or a combination of the three have devastating consequences on agricultural participants and the economy as a whole. Some of these effect of agricultural risks are farm planning difficulties, unstable farmer income and household food production, unstable quantity supply of agricultural produce to the manufacturing sector and high agricultural commodity prices to consumers, difficulties in credit accessing, inefficient resource allocation to the agricultural sector and in the long run food insecurity (Smart, Nel and Binns, 2015). There is therefore the need for farmers to take adequate steps to mitigate such risks in order to stabilize their yields and eliminate or reduce the variability in their farm incomes.

2.3 Agricultural Risk Management

Owing to the fact that risk permeates every business, diverse means of dealing with the different kinds of risk faced have also been developed (Spikin, 2013). Agricultural risk management, an aspect of risk management, deals with taking steps to mitigate risks associated with agricultural production (Muchapondwa and Sterner, 2012). Risk management strategies can be classified into two broad categories; ex-ante risk management and ex-post strategies. However, ex-post strategies are usually not highly considered as very good risk management strategies since they are usually implemented after the occurrence of the risk event which is contrary to the popular intent of risk management of which the strategies have to be taken before the occurrence of the event in order to appropriately mitigate an initially perceived risk which has occurred. Therefore the focus will be on ex-ante agricultural risk management strategies. The ex-ante agricultural risk management strategies can also be grouped into on-farm and off-farm risk management strategies.

2.3.1 On-farm Risk Management Strategies

On-farm risk management strategies are techniques or steps taken by farmers to mitigate risks on the field of production. Some of the agricultural risk management techniques that empirical research have shown to be effective in mitigating production related risks are diversification (mixed-cropping and mixed farming), seasonal migrations, growing resistant varieties, new crop varieties, irrigation, timing planting, avoiding the use of risky technologies and making use a meteorological information to inform production activities (Mishra and Lence, 2005; Tambo, 2016).

2.3.2 Off-farm Risk Management Strategies

Off-farm risk management strategies are techniques or steps taken by farmers to mitigate risk off the field of production. Some of the agricultural risk management techniques that have been empirically proven as effective in mitigating agricultural risks are building financial reserves, hedging using derivatives, making use of production and marketing contracts, running other businesses, leasing inputs and buying insurance among others (Pelka, Musshoff and Finger, 2014; Sun and van Kooten, 2015). Zhang and Hui Huang (2014) and Machinski, de Faria, Moreira, and Ferraresi (2015) have also found cooperatives as a good risk management mechanism although cooperatives, they noted, have their own inherent risks too. Moreover, some recent developments in income stabilization instruments like purchasing hedge assets on the capital markets, use of mutual funds and government bonds have also become effective ways of dealing with risk (Muchapondwa and Sterner, 2012; Janowicz-Lomott and Łyskawa, 2016).

Notwithstanding, most of these strategies, like hedging with derivatives and mutual funds, are not feasible options for rural farmers whilst others like insurance as observed by Korir (2011) have not been well developed in developing countries. Off-farm strategies mostly used in Ghana are in the form of off-farm employment such as running grocery shop, savings, cooperatives and production and marketing contracts (not formal derivatives like futures and options).

2.4 Agricultural Insurance

Among the off-farm measures for mitigating agricultural risks is insurance. Generally, insurance is a risk transfer mechanism by which an individual (the insured) pays a premium to another party (the insurer) who in turn agrees to take care of the risk faced by the insured (Miller, Dobbins, Pritchett, Boehlje and Ehmke, 2004). In case of loss, the insurer indemnifies the insured for losses suffered in accordance with the agreed terms of the contract. Agricultural insurance is a type of insurance where farmers pay premium to an insurance company who agrees to indemnify them in event of the agreed agricultural related peril. Agricultural insurance is therefore a kind of risk management measure which protects farmers against farm production and/or revenue losses and by so doing helps to smoothen farmers' income over the years of their engagement in agriculture. Moreover, it assures farmers of their expected farm incomes and provides them with a basis to access credit from financial institutions to expand their production.

Agricultural insurance has been identified as one of the key off-farm strategies for protecting agricultural participants' investments against losses caused by catastrophic events (Miranda and Farrin, 2012; Pavlov, Kindaev, Vinnikova and Kuznetsova, 2016). It is widely used in the United States and making waves in Europe and other continents but quite unpopular in Africa (Goodwin, 2015). There are two main types of agricultural insurance namely Index Based Insurance products and Traditional Indemnity Insurance products.

2.4.1 Traditional Indemnity Insurance

Traditional indemnity insurance protects individual policy holders by paying indemnities to only injured parties for losses resulting from the occurrence of agreed perils (Chatterjee, 2015). Traditional indemnity insurance pays indemnity based on the actual loss ascertained as a result of the occurrence of an insured peril and is usually available to commercial farmers (Mahul and Stutley, 2010). It comes in the form of either multi-peril crop insurance or single named peril insurance. It is characterized by high operating cost because the extent of actual loss on each farm has to be ascertained separately before the payment of indemnities to the insured parties. Moreover, moral hazard and adverse selection are highly probable and thus the need for constant monitoring of farm practices which adds up to administrative charges in administering the insurance contract.

2.4.2 Index Based Insurance

Indexed insurance, unlike the traditional agricultural insurance makes payments for losses based on an independent measure which is highly correlated with yield and revenue outcomes (Hess, Skees, Stoppa, Barnett and Nash, 2005). The measure is the index and it is used to determine the extent of loss is exogenous to the policy holders. There are two main types of index based insurance contracts- Area Yield Indexed Insurance and Weather Indexed Insurance. The indexed insurance contract is considered as an Area Yield Indexed Insurance or Weather Indexed Insurance when the measure of expected loss is area-level yield and weather event respectively. To ensure fairness, the index used must be reliable, timely and devoid of human manipulation (Ruck 1999). Thus, publicly available indexes such as rainfall, temperature and yields measured by an independent work station or agency are preferable. A more modern method like the satellite imagery which measures precipitation and covers a wider area unlike the work station which covers a particular radius is advantageous.

In determining whether an insured qualifies to be indemnified under an index based insurance contract, a predetermined agreed threshold known as the trigger is used. An insured gets indemnified when the measure of the index falls below the trigger, indicating a loss to the insured. This, however, can give rise to basis risk. Basis risk has to do with the possibility of an individual receiving more or lesser payout than the actual loss simply because the index has been triggered. To eliminate this risk to ensure effectiveness of indexed insurance, Hess et al. (2005) posit that parties involved in the contract should ensure that farm yield losses and the index are positively correlated.

Barring this potential disadvantage of indexed insurance, it offers better protection compared to the traditional agricultural insurance. Indexed insurance is characterized by no moral hazard and adverse selection, and low operating cost selection which make it more suitable for developing countries which are in the early stages of using agricultural insurance and might not also have government subsidies in premiums (Iturrioz, 2009; World Bank, 2011).

2.4.3 Agricultural Insurance in Ghana

Catastrophic weather events rob agricultural participants, farmers and lenders alike, of their investments in agriculture. The variability in agricultural yields decreases investments in agriculture which in turn deceases the growth of the sector. Moreover, inadequacy of protection against agricultural risks has left many small-scale farmers stuck in poverty (Quang Dao, 2009). These have heightened the need for agricultural insurance in areas with higher rural population like Africa and Ghana for that matter.

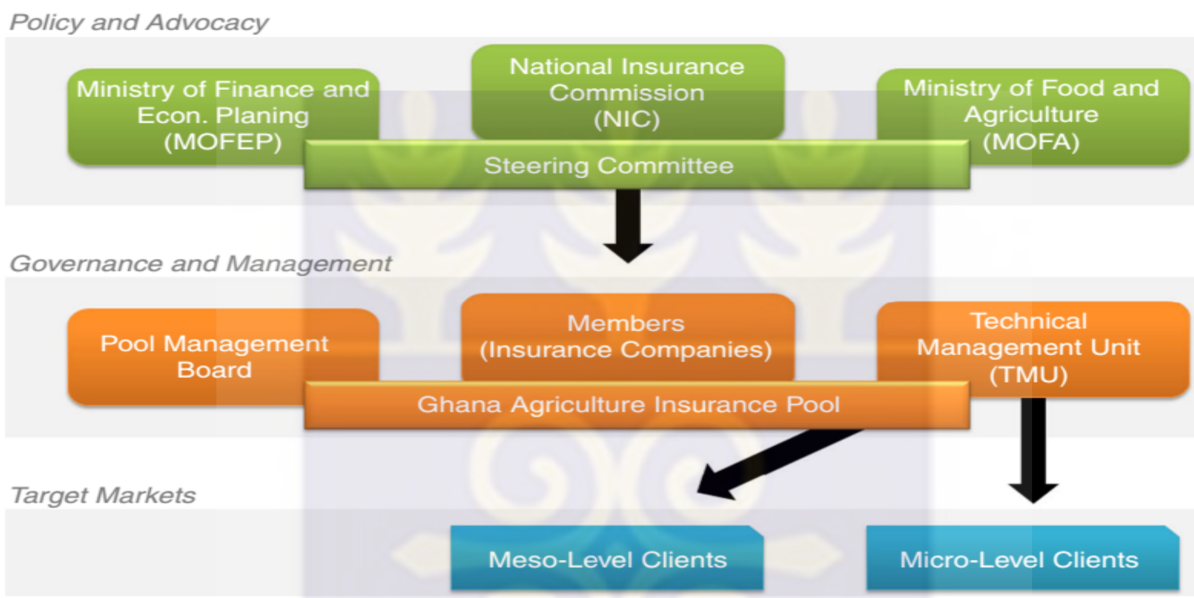
Ghana caught the fever of commercial agricultural insurance in 2011 although the first weather index insurance for maize called "Takayua rainfall insurance" was piloted in 2009 yet its progress since that time has been slow (Innovations for Poverty Action (IPA), 2010). Up until then Ghanaian farmers had no commercial agricultural insurance to salvage their losses resulting from adverse weather conditions.

According to Nunoo and Acheampong (2014), the German Development Cooperation (GIZ) in 2011 through its "Innovative Insurance Products for the Adaptation to Climate Change" (IIPACC) project initiated the Ghana Agricultural Insurance Program (GAIP), an insurance initiative against crop failure and financial losses caused by adverse weather indexes (drought and excess rainfall). The project was tested with farmers in the three Northern regions with 3000 farmers benefiting and later extended to the Ashanti, Brong Ahafo and Eastern regions in 2012.

This Ghana Agricultural Insurance Program (GAIP) transcended into a more commercial insurance through a public-private partnership incorporating other stakeholders like the National

Insurance Commission (NIC), the Ghana Insurers Association (GIA), Agricultural Development Bank (ADB), Stanbic Bank, the Ministry of Food and Agriculture (MoFA), the Ministry of Finance and Economic Planning (MoFEP) and the Ghana Meteorological Agency (GMet). Figure 2.1 below show a diagrammatic representation of the current structure of the GAIP.

Figure 2.1: GAIP Structure



Source: GAIP Brochure (2012)

Currently, the agricultural insurance products on the horizon in Ghana by the now Ghana Coinsurance Pool under the GAIP are Index Insurance contracts written on food crops like maize, soya, sorghum and millet and for that of the Traditional Indemnity Insurance are on cash crops like rubber, forestry and plantation crops. Measurement of the index for a Weather Indexed Insurance in Ghana is done by the GMet whereas the measurement of the index for Area Yield Index Insurance is done by the Statistics, Research and Information Directorate (SRID) of the Ghana Statistical Service. Moreover, there is also an attempt by GAIP to develop appropriate insurance products that will meet the needs of both small-scale and commercial farmers, processors, exporters and investors (banks) in the agricultural sector.

2.4.4 Challenges and Potential Remedies of Agricultural Insurance in Ghana

Agricultural insurance in Ghana like in many other less developed countries is embattled with challenges. Reliable data accessibility is the most challenging. Others include lack of awareness of the existence of such insurance products and negative perception of insurance, less active involvement of local practitioners, and inadequate capacity and expertise (Nunoo and Acheampong, 2014). Government's role of providing regulatory framework, infrastructural support and funds to subsidize insurance premiums so as to make them affordable has also been described by Nunoo and Acheampong (2014) as minimal in Ghana's case. Agricultural insurance awareness creation, creation of farmer database and risk profiles of crops, capacity building and training of the local insurance industry and increase government participation are some of the ways identified in literature to deal with the challenges faced in Ghana.

2.5 Theoretical Framework

In economic theory, demand for a given product is dependent on the consumer's willingness and ability to pay for the given price. This implies that an individual should first have the desire for (the willingness to obtain) a commodity before exercising his or her ability to buy in order to obtain that commodity. This willingness is borne out of the utility the individual's expects to derive from the consumption or usage of that commodity. Conversely, a person undertaking an investment to produce a commodity which offers value (utility) to consumers also expects that the future revenues from his sales brought in today's terms should exceed the cost being incurred today to come out with the product in order to ensure that the venture is viable and worth entering. The theoretical underpinning of the study is therefore based on the expected utility model and the net present value investment theory.

2.5.1 Expected Utility Theory

The expected utility theory according to Schoemaker (1982) was elicited by von Neumann and Morgenstern. It postulates that individuals make decisions to satisfy their utility under uncertainty based on the utility of the outcomes and their relevant chances (Machina and Viscusi, 2013). Farmers like any other rational economic agent prefer an activity with a certain return than a risky one. Under this theory the farmer is assumed a utility function, ***u*** and ensures that he or she maximizes the expected value ***(y)*** of his utility function subject to income constraint.

The expected utility of a random income taking two values with equal probability can be computed as:

$$\mathrm{Eu}(\mathrm{y}) = \frac{1}{2}\mathrm{u}(\mathrm{y}+\delta) + \frac{1}{2}\mathrm{u}(\mathrm{y}-\delta) \qquad \textbf{(1)}$$

The expected utility of a random income, ***Eu(y)*** is less than $\boldsymbol{u}(\tilde{y})$, the ultility of the certain income, due to the concave nature of the assumed utility function. The difference is a loss in expected utility and is therefore a measure of cost of risk. This cost is equivalent to the risk premium which is the amount the individual (farmer) would be willing to pay to be in the same position as having a sure income as with the risky income. This income level is known as the certainty equivalent income. Thus, a farmer with a random income, due to variability in his crop yield which is also as a result of weather variability, who wants to be in the position of a sure income must pay the risk premium, which in essence is the price of the insurance contract purchased which offers him or her protection against possible variability in farm yields and incomes.

2.5.2 The theory of Net Present Value

Net present value of an investment is the sum of the discounted expected benefits less the discounted associated costs of the investment. Every rational economic agent seeks to maximize utility subject to his/her limited resources whiles minimizing risk. Thus an individual will only invest if the present value of the cash inflows exceeds the present value of the cash outflows of the investment (Mishra and Morehart, 2001). Moreover, given a number of investments with positive NPVs, an individual will select the investment with the highest NPV. The NPV is given by Korir (2011) as:

$$\mathrm{NPV} = \int_{t=0}^{T} e^{-rt} (R_t - C_t) dt \qquad \textbf{(2)}$$

Where T is time, r is the discount rate, R_t the expected cash inflows of the investment and C_t represents the expected costs of the investment.

Just as the insured (farmer) seeks to minimize his risk and maximize his return, so does the insurer. The insured does that by paying premium to transfer the risk faced to guarantee himself of a sure income. Conversely, for the insurer to be assured of the position he is taking in the insurance contract, the present value of all the future payout in indemnity should be less or equal to the premiums receives to induce the insurer to engage in the insurance contract. The reverse will be unprofitable to the insurer and will therefore not undertake such business venture. This is therefore fundamental to the insurance contract since it provides the insurer with the financial base to be able to indemnify the insured in times of peril which in turn assures a prospective insured party (farmer) and induces him or her to participate in such a contract.

2.6 Factors that determine Farmers' Willingness to Pay for Agricultural Insurance

Research has shown that risks reduce willingness to undertake economic or investment activities or adopting innovative strategies and technologies with high expected returns and potential losses (Korir, 2011). This is more so in the case of the less endowed because the severity of risk impact is more on the poor than the rich and this has the potency to widen the inequality gap (Quang Dao, 2009).

Goodwin and Smith (2013) observed that farmers' demand for multiple-peril crop insurance in the USA is high due the subsidies (more than 60%) in premium farmers pay and subsidies given to insurance companies to reduce their administrative costs. This cannot be said of developing countries. Odening and Shen (2014) also noted that demand for and penetration of such unsubsidized crop insurance in less developed countries is low compared to the USA and other European countries. However, there is a passionate furtherance of index-based (weather and area yield) insurance in less developed countries with a great expectation of it growth due to the low operating cost, no moral hazard and adverse selection associated with it (World Bank, 2011).

Several authors have identified and empirically tested a myriad of factors that determine farmers' willingness to adopt or pay for agricultural insurance. These factors or variables can be classified into farm structural characteristics, farmer characteristics, risk perception, premium and indemnity, off-farm income and government support. These factors or variable are explained below:

- **Farm structural characteristics:** farm size, land occupancy and farm location are some of the factors under this classification which have been identified in literature as estimates of risk exposure and also determinants of willingness to pay for agricultural insurance. Lefebvre, Nikolov, Gomez-y-Paloma, and Chopeva (2014) and Liesivaara and Myyrä (2014) among others found out that the larger the farm size and the location of a farm in an area highly prone to particular agricultural risk factors widen risk exposure and therefore impact positively on farmers' willingness to pay for insurance for such perils. Conversely, Ullah et al. (2015) say farm size negatively affects willingness to pay. This may be as a result of a farmer having larger farmland size having to pay higher premium which he or she might find expensive. Moreover, Ullah et al. (2015) further posit that land ownership positively affects willingness to pay which contradict the popular assertion which Lefebvre et al. (2014) confirmed that farmers with rented land are more willing to purchase insurance compared to those who owned their farmlands.

- **Farmer characteristics:** under this classification, factors such as farmer's gender, household size, marital status, educational level and age, which is usually used to represent length of experience, have been empirically tested and found to be positively correlated with willingness to pay for insurance. Lin, Boyd, Pai, Porth, Zhang and Wang (2015) observed that women are more likely to adopt agricultural insurance compared to men. Also, Showers and Shotick (1994) and Amponsah, Vigre, Braimah, Schou and Abaido (2015) found the size a household to positively and significantly determinant willingness to use insurance. Liesivaara and Myyrä (2014) among other authors found out that younger farmers are less willing to pay for agricultural insurance compared to the elderly ones. This may be the case because younger farmers feel they have more year ahead to recover from any adverse weather effects. They also found out that married people are more willing to use insurance. This might be the case due to the fact that married people have higher responsibilities and therefore would need to stabilize their income. The findings of Ullah et al. (2015) supported that of Liesivaara and Myyrä (2014) and contradicted that of Amponsah et al. (2015), stating that household size and farming experience as negatively impact on willingness to purchase agricultural insurance. This might also be the case because bigger household demand larger incomes and might therefore not have enough to pay premium. Moreover, experienced farmers feel they can management the situation without insurance. Finally, it is also evident from empirical literature that less educated farmers are less willing to pay for agricultural insurance compared to those who are highly educated (Seth, Ansari and Datta, 2009; Ullah et al., 2015).

- R**isk perception:** this has to do with farmers' level of risk aversion (risk averse, risk neutral and risk loving), their perception of the likelihood of peril occurrence and their perception about insurance. Farmers are generally considered to be risk averse although there is evidence to the contrary in behavioural finance studies (Carter, Elabed and Serfilippi, 2015). Khuu and Weber (2013) observed that risk averse farmers are more willing to pay for agricultural insurance. Ullah et al. (2015) also found out that farmers who perceive a possible peril in the near future are more like to pay for insurance. Again, Lin et al. (2015) confirmed the assertion that positive attitude on the part of farmers toward insurance and trust in insurance companies affect willingness to pay for insurance positively.

- **Coefficient of variation of farm income:** Risk in business can be measured by two methods: the standard deviation or the coefficient of variation (Alimi and Ayanwale, 2005). The coefficient of variation is a risk-return ratio calculated as standard deviation divided by mean. It measures the risk taken on by an individual compared to his/her return on an investment. Thus, the coefficient of variation provides an individual with more information when choosing from investments with the same standard deviation. Penson and Lin (1980) affirm the coefficient of variation as a better measure because it normalizing effect. Seth, Ansari and Datta (2009) have also established that coefficient of variation positively and significantly affects a person's willingness to purchase agricultural insurance.

- **Premium and indemnity:** amounts to be paid in premiums by farmers and in indemnities by insurers are some of the other factors to consider. High, unsubsidized premiums and lower percentages payments of losses incurred in indemnities have been identified as disincentives to willingness to pay for insurance (Musshoff, Hirschauer and Odening, 2008; Howley and Dillon, 2012; Liesivaara and Myyrä, 2014).

- **Off-farm income:** off-farm income refers to any income earned from any legal economic activity outside of the farmer's agricultural activities. In times of poor yield, farmers engaged in other off-farm economic activities sustain themselves with incomes from such activities till the next planting season. Empirical study have shown that farmers who have other non-farm engagements that earn them income are less likely to adopt agricultural insurance (Ullah et al., 2015).

- **Government support:** Governments have been supportive assisting individuals get back to business after catastrophic events by way of offering cash and in-kind items like business inputs. Khuu and Weber (2013) established that governmental emergency assistance in events of perils which were "beyond the scope of normal risk management" reduces willingness to adopt or pay for insurance.

2.7 Pricing Crop Insurance

As noted earlier, in economic theory, price plays a big part in determining demand. To a major extent, it indicates whether an individual will be able to pay for a given commodity he or she desires to purchase.

In determining insurance premium, two things come to play: the actuarial value and loading factor. The actuarial value which is also known as the pure or fair price is the expected payoff from an insurance policy. A risk-averse individual would always prefer insurance cover with values which are actuarially fair (Hofmann, 2009). The second price component, the loading factor usually includes a safety buffer, taxes, and all the administrative expenses associated with the provision of insurance contract (Vaté and Dror, 2002). Besides these two components, Musshoff, Hirschauer and Odening (2008) have found out that insurance premium also contains the profit loading of the insurer for the risk it takes to indemnify the insured in case of peril.

In terms of empirical researches, extant literature has found premium (price) to negatively affect willingness to adopt agricultural insurance which is consistent with the law of demand: higher price, low quantity demanded (Musshoff, Hirschauer and Odening, 2008; Kong, Turvey, He, Ma and Meagher, 2011). Interest rate is one of the variables which affect premium. Pavlov, Kindaev, Vinnikova and Kuznetsova (2016) proved the effectiveness of crop insurance at low interest rate.

Most individuals are risk averse and thus in pricing weather indexed insurance, the premium is expected to be equal to the expected loss or cost in order to induce a risk averse individual to purchase such insurance contract to mitigate his or her exposure to adverse weather conditions with the view of benefiting in times of peril (Martin, Barnett and Coble, 2001; Turvey, Weersink and Chiang, 2006).

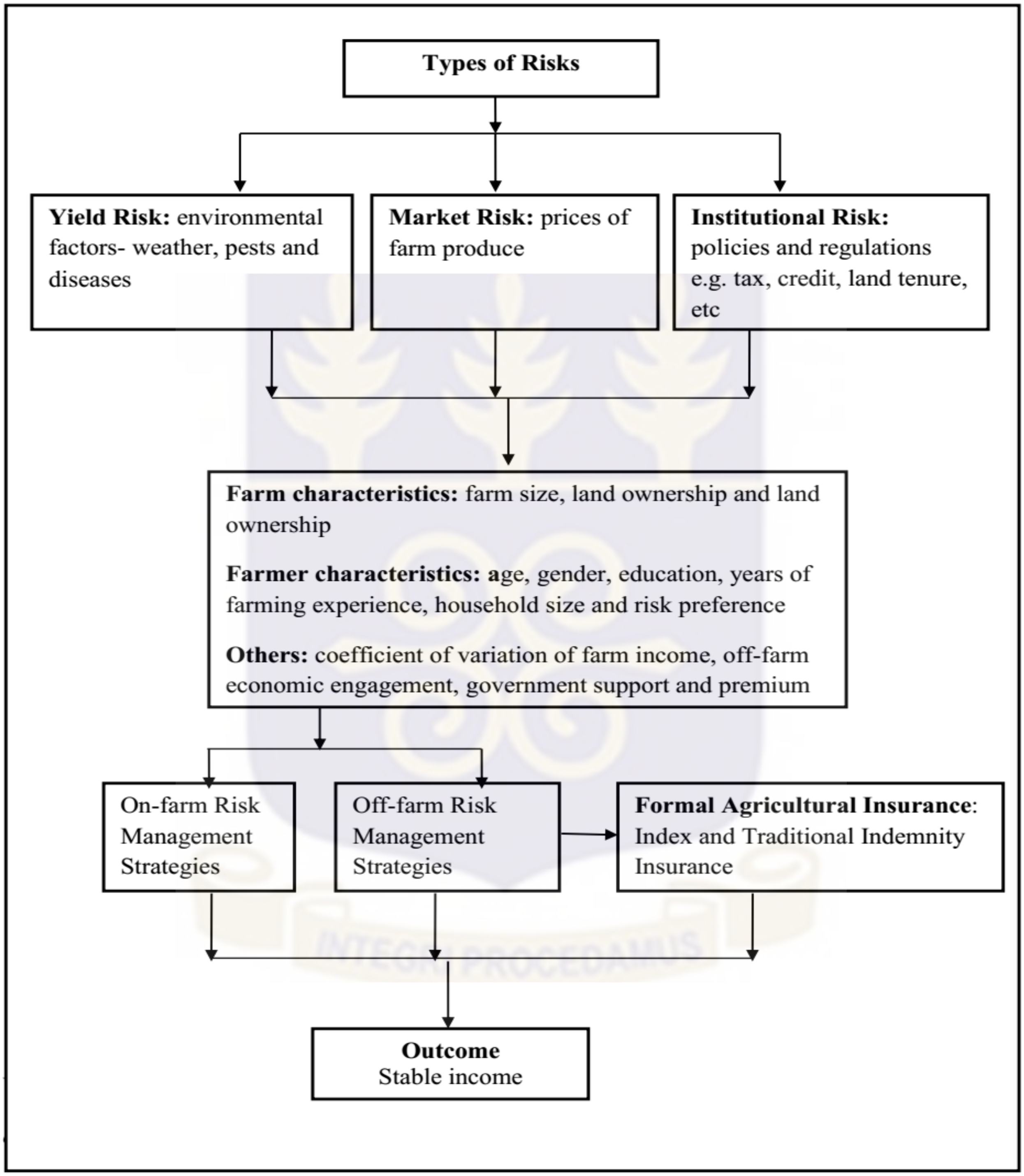
Ozaki (2009), Taib and Benth (2012), Porth, Zhu and Tan (2014), Assa (2015) and Choudhury et al. (2015) have proposed varying approaches, like the hierarchical Bayesian approach, classical burn and temperature modeling, Erlang mixture model, financial engineering and model-based clustering approaches respectively, to price index-based insurance.

The conventional way of determining the pure insurance premium is by ensuring “that the present value of expected premiums is equal to the present value of expected losses and expected cost for providing insurance coverage” (Biener, 2012, p.133). With the push being more for index-based insurance in developing countries due to its low administrative cost, its elimination of moral hazard and adverse selection problems associated with the traditional indemnity insurance and a better means for small-scale farmers, payout for indexed insurance is calculated in extant literature by finding the difference between some determined threshold or critical level (point where payments start) and the actual level of index (say rainfall) measured over a period of time which is below the threshold. This is multiplied by some determined conversion factor into monetary term to determine the payout and then premium.

2.8 Conceptual framework

The issues discussed above concerning agricultural risks and mitigating strategies have been conceptualized in Figure 2.2. There is a wide array of risk factors farmers face which have the potency of causing variability in farmers yields and incomes. Majority of these factors are out of farmers' control. These risks can be classified into production/yield, market/price and institutional risks. These risks interact with farm and farmer characteristics and other factors which influence the kinds of risk management strategy chosen by farmers to mitigate such risks. Agricultural insurance is a viable option that farmers in developing countries like Ghana can take advantage of to stabilize their farm income.

Figure 2.2: Conceptual framework of Agricultural Risks, Agricultural Risk Management and Agricultural Insurance



Source: Adopted and modified from Korir (2011)

2.9 Conclusion

This chapter examined the concepts of agricultural risk and its management taking a critical look at agricultural insurance as a tool for mitigating weather related risks. It also look at farmers' willingness to adopt or pay for and pricing of agricultural insurance products. According to literature, agricultural risk has a negative effect on farmers' income. Thus, farmers strive through diverse means to reduce their exposure in order to stabilize their yield and income. In dealing with risk, Shannon and Motha (2015) recommend that individuals and organizations adopt and implement more than one risk treatment programme in order to ensure successful risk mitigation.

CHAPTER THREE

METHODLOGY

3.0 Introduction

This chapter addresses the question of how the research will be carried out. It outlines the research approach that will be employed to achieve the research objectives (Babbie, 2011). It also describes the population considered, the sample size and the sampling procedure. It also discusses the sources of data, the method that will be used to collect data and data analysis tools and techniques for the study. The rationale for their selection will also be explained.

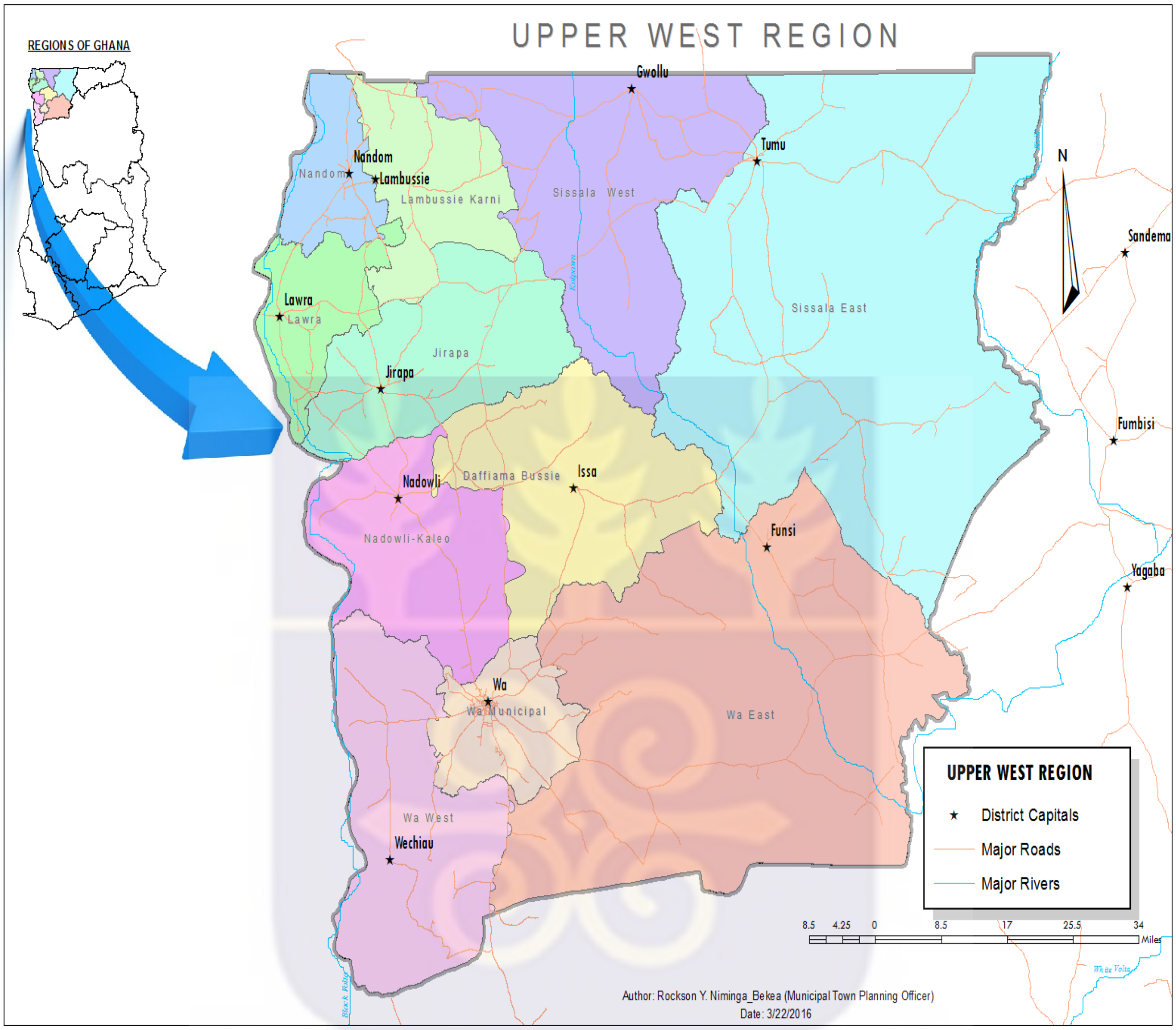
3.1 Area of Study

The Upper West Region of Ghana is the selected study area for this research. The region lies in the Guinea Savannah belt and it is located on the north-western part of Ghana with latitude 9.35°-11.O° North and longitude 1.25°- 2.50° West. Wa is the capital town of this region and it shares boarders with Burkina Faso to the north, La Cote d'Ivoire to the west, the Northern and Upper East regions of Ghana to the south and east respectively. It consists of one municipal assembly (Wa Municipal) and 10 districts assemblies namely Lawra, Wa West, Wa East, Sissala West, Sissala East, Jirapa, Nadowli-Kaleo, Lambussie-Karni and Daffiama-Bussie-Issa. Dagaaba, Sisaala and Waala are the major ethnic groups in the region. It covers a geographical area of 18,480 sq. km. representing 12.7% of the total land area of Ghana. 70% of the land size is cultivatable. Laterite, sandy and sandy loam are the soil types found in the region which have soil pH ranging between 6.0-6.8 and the average annual rainfall is around 1022mm (Government of Ghana, 2016; Ministry of Food and Agriculture, 2011). Like the other two northern regions, it has a single rainy season in a year compared to the remaining seven regions in the mid and southern belts of Ghana which have two, almost all of which occurs between May and October. Following these months is a cool dry period called the harmattan from the Sahara. The hottest period of the year in the region is February to March. Temperature ranges between 15°C and 40 °C. Rainfall pattern of the region is highly variable and unreliable compared the Upper East Region which has a more steady rainfall pattern and the Northern Region whose rainfall pattern is more like that of the chosen region (Katie School of Insurance, 2011).

The region is primarily agricultural. Maize, millet, yam, beans and vegetables are the staple crops grown in the region. People in the region also engage in the rearing of cattle, goat, sheep and poultry, especially, guinea fowls. The estimated population of the region is 702,110 (of which 51.4% are females) representing 2.8% of the nation's population with an annual average intercensal growth rate of 1.9% and of which 72.3% of the economically active population aged 15 years and older who are engaged in agriculture according to the 2010 population and housing census by the Ghana Statistical Service.

The region was chosen based on it agrarian nature and also because it is one of the three northern regions that are highly prone to agriculture production related risks like drought, bush fires and sometimes heavy rains and occasional spill-overs from rivers and dams flowing from Burkina Faso. Moreover, the few studies done in Ghana in relation to agricultural risk management were done in the Northern and Upper East Regions (Choudhury et al., 2015; Tambo, 2016).

Figure 3.1: Map of the Upper West Region



Source: Upper West Regional Coordinating Council (2017)

3.2 Research Design

A quantitative approach will be used for the study. A questionnaire-based survey with both closed and open ended questions will be conducted on farm risks, farmers' risk management methods and their willingness to pay for agricultural insurance and how much they will be willing to pay for an index insurance.

3.3 Data and Data Sources

Primary data will be collected from crop farmers by means of a questionnaire. Data on currently proven risk management strategies and techniques used by farmers to mitigate agricultural production risk will be collected from farmers. Moreover, data on farm structural characteristics (farm size, farm yield and land ownership), government compensation after the occurrence of a catastrophic event, farmers' off-farm economic engagement, and farmers' individual characteristics (farmer's age, years of farming experience, number of years of formal education and household size) will be collected to help determine farmers' willingness to pay for agricultural insurance. Also, secondary data on rainfall and yield levels from the region will be collected from GMet and MoFA respectively. That will be used in pricing rainfall-indexed insurance contract.

3.4 Population, Sample and Sampling Technique

The total number of farmers in the Upper West Region of Ghana who are engaged in food crop farming grown annually will be the population for this study. Due to the lack of data on the number of farmers who are annual food crop growers, with the only data available being the agricultural labour population of the region within the ages of 15 and 65 who are deemed economically active being 367,065 according to the 2010 population and housing census by the Ghana Statistical Service, the sample size will be determined by using a formula proposed by Cochran (1977). The sample size formula is of the form:

$$n = \frac{Z^2(p) \times (1 - p)}{d^2}$$

Where: n = sample size; z is z value associated with desired confidence level; p is the probability of picking a choice; and d, confidence interval.

Taking a confidence level of 95% with its z value being 1.96 and a confidence interval, d of 0.05, and P = 0.5, the sample size, n will be;

$$n = \frac{1.96^2(0.5) \times (1 - 0.5)}{0.05^2} = 384.16$$

Therefore, a sample size of 384 food crop farmers will be randomly selected from the region. Respondents will be farmers who are directly involved in choosing risk management strategies for farming units.

3.5 Models Specification

Descriptive statistics will be used to identify and describe the prevalent risks faced by food crop farmers and the risk management techniques and strategies used by farmers in mitigating the yield and income variability resulting from the elicited risks.

In determining farmers' willingness to use crop agricultural insurance a binary logistic model will be used. Regression is one of the best predictive tools for measuring the relationship between a dependent variable and one or more independent variables. However, the type of regression to be used is dependent on the nature of the data being used for the study. Logistic regression is generally used to describe the relationship between a categorical outcome and a set of categorical or continuous independent variables. According to Cox and Snell (1989), logistic regression is flexible, easy to use and offers good interpretation for categorical outcomes. Cabrera (1994) also posit that logistic regression is ideal and most acceptable method for predicting dichotomous outcomes due to the strict assumptions such as linearity and normality of the Ordinary Least Squares. In support of the above, Hosmer and Lemeshow (2000) postulate that logistic regression helps to elicit a best fitting model to analyze and describe the relationship between a categorical dependent variable and a set of both categorical or continuous independent variables. Thus, in determining farmers' willingness to use crop agricultural insurance (indexed insurance from hence forth) to mitigate agricultural risk, particularly yield variability resulting from rainfall variability, a binary logistic regression model will be used since the dependent variable is categorical and has a dichotomous outcome of a farmer either being willing or not willing to use agricultural insurance.

The general logistic model is expressed as:

$$ln(\mathrm{ODDS}) = ln\left[\frac{\mathrm{P}}{1-\mathrm{P}}\right] = \beta_0 + \beta_i x_i + u_i$$

Where:

$ln\left[\frac{\mathrm{P}}{(1-\mathrm{P})}\right]$ is the logarithm of the odds, in this case, the odd that farmer is willing to mitigate yield variability resulting from the risk of rainfall variability by purchasing agricultural insurance.;

X_i a set of both categorical and independent variables;

$\mathrm{P} = \frac{\mathrm{e}^{(\sum \mathrm{B_i})}}{(1+\mathrm{e}^{(\sum \mathrm{B_i})})}$ is the probability of the response variable, in this case, the probability that a farmer is willing to adopt agricultural (index) insurance.

Following Ullah et al. (2015), the model for willingness to adopt agricultural (index) insurance is specified as:

$$WTP = ln\left[\frac{P}{1-P}\right] = \beta_0 + \beta_1 CVInc_i + \beta_2 FarmSize_i + \beta_3 LandOcc_i + \beta_4 Age_i + \beta_5 Gender_i + \beta_6 FarmExp_i + \beta_7 OffFarmEng_i + \beta_8 Marital_i + \beta_9 Educ_i + \beta_{10} GovSup_i + u_i \quad \textbf{(3)}$$

Table 3.1: Variables to be used in Determining Willingness to Adopt Agricultural Insurance

Variable	Description	Units	Prior Symbol
WTA	Willingness to adopt or buy index insurance	0 = not willing to purchase agricultural insurance 1 = willing to purchase agricultural insurance	Dependent variable
CVInc	Coefficient of variation of farmer's farm income for the past 5 years (2011-2015)	Dimensionless	+
FarmSize	Farm size	Acres	+
LandOcc	Land occupancy status	1 = personally owned 2 = rented/lease holding 3 = Family owned (reference category)	+
Age	Famer's age	Years	+
Gender	Gender of the farmer	0 = female (reference category) 1 = male	+
FarmExp	Number of years in crop farming	Years	+
OffFarmEng	Off-farm economic engagement	0 = not economic engagement off-farm (reference category) 1 = economic engagement off-farm	+
Marital	Marital status of farmer	1 = married 2 = Single 3 = Divorced 4 = Widowed (reference category)	+

Educ	Highest level of formal education attained	1 = None (reference category) 2 = Primary 3 = Junior High School 4 = Senior High School	+
GovSup	Government Support	0 = Have ever received (reference category) 1 = Have never received	+

The rationale for the inclusion of these variables is that previous studies have found farm size, education level and age to positively impact on a person's willingness to pay for agricultural insurance (Seth, Ansari and Datta, 2009; Kong, Turvey, He, Ma and Meagher, 2011; Liesivaara and Myyrä, 2014; and Ullah et al., 2015). Governmental assistance in events of devastating weather events on the other hand, impact negatively on willingness to pay for insurance (Khuu and Weber, 2013). Other factors like farmers years of farming experience, off-farm engagements that earn them income and land occupancy status can help determine their willingness to pay for insurance. Moreover, the findings from previous researches on the impact of some of the variables on willingness to adopt agricultural insurance have been inconclusive as were shown in the literature review and hence worth testing to contribute to the arguments in the literature.

Household size was not included in the model because the study is conducted at the individual level instead of the household level. Moreover, two farmers selected at random could be a couple who might have the same family and hence including household size could distort the results since two farmers from the same household would result in a double count. Location of farmland was not also included in the model because the whole region is being covered. Moreover, not only work stations are used to record indexes like rainfall. Other technologies like the satellite imagery are also used to capture rainfall or precipitation level irrespective of where the farm land is located. Also, price was not included because commercial insurance products have been non-existent and for that matter prices of such insurance products are less known or unknown by farmers who are expected to be one of the active parties in the insurance contract.

3.6 Pricing Rainfall-Indexed Agricultural Insurance

After the determination of farmers' willingness to adopt agricultural insurance, the next step of the study is to measure how much premium would be fair to charge, besides the insurers' administrative charges and profit margin, so as to peg it against how much the would-be insured would be willing to pay. In pricing index insurance, the conventional way of determining the pure insurance premium is by ensuring "that the present value of expected premiums is equal to the present value of expected losses and expected cost for providing insurance coverage" (Biener, 2012, p.133). Daron and Stainforth (2014) expressed premium as a function of expected loss in yield and policy loading. Martin, Barnett and Coble (2001), Assa (2015) and Choudhury et al. (2015) among others have used diverse forms of derivatives contracts to price weather-related insurance mostly using yield.

Taib and Benth (2012) expounded the classical and index modeling approaches by Jewson and Brix (2005) to develop an index insurance pricing formula for crops in the cold regions. This study seeks to adopt the standard form of weather insurance pricing model postulated by Taib and Benth (2012) to come out with another form of derivative pricing measure of calculating pure premium of weather index insurance for food crops in the temperate regions.

The study introduces variables such as sum insured, crop growing period and trigger period which have not been used jointly in determining premium of indexed insurance by previous researchers. Sum insured is the amount of money a person wishes to insure against a peril. It is also, the amount an insurer will pay to the insured in the event of a peril, barring any percentage agreement in the insurance agreement. Sum insured will be included in the derivate measure to allow for the portion of a farmer's expected yield income he or she wishes to insure against weather related perils. It will also represent the expected loss for which when discounted will contribute in the determination of the premium as noted by Biener (2012) and Daron and Stainforth (2014). Again, since different crops take different time period to mature after planting, crop growing period will been included to take care of the maturity period of the specified crop of the insurance contract. Also, with the measure being a derivative one, a threshold of the index below which the payment of indemnity to the contract will be triggered should be included. Notwithstanding the inclusion of the trigger level of the index being used, trigger period will also be included to cater for the period for which a trigger must persist to warrant the payment of indemnity. This is because the objects of discussion under such contracts are crops and crops do not mature in a day. Therefore, it is imperative to include a period for which a distortion in growth within the crop growing period can affect yield to trigger the payment of indemnity and hence, its inclusion in the derivative measure.

The joint usage of these variables is expected to take away the assumption of a monetary conversion factor used by some authors. Moreover, it is expected to provide the premium as a percentage of the sum insured which will give farmers who are willing to use index insurance the flexibility of choosing which ever amounts of yield income they would want to insure against its variability.

Katie School of Insurance (2011) and Duangmanee and Fransen (2013) among other authors have found rainfall to be positively correlated with yield losses and since the area for the study is prone to drought, the study will use rainfall as the index. Also, maize will be used as the crop to experiment the measure of calculating premium. Maize will be used because nearly all the regions of Ghana are accustomed to maize dominant staple foods.

Following Taib and Benth (2012) who expressed the fundamental premium equation of the form, $X(\tau_1, \tau_2) = k \times \sum_{s=\tau_1}^{\tau 2} \max(T\,(s) - c, 0)$ where **T** is the trigger for the index insurance, ***c*** measures the critical temperature level, **k** is the conversion factor into money and τ_1 to τ_2 being the time period.

This study extends payout of rainfall index insurance expressed as:

$$\text{Indemnity/Payout} = \max\left(\mathrm{E}\left[\frac{\mathbf{T-L}}{\mathbf{T}} \times \frac{\mathbf{SI}}{\mathbf{CGD}}\right] \times \mathrm{TP}\,, 0\right) \qquad \textbf{(4)}$$

Where:

- **T** = Threshold or trigger (rainfall in this case) of the indexed insurance. This is the level of rainfall below which payouts are expected be made to farmers. Rainfall is measured in millimeters.
- **L** = The possible levels of daily rainfall over the crop growing season- measured in millimeters
- **SI** = Sum insured: the amount of expected earnings or income from crop yield that a farmer will be willing to insure- this is measured in Ghana Cedis (GH¢)

- **CGD** = Crop Growing Days: the period it takes from when the crop is planted till when it matures- measured in days
- **r** = Discount rate: this is the rate at which the expected payout will be discounted- the Government of Ghana Treasury Bills rate will be used as proxy
- **t** = The period for the indexed insurance contract: intuitively, it is the period between planting and harvesting or the period of the planting season- it is measured by dividing the crop's growth months by the number of months in a year, 12 months.
- **E** = This refers to the expectation that actual rainfall levels might possibly fall to different levels below the trigger level.
- **TP**: Trigger period- the number of days which when a trigger persists it will call for the payment of indemnity.

In case of peril which is described as trigger, that is rainfall falling below the threshold, an insured is expected to receive the indemnity or nothing (zero) in the absence of a trigger as stated in equation **4** above. The payout as expressed in equation **5** below is determined by deducting the various possible levels of rainfall recorded in a day from the trigger and then divided by the trigger to know the proportion of loss in rainfall. The expectation of these are taken and multiplied by the sum insured per day for the crop growth period (days). The resultant is multiplied by the number of days the trigger must persist to warrant the payment of indemnity. This is so because a single day's shortfall in rainfall is not a guarantee enough to say there is drought for which reason the crop will fail and should therefore warrant the payment of indemnity.

$$\text{Payout} = e^{-rt}E\left(\frac{T-L}{T} \times \frac{SI}{CGD}\right) \times TD \qquad \textbf{(5)}$$

Pure premium in percentage terms is determined by dividing the payout by the sum insured and multiplied by 100%. Premium which is the price of the rainfall index insurance is expressed as:

$$\text{Premium, P}(\%) = \frac{\left[\mathbf{e}^{-\mathbf{rt}}\,\mathbf{E}\left(\frac{\mathbf{T-L}}{\mathbf{T}} \times \frac{\mathbf{SI}}{\mathbf{CGD}}\right) \times \text{TD}\right]}{\text{SI}} \times 100\% \qquad \textbf{(6)}$$

The next chapter presents the data used, the results and the discussion of the results. IBM SPSS Statistics 20 and Microsoft Excel will be used to run the results. Moreover, tabular and graphical presentations will be employed to enhance clarity in presenting the results for the analysis.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the analysis of the results. The results were processed from the data collected from the field and it seeks to answer the questions posed in the introductory chapter. The data collection was driven by the quest to identify prevalent agricultural risks facing farmers, their preferred agricultural risk management methods, to determine farmers' willingness to adopt agricultural insurance as a risk management option, and to determine how much they will be willing to pay for rainfall-indexed insurance in case they want to adopt that option. These objectives were met. The findings from results in this chapter are foundational to the conclusions and recommendation drawn.

4.1 Response Rate

A total of 384 questionnaires were administered to gather data from respondents. The questions were personally administered by the researcher. Some of the respondents who were literate filled the questionnaires handed over to them themselves. For those who were illiterate, the questions were read, translated to them and filled by the researcher as they provided answers to the questions. 300 out of the 384 representing 78% were retrieved and used for the analysis.

4.2 Demographics of Farmers

This section describes the statistical data taken from sampled farmers. Data were on both farmer and farm characteristics. The variables under considerations are farmer's age, years of crop farming experience of farmer, gender, marital status, highest level of education of farmer, land occupancy status, crop farm size, coefficient variation of farm incomes and off-farm engagement of farmer.

Table 4.1: Descriptive Statistics of the Continuous Variables

	N	Minimum	Maximum	Mean	Std. Deviation
Coefficient of Variation of Farm Income	300	.13	.53	.2914	.06493
Farm Size	300	1.5	11.0	4.712	2.0392
Farmer's Age	300	24	65	41.31	11.053
Crop Farming Experience	300	5	40	13.67	8.221
Valid N (listwise)	300				

Source: Field Survey Data (2017)

The coefficient of variation of farm income was calculated using the past five years of farmers' incomes: 2011 to 2015. This is used as a proxy for risk taking of farmers instead of just the standard deviation because of its normalizing effect. The mean coefficient of variation of farm income of 0.2914 shows that for every 1 return of farm income earned, a farmer bear a 0.2914 level of risk and the minimum risk-return ratio being 0.1. This indicates that farm incomes are quit variable and thus, there is the need for farmers to take adequate measures to decrease the risk of variability in their farm income as much as possible in order to maximize their returns and enhance their chances of expansion.

Farm size represents the size of land the farmers use in cropping and not the total land size owned by the farmers, including those they use for other agricultural and non-agricultural purposes. This is used in the study to ensure that farmers' willingness is tied exclusively to mitigating the variability in their returns from cropping that land and not any other activity engaged in on the land. The size of their farm lands, ranging from 1.5 to 11 acres with a mean of 4.7 acres gives is an indication that these farmers operate on small scale type of farming.

The ages of the farmers range 24 to 65 years with a mean age of 41.31 years. This falls within the class of economically active and energetic individuals as classified by the Ghana Statistical Service. Pegging their ages with their level of farming experience, it can be inferred that these farmers have been in the business for quite a period of time such that they are very much aware of the challenges they face and have somehow been trying to manage them. Farming experience in this study is defined as the number of year an individual has been farming on his own (not for anybody as a labourer), taking every decision concerning his/her farming, including the choice of risk management strategy. The minimum crop farming experience is 5 years. This is so because data were taken on farmers' past five years farm incomes and hence a famer was expected to have at least 5 year farming experience before he/she could be included in the study. The mean years of farm experience of 13.67 (approximately 14) years indicates that the farmers sampled are well vexed in farming and have battled with managing risk long enough to be able to determine which risk management techniques work for them as well as whether they are willing or not to use agricultural insurance.

Table 4.2: Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	118	39.3	39.3	39.3
	Male	182	60.7	60.7	100.0
	Total	300	100.0	100.0	

Source: Field Survey Data (2017)

The region, as noted earlier has more females (51.4%) than males, however, the results from the data gathered as shown in Table 4.2 indicates that there are more males (60.7%) who are engaged in agriculture than females. This is probably so because the region practices patrilineal inheritance and thus females are less likely to own land and hence less likely to be engaged in agriculture compared to males. Moreover, they people are engaged in small scale farming, more labour intensive than a mechanized form of agriculture and therefore majority of them use their own strength and effort instead of hiring labour. Due to these reasons, more men are engaged in this venture than females.

Table 4.3: Land Occupancy Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Family owned	43	14.3	14.3	14.3
	Personally owned	127	42.3	42.3	56.7
	Rented/Lease holding	130	43.3	43.3	100.0
	Total	300	100.0	100.0	

Source: Field Survey Data (2017)

The data collected indicated that only 42.3% of the farmers sampled as shown in Table 4.3 owned the lands on which they farm. Due to the patrilineal nature of the region, majority of those owning land are males. The few females who own lands are lands which were bought by their husbands and have been reverted to them after their death. The probability of getting a married woman who owns a farmland is very low. Also, majority (43.3%) of the farmers were using lands they rented. Majority of these rented farmlands are located around the municipality (Wa Municipal). The landowners of these rented farmlands are engaged in some form of trading or work in other formal organizations and have leased their lands for others to farm on them. The remaining 14.3% were using lands which they did not own or rent but were freely lease to them by their families to use.

Table 4.4: Farmer's Marital Status

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	267	89.0	89.0	89.0
	Single	14	4.7	4.7	93.7
	Widowed	19	6.3	6.3	100.0
	Total	300	100.0	100.0	

Source: Field Survey Data (2017)

As shown in Table 4.4 above, only 11% of the farmers involved in the study are not married (single and widowed). The number of farmers sampled who are single are all men. This is the case because of the culture of the region. Lands are shared among only the male children of a father. A female will only own a land possibly after the death of her husband who should personally have owned the land or will only use part of the land which belongs to her husband. Until she is married, she continues to work for her father. The widowed farmers in this study were dominantly females with only one being a male. Some of the widows owned the lands they were using whereas the others are using family and rented lands.

Table 4.5: Highest Level of Formal Education Attained

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	224	74.7	74.7	74.7
	Primary	23	7.7	7.7	82.3
	JHS	27	9.0	9.0	91.3
	SHS	26	8.7	8.7	100.0
	Total	300	100.0	100.0	

Source: Field Survey Data (2017)

Table 4.5 indicates that most of the farmers sample do not have formal education with only about 16% of them who have received basic formal education (Primary and JHS). This may be attributed to the fact that the region is one of the poorly resourced in Ghana and therefore lacked adequate educational facilities during the school going stage of such farmers. Moreover, those who cannot afford to formally educate their wards resort to infusing them into what they do for living which is agriculture. The high level of illiteracy suggests that the probability that farmers are exposed to modern risk management methods and techniques is low.

4.3 Risks Faced by Crop Farmers

Table 4.6: Common Risks Farmers face

Production related risks	Frequency	Percent
Drought	300	100.0
Storm	42	14.0
Pest	28	9.3
Flood	15	5.0
Bush fire	3	1.0

Source: Field Survey Data (2017)

The most prevalent and devastating risk that affect the farming activities of the sampled farmers is drought. All 300 confirmed that they have been affected by drought over the years. This is consistent with the findings of Katie School of Insurance (2011) who also found drought as the greatest peril to crop production in the northern part of Ghana. The next devastating peril elicited by the farmers is storm. 14% of the farmers have ever had storms uprooting their immature crops. Storms were prevalent mostly among farmers in the middle belt of the region. 9.3% and 5% of the farmers as shown in Table 4.6 have also been affected by pests and floods respectively in some planting seasons. Pests are among the less pervasive because they can curbed with pesticides.

Floods were prevalent mostly among farmers in the southern belt of the region. This is as a result of the nature of some of farmlands those affected farmers in that area use. Those lands are not able to absorb rainfall faster causing stagnation and floods consequently. Thus, the issue of floods is more of stagnation than excess rainfall. Bush fires are the lowly rated peril crop farmers in the region face, with only 1% of the farmers ever haven been affected by its menace. This is probably the case since bush fires usually occur in the region around the dry season by which time most farmers would have already harvested their crops. Notwithstanding, virtually all risk factors are difficult to control with others being uncontrollable and their occurrence have adverse effect of farm yield and consequently, affects the stability farmers expect from their yields and hence it is needful for them to take adequate steps to mitigate their adverse effects.

4.4 Informal Risk Management Strategies

The first objective this study also seeks to achieve is to identify the risk management methods farmers use to mitigate the production risks they faced in order to smoothen their farm yields and incomes from one cropping season to another. The results from the field data collected have been presented below in Tables 4.7 and 4.8.

4.4.1 On-farm Risk Management Strategies Used by Crop Farmers

Table 4.7 below shows the results of the risk management strategies taken by the farmers on the farm in order to reduce yield variability.

Table 4.7: On-Farm Strategies used by Farmers

On-farm strategies	Frequency	Percent
Mixed cropping	300	100.0
Using improved seeds	300	100.0
Timing planting	300	100.0
Mixed farming	74	24.7
Irrigation	2	0.007

Source: Field Survey Data (2017)

The results from the data show that all the sampled farmers employ mixed cropping, the use of improved seeds and timing planting. Farmers usually do a mix of legumes (cowpea, bean and groundnut) and cereals (maize, millet, wheat and sorghum) so as to ensure that they can get their expected yield at least for one of those two classes since they both do not require the same amount of water in their production. Moreover, as one class of crops pulls a lot of nutrients from the soil, another fixes nutrients into the soil. This helps improve soil fertility and maintain yield level of the crops. Also, farmers use improved seeds which are drought resistant. Such seeds thrive with minimal rains and thus, help them maintain yield levels amidst low levels of rainfall. Again, farmers also time planting. Most of them plant after the second or third rain in May. Others wait till June before planting. This is solely based on the farmers' judgment which is dependent on how they perceive the rainy season will be with respect to timing of the onset of the rains in the year. They do that to ensure that the crops are planted at the right time so they get enough rains to grow and produce the maximum expected yield. These findings are consistent with the findings of Korir (2011) and Tambo (2016) and this is due to the fact that these methods of mitigating weather variability related risks have become more of conventions among farmers in Ghana and Africa than planned strategic decisions taken to tackle such issues.

Other farmers do a mix of crops and animals (usually fowls, guinea fowls, goat, sheet and cattle) which is known as mixed farming. This is done by the male farmers. They do this to compensate crops yield and income losses with revenues from the sale of their reared animals to save some funds for the next planting season. Irrigation is however, nearly nonexistent in the region. Only 0.007% of the farmers practice irrigation, all of whom were male farmers. The type of irrigation practiced by farmers is a small scale type where such practicing farmers move from their original farms to cultivate crops on lands located around nearby streams and rivers which are usually rented. This is so because little have been invested in irrigation and on the whole, very few irrigation facilities are available in Ghana as noted by Katie School of Insurance (2011) and Choudhury et al. (2015). These findings are in accordance with that of Tambo (2016) who opined that these strategies are less expensive strategies for farmers to use among others like avoiding the use of risky agricultural technologies.

4.4.2 Off-farm Risk Management Strategies Used by Crop Farmers

Table 4.8 below shows the results of the risk management strategies taken by the farmers off the farm in addition to the on-farm strategies all geared towards reducing the variability in their farm income.

Table 4.8: On-Farm Strategies used by Farmers

Off-farm strategies	**Frequency**	**Percent**
Cooperatives	210	70.0
Off-farm engagement	62	20.7
Seasonal migration	26	8.7
Storage for later sales	22	7.3

Source: Field Survey Data (2017)

Off-farm, farmers use strategies such as forming cooperatives, taking on some profitable economic engagements, migrating to farm in other regions in the mid and southern parts of Ghana and storing up part of their yields from the previous years for later sales, all in the quest to smoothen their incomes from one season to another.

70% of the farmers sampled are joined in farmer cooperatives, 40% of whom are males. Cooperatives serve as avenues where members make periodic contributions from their farm incomes which are saved in money boxes or with agreed financial institutions from which they can access credit at very low interest rate. Moreover, periodic distribution of part of the funds are given to members to start the next season's farming activities. This helps members with available funds to continue their agricultural operations and hence, eliminates the possible ceasure in any planting season. Some of the farmer cooperatives in the region are Sumbawere, Sunwere, Suntaa, etc which translated from the Dagaare dialect mean "help raise up" or "help one another". This confirms that of Zhang and Hui Huang (2014) and Machinski et al. (2015) who enlisting farmer cooperatives as one way by which farmers mitigating income variability off the farm.

Also, 8.7% of the farmers do migrate to farm in other regions in times of drought in their original place of residence. Farmers who employ this strategy are males. The females in times of such droughts do other off-farm work or depend on what they have till the next planting season. Moreover, most of the farmers engaged in seasonal migration are those with either no or only primary formal education. They either rent farms and share the yields with the farmland owners or work on people's farmlands as labourers and get paid wages by day, at the end of the week, or when the contracted engagement have been completed. Again, some farmers store part of their yields, usually excess expected yields, from previous farming season and sell in current farming season where yields were below expectation. This is usually done for nonperishable crops. Farmers who use this method want to smoothen their income year on year. Older and more experienced farmers as well as farmers with higher levels of formal education were found to use this strategy of stabilizing farm income. 7.3% of the sampled farmers make use of this strategy to reduce income variability. Tambo (2016) also reported these as some off-farm methods farmers in the Upper East region use. This study confirms same for crop farmers in the Upper West, the area of study for this study.

A number of the farmers, 62 representing 20.7% of the sampled farmers are also engaged in other economically rewarding endeavours alongside farming, their main occupation. As a result of the high variability in rainfall and drought risk in the region, some of the farmers have resorted to engaging in some other works to supplement their farm income. The proportion of the farmers engaged in off-farm activities (20.7%) lies between what was reported by Korir (2011) for Kenya and Oseni and Winters (2009) for Nigeria. They reported 59% and 17% respectively. The country to country variations could be down to individual preferences in either one job or combining jobs as well as the availability of jobs in the above mentioned countries. Also, it could be a reflection of the severity of the variation in yield and income levels and the rate at which it necessitates farmers' engagement in off-farm income yielding activities, with a high rate representing a high variation in yield and participation in off-farm engagements and vice versa. Table 4.9 shows the kind of work such farmers are engaged in off-farm as well as the number engage in each kind of work and their respective proportions.

Table 4.9: Gainful Off-farm Economic Engagements of Farmers

Gainful Economic Activities	Frequency	Percent
Masonry	8	12.9
Mechanics	4	6.5
Bar	1	1.6
Charcoal burning	7	11.3
Local spices making	7	11.3
Pito brewing	8	12.9
Sale of indigenous cake	10	16.1
Rice processing	5	8.1
Tobacco selling	2	3.2
Shea butter making	10	16.1
Total	**62**	**100.0**

Source: Field Survey Data (2017)

The numbers of farmers who are engaged in masonry, mechanics (repairs of bicycles and motor bikes) and bar (sales of soft and strong drinks) are all males whereas those engaged in burning of charcoal, making of local spices ("dawadawa"), sale of indigenous cake ("koose"), shea butter, rice processing and the brewing of local gin ("pito") are all females. This finding is consistent with that of van den Berg and Kumbi (2006) who found females dominating in businesses which have to do with the sale of food and drinks in rural Oromia, Ethiopia. This is also the case in Ghana due to the cultural orientation which classifies such jobs into male and female jobs.

4.5 Formal Agricultural Insurance Contracts

Table 4.10: Farmers who have formal insurance contracts

Response	Frequency	Percent
Yes	0	0.0
No	300	100.0
Total	300	100.0

Source: Field Survey Data (2017)

None of the farmers sampled currently have formal agricultural insurance contract, as seen in Table 4.10 above. Notwithstanding, data gathered from farmers also indicate that 90% of the farmers sampled as show in Table 4.11 below are willing to purchase or adopt agricultural insurance. For farmers who were willing to use agricultural insurance, their reason for not currently having formal insurance is because they did not have access to such products and for that matter, resort to using informal risk management methods (on-farm and off-farm). For the remaining 10% who are not willing to use formal insurance, the reason for them not having and not going to use formal insurance at least in the near future is because insurance is not necessary and by that they are content with the methods they are using to minimize their exposure. These reasons are so because formal agricultural insurance is still in its budding stage in Ghana unlike other developed countries where Skees and Barnett (2006) enumerated high cost of transaction, asymmetric information and poor contract enforcement as some of the reasons for the non-usage by some farmers.

Table 4.11: Willingness to Adopt Index Insurance

		Frequency	Valid Percent
Valid	Not willing	30	10.0
	Willing	270	90.0
	Total	**300**	**100.0**

Source: Field Survey Data (2017)

4.6 Willingness to Adopt Agricultural Insurance

4.6.1 Assessing Willingness to Adopt Agricultural Insurance

The factors that were used in the logistic model for determining farmers' willingness to use agricultural insurance are coefficient of variation of farm income (CVInc), farm size (FarmSize), land occupancy status (LandOcc), gender, number of years of farming experience (FarmExp), off-farm engagement (OffFarmEng), marital status (Marital) and level of farmer's education. Farmer's age (Age) is highly correlated with years of farming experience (0.809) as seen in the Table 4.12 and was therefore excluded from the analysis. Moreover, years of farming experience was used instead of farmer's age because being older does not necessarily mean an individual has more farming years of experienced than a younger person. Also, government support was excluded from the analysis because the results from the field survey indicated that none of the farmers sampled had ever received government support for any past catastrophic weather event and as such cannot base on that to make informed decision as to whether they will be willing to adopt index insurance.

Table 4.12: Correlation Matrix

	CVInc	FarmSize	LandOcc	Age	Gender	FarmExp	OffFarmEng	Marital	Educ
CVInc	1								
FarmSize	0.028	1							
LandOcc	-0.057	-0.487**	1						
Age	0.028	0.390**	-0.547**	1					
Gender	0.094	0.437**	-0.485**	0.049	1				
FarmExp	-0.001	0.294**	-0.523**	0.809**	0.148*	1			
OffFarmEng	-0.013	-0.110	0.128**	0.061	-0.381**	-0.025	1		
Marital	-0.024	-0.034	-0.181	0.283**	-0.101	0.236**	0.037	1	
Educ	-0.060	-0.164**	0.127	-0.410**	0.189**	-0.285**	-0.026	-0.081	1

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

The logistic regression results for the determinants of willingness to adopt agricultural insurance is shown in Table 4.13 below but before that it is necessary to identify the reference categories of the various categorical explanatory variables used in the binary logistic regression analysis. Firstly, the reference category for land occupancy status is family owned land, with LandOcc(1) and LandOcc(2) being personally owned and rented respectively. Secondly, the reference category for gender is female, with Gender(1) representing male. Thirdly, the reference category for off-farm engagement is farmers who are economically engaged off-farm whiles OffFarmEng(1) represents farmers who not economically engaged off-farm. The reference category for marital status is widowed, with Marital(1) and Marital(2) representing married and single respectively. Lastly, the reference category for highest level of formal education attained is farmers with no formal education, with Educ(1), Educ(2) and Educ(3) being farmers with basic, Junior High and Senior High levels of formal education respectively.

Table 4.13: Logistic Regression Outputs for Willingness to Adopt Agricultural Insurance

		B	S.E.	Sig.	Exp(B)
Step 1[a]	CVInc	7.871*	3.578	.028	2619.038
	FarmSize	.146	.137	.286	1.157
	LandOcc			.043	
	LandOcc(1)	.247	.775	.750	1.280
	LandOcc(2)	-1.228	.705	.081	.293
	Gender(1)	-1.544*	.611	.011	.213
	FarmExp	-.021	.032	.507	.979
	OffFarmEng(1)	.105	.636	.869	1.111
	Marital			.044	
	Marital(1)	1.874*	.789	.018	6.515
	Marital(2)	1.451	1.175	.217	4.269
	Educ			.474	
	Educ(1)	1.044	1.116	.349	2.842
	Educ(2)	.002	.758	.998	1.002
	Educ(3)	-.656	.637	.303	.519
	Constant	-.503	1.533	.743	.604
Pseudo R	Cox & Snell R Square	.095			
	Nagelkerke R Square	.198			
Omnibus Tests		29.877		.003	
Hosmer and Lemeshow Test		8.084		.425	

$*p < 0.05$
Source: Field Survey Data (2017)

The logistic regression results for the determinants of willingness to adopt agricultural insurance show that coefficients of coefficient of variation of farm income, gender and marital status are statistically significant.

The coefficient for coefficient of variation which is a ratio of risk and return is 7.871 with an odd ratio of 2619.038. This is positive and statistically significant in determining willingness. It indicates that the higher the risk-return ratio of a farmer's farm income, the higher the likelihood of the farmer adopting agricultural insurance. This finding concurs with that of Seth, Ansari and Datta (2009) who also found high risk correlating positively with willingness to adopt insurance. This is also consistent with the risk-return theory of high risk, high return in Finance. Moreover, every rational economic agent seeks avenue to minimize his/her risk to maximize returns. This therefore explains the positivity in farmers' willingness to adopt agricultural insurance. The odd ratio of 2619.038 further implies that farmers with higher variation in farm income are 2619.038 times more likely to purchase agricultural insurance than farmers with lower risk to return ratio of farm income. This is the case because people with higher risk exposures are more aggressive in seeking avenues to mitigate their exposures compared to those with lower risk exposures.

Gender has a coefficient of -1.544 and an odd ratio of .213. It is negative and statistically significant in determining willingness to adopt agricultural insurance. The coefficient of -1.544 indicates that a male farmer, would be less likely to adopt agricultural insurance compared to a female farmer. This finding is consistent with that of Lin et al. (2015) who also found women to be more likely to adopt agricultural insurance compared to men. This also supports the popular notion which has also been supported in empirical literature that females are more risk averse compared to men (Khuu and Weber, 2013). The odd ratio of .213 implies that a male farmer is .213 times less likely to adopt agricultural insurance than a female farmer.

The coefficient for married farmers is 1.874 with an odd ratio of 6.515. This is also positive and statistically significant in determining willingness to adopt agricultural insurance. The coefficient of 1.874 indicates that a married farmer, would be more willing to adopt agricultural insurance. This finding is also agrees with that of Ullah et al. (2015). This is probably the case because married farmers most likely might have to share their income with their dependants, nuclear and/or extended family members, and would more likely take any measure which stabilizes their income. The odd ratios further support this assertion with that a married farmer being 6.515 times more likely to adopt agricultural insurance than a farmer who is not married (either single or widowed) and that of the single being 4.269 times more likely to adopt agricultural insurance than a widowed farmer.

Land size (0.146), personally owning farmland (0.247), having off-farm engagement (0.105) and having lower level of formal education positively impact on willingness to adopt insurance as also seen in other studies discussed in the literature review. Also, acquiring many years of farming experience (-0.021), renting farmland (-1.228) and acquiring higher level of formal education (-0.656), on the other hand, negatively impact on willingness to adopt insurance as seen in extant literature. However, all these variables are statistically insignificant in determining willingness to pay for agricultural insurance.

4.6.2 Model Diagnostics

The Omnibus Tests of Model Coefficients gives a Chi-Square of 29.877. This is significant at 1%. The Omnibus Test tests the null hypothesis that including the coefficient of variation of income, farm size, land occupancy status, gender, years of farming experience, off-farm economic engagement and education in the model has jointly not significantly increased the ability to predict willingness to adopt agricultural insurance. Hence, we therefore reject the null hypothesis and conclude that they are jointly significant. Also, the Nagelkerke R Square in Table 14 indicates that 9.5% to 19.8% of the variability in the dependent variable, willingness to adopt agricultural insurance is explained by the independents variables. Furthermore, the Hosmer-Lemeshow tests the fitness of the model with the data. The null hypothesis is that predictions made by the model fit perfectly with the sampled data. The non-significant chi-square in Table 14 indicates that the model fits the data well. Also, there is a moderate correct prediction for willingness to adopt agricultural insurance of 89.3%.

4.6.3 Model Prediction

The model shown below can now be used to predict the likelihood that a farmers will or will not be willing to adopt agricultural insurance as a risk management method for mitigating yield and income variability.

$$\text{WTP} = ln\left[\frac{P}{1-P}\right] = -.503 + 7.871CVInc_i - 1.544Gender_i + 1.874Marital_i$$

Given two married farmers, a male and a female with same coefficient of variation in farm income of 0.291 (the mean CVInc from the descriptive statistics), the probability that they will be willing to use agricultural insurance are as follows:

$$ODDS = \ e^{(\sum B_i)}$$

$$ODDS(male) = e^{-0.503+7.87(0.291)-1.544+1.874} = 8.306$$

$$ODDS(female) = e^{-0.503+7.87(0.291)-1.544(0)+1.874} = 38.906$$

$$\text{Probability}, P = \frac{e^{(\sum B_i)}}{\left(1 + e^{(\sum B_i)}\right)}$$

$$P(males) = \frac{8.306}{1 + 8.306} = 89 = 89\%$$

$$P(females) = \frac{38.906}{1 + 38.906} = 0.97 = 97\%$$

Therefore the probability that a married man and a married woman with CVInc of 0.291 will be willing to use agricultural insurance are 89% and 97% respectively.

4.7 Determination of Pure Premium as Against How Much Farmers are Willing to Pay

As much as it is necessary to know whether farmers are willing to adopt agricultural insurance as a means to mitigating yield and income variability, it is however not sufficient since price also plays a key role in the wider equation. Thus, it is important to consider price since exorbitant price charges on agricultural insurance contracts for example could negatively affect farmers' adoption. This section therefore seeks to answer the third and fourth questions which achieve objectives 3 and 4. It seeks to measure the price (pure premium) of a weather indexed insurance whose index is rainfall and to juxtapose it with what farmers are willing to pay in order to arrive at a conclusion on how much will be in farmers ability to pay should such an insurance product or contract be created by insurers for Ghanaian farmers.

4.7.1 Determination of Pure Premium of a Rainfall-Indexed Insurance Contract

In pricing indexed insurance, Hess et al. (2005) advise that yield losses should positively correlated with the respective index being used, otherwise, a basis risk might arise. This is the risk of a miss match between premiums received and payout which has adverse effect on parties to the insurance contract. In view of this, the study first seeks to establish the relationship that exists between yield and rainfall, the index being used to determine the price for this index insurance.

4.7.2 Relationship between Rainfall and Yield in the Upper West Region

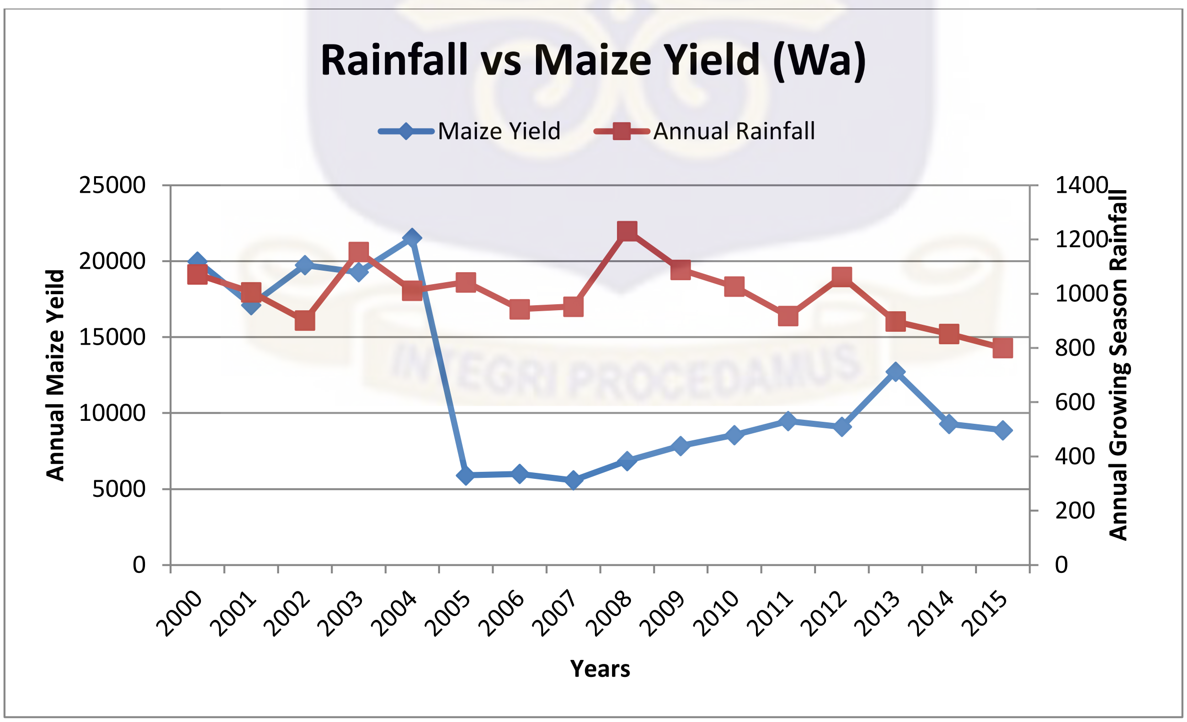
Annual yield data were matched with annual rainfall data for the period of 2000 to 2015 and used to establish the relationship between them. The period above was used because of unavailability of data for some of the years prior to 2000. Also, annual rainfall data and annual yield for Wa Municipal was used as proxies for the region. Figure 4.1 and Table 4.14 are the results showing the relationship between rainfall and yield for maize, a prime crop for most staple foods in Ghana.

Table 4.14: Regression of Rainfall on Maize Yeild for the Wa Municipal

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0	#N/A	#N/A	#N/A
Annual Rainfall	11.67946	1.442942	8.094198	7.45E-07

Source: Researcher's analysis of data from MoFA and GMet (2017)

Figure 4.1: Graphical representation of the relationship between rainfall and yield



Source: Researcher's analysis of data from MoFA and GMet (2017)

Figure 4.1 shows that rainfall is positively correlated with yield and hence a fall in annual rainfall indicates a fall in yield. It however does not show a perfect positive correlation since years like 2002, 2005, 20011 and 2013 indicates the vice versa, showing negative correlations between rainfall and yield. This may be attributed to the use of improved seeds which might not need so much water to thrive. Notwithstanding, it shows a significant patterns of correlation between them. Also, Table 4.14 show a positive correlation between rainfall and yield with a positive coefficient of 11.67 which is significant at 95% confidence level. In conclusion, both the graph and regression indicate positive (though not perfect) relationship between yield and rainfall. This is consistent with the finding of Katie School of Insurance (2011) who found same in the Northern Region of Ghana. This positive relationship therefore permits use of rainfall as an index to price index insurance contract for farmers in the area of the study.

4.7.3 Derivative price measure of calculating pure premium for Rainfall Index Insurance

The variables used in this derivative measure of calculating the actuarial (fair) value of the indexed insurance which is also known as the pure premium are sum insured, crop growth days, trigger, levels of index, trigger days, interest rate and time. The sum insured is the amount of the farmer expects to earn from his or her harvest against which he/she wants to insure its variability. It is represented in the formula as **SI**. The crop growth days is the planting to maturity period of the crop being insured. This is represented in the formula as **CGD**. The **CGD** is calculated by dividing the number of days it takes to cultivate the crop by the number of days in a year. The trigger represented as **T** is the level of the index (rainfall) below which drought is perceived to have occurred and indemnity expected to be paid to the insured. The levels of the index represented with **L** are the possible levels the index (rainfall) could fall below the trigger. Trigger days, **TD** is the length of time (in days) that trigger must persist to warrant payment of indemnity. The interest rate, **r** is the rate at which the payout is discount to its present value as well as the rate at which the premiums can be invested by the insurer. Time, **t** is the period of the insurance contract which is also the period from planting to maturity of the crop being insured. This is calculated by dividing the number of month from planting to maturity divided by the number of months in a year.

The GAIP, the only agricultural insurer which is in the process of rolling out its maiden commercial drought index and multi-peril insurance products has established that drought exists if rainfall recorded during the rainy-planting season is below 2.5 mm per day and persists for 10 consecutive days in any of the insured crop's development stages over the crop's growth period with an accumulated rainfall below 25 mm.

The derivative measure for calculating pure premium is therefore expressed as:

$$\text{Premium, P}(\%) = \frac{\left[\mathbf{e^{-rt}\,E}\left(\frac{\mathbf{T-L}}{\mathbf{T}} \times \frac{\mathbf{SI}}{\mathbf{CGD}}\right) \times \mathbf{TD}\right]}{\mathbf{SI}} \times 100\% \qquad \textbf{(5)}$$

4.7.3 Model Testing

Using maize as the crop to test the model, the premium rate given the following data is calculated below:

Rainfall trigger level **(T)**	2.5 mm
Range of values below trigger (**L)**	0 to 2.5 mm
Crop growth months	4
Number of months in a year	12

Time **(t)**	0.333333
Interest rate **(r)** (BoG T.Bill rate as at March 2017)	0.175103
Sum insured **(SI)** GH¢	1000
Crop growth days **(CGP)**	120
Trigger days **(TD)**	10

$$\mathbf{Premium, P}(\%) = \frac{\left[e^{-0.1751*0.33}\ \mathbf{E}\left(\frac{2.5 - \sum_0^{2.5} L}{2.5} * \frac{1000}{120}\right) * 10\right]}{SI} * 100\% \approx 4\%$$

Taking another farmers who intends to insure GH¢ 100.00 for this same products, the premium percent will be:

$$\mathbf{Premium, P}(\%) = \frac{\left[e^{-0.1751*0.33}\ \mathbf{E}\left(\frac{2.5 - \sum_0^{2.5} L}{2.5} * \frac{100}{120}\right) * 10\right]}{SI} * 100\% \approx 4\%$$

The full output of the how the pure premium is calculated is shown in Appendix II.

The results imply that irrespective of the amount farmers will be willing to insure their yield for, once it is the same insurance contract or policy undertaken for the same crop with the same characteristics, each will have to pay the same percentage of his/her sum insured. Also, the 4% is the actuarial fair value or the pure premium without any loading such as administrative charges or processing fee and profit margins of the insured. Thus, given an agricultural insurance with a market price of 10% suggests that the remaining 6% is catering for the loading factor (administrative expense, taxes, processing fee, profit margin, safety buffer, etc.). The 4% pure premium arrived at from the derivative elicited in this study is not far from the finding of Ozaki (2009) who used a hierarchical Bayesian model and found a premium rate of 4.87%.

4.7.4 How Much are Farmers Willing to Pay for Rainfall-Index Insurance

The result from the data collected as presented in Table 4.15 below indicates that only 16.7% of the sampled farmers, also representing 18.55% of the farmers who are willing to adopt rainfall-indexed insurance will be willing to pay a premium below of 10% of the sum insured. 81.56% of the 90% of the farmers who are willing to adopt index insurance and also representing 73.3% of farmers sampled will be willing to pay a premium of 10% of the sums insured. Interestingly, 23.4% of those who are willing to adopt this risk management measure are even willing to pay as much as 10 % to 30% of sum insured should they have access to this measure. This further gives an indication that farmers are not only willing to adopt agricultural insurance but will also be able to pay if offered to them.

Table 4.15: Premium percent farmer will be willing to pay

Percentage of SI as Premium	Frequency	Percent
0%	30	10.0
2%	4	1.3
3%	7	2.3
3.5%	2	0.7
4%	5	1.7
5%	30	10.0
6%	2	0.7
10%	150	50.0
15%	17	5.7
20%	32	10.7
25%	16	5.3
30%	5	1.7
Total	300	100

Source: Field Survey Data (2017)

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter summarizes the whole study on agricultural risk management options and pricing of indexed insurance in Ghana, the main findings and the contribution of the study as well as the recommendations for policy implementation and further studies.

5.1 Summary of Findings

This research focused on identifying the most pervasive risks faced by farmers, the kind of risk management methods and strategies they utilize in managing such risks and whether they are willing to use agricultural insurance. The study also touched on measuring pure premium using a proposed derivative measure of pricing insurance and juxtaposing it how much farmers who are willing to adopt agricultural insurance will be willing to pay for such a contract or product.

All the farmers (100%) outlined drought as the most prevalent and devastating risk they face in their farming activities with the others being storm and pest. This could be attributed to the continuous increase in Ghana's mean annual temperature and the decrease in monthly rainfall which has the potency of increasing drought incidences. None of the farmers is currently using any formal insurance contract with reason either being the unavailability of agricultural insurance then or a sheer lack of need for their use. However, farmers make use of a portfolio of some on-farm and/or off-farm risk management strategies. The most common strategies employed by farmers are mixed cropping, use of improved seeds and timing best planting time. Other fairly used strategies are formation of cooperative, mixed farming and seasonal migration due to the lack of irrigation facilities. Quite a number of the farmers (20.7%), majority of who are females (16.3%)

supplement their farm incomes with income from non-farm activities.

90% of the farmers are however willing to adopt agricultural insurance. Using a logistic regression model, three variables were significant statistically in determining willingness to adopt agricultural insurance: coefficient of variation of farm income, gender and marital status. Farmers with higher coefficient of variation in farm incomes were more likely to adopt agricultural insurance. Female farmers and married farmers were found to be more willing to use agricultural insurance than male farmers and unmarried farmers. Farm size, land occupancy status, off-farm engagement and level of education positively impact on willingness but are however not significant in determining willingness to adopt insurance. Years of farming experience also negatively impact on willingness but is however in significant in determining willingness to adopt insurance.

Rainfall was found to be positively correlated with yield and was therefore used as index to formulate a derivative measure for calculating pure premium for rainfall index insurance which is a more welcoming type of agricultural insurance for a country like Ghana who is developing it insurance sector. The derivative pricing measure formulated yielded a pure premium rate of 4% of sum insured (excluding loading factor and profit loading of the insurer) for an index insurance for maize against drought. 73.3% of those willing to adopt insurance stated that they will be will to pay a premium of 10% of sums insured with the remaining 16.7% only willing to pay a premium less than 10% of the sum insured.

5.2 Conclusion

This study attempted to establish the prevalent risks facing crop farmers in Ghana and income and risk management strategies employed by mitigate the risks being faced. It also sought to empirically determine whether farmers are willing to adopt agricultural insurance, the factors that influence their willingness, determine premium and to examine how much farmers will be willing to pay for rainfall indexed insurance. From the study, it was found that drought, storms, pests, floods and bush fires are the risky peril that farmers face, with drought having the most devastating consequences on farmers' yields and income. The study also revealed that mixed cropping, use of improved seeds, timing planting, mixed farming, farmer cooperatives, engaging in other profitable off-farm economic activities, seasonal migration, and storing of excess yield for future sales are the strategies farmers adopt to mitigate the risks they face. This was due to the fact that the farmers do not have access to formal agricultural insurance. It was also found that farmers are willing to adopt agricultural insurance. The variation in farm income, gender and marital status of a farmer are the factors that significantly impact on a farmer's willingness to adopt agricultural. Finally, it was observed that farmers, though willing adopt agricultural insurance, will however savour a premium rate of 10% or below of sum insured.

5.3 Policy Recommendations

Following from the findings of study which pointed out the risks that famers face, there is the need for policies to be put in place by government to intensify education and agricultural extension services, construct irrigation facilities, and enhance accessibility of agricultural insurance to farmers all over the country.

The positive correlation between rainfall and yield found is an indication of reduction in the probability of basis risk and the willingness of farmers to adopt insurance form a solid base for take-off of index insurance in particular in Ghana. Stakeholders such as banks, insurance companies and government institutions should come on board to make use of the availability of market base to help grow this budding branch of the developing insurance sector. The coming together of these stakeholders will strengthen the protection base of the insurance and increase farmers' credulity and usage of agricultural insurance. With their expected farm incomes being assured by the use of insurance, farmers can access credit from financial institutions to expand which will eventually boost the growth of the agricultural sector, increase GDP, reduce poverty and increase economic growth and development.

The derivate measure for pricing index insurance put forward by this study can also be used by GAIP and other incoming agricultural insurers in the determination of fair premiums. It can be used to improve existing ones and help develop other pricing measures.

5.4 Further Research

This study focused on the determination of whether farmers are willing to adopt agricultural insurance or not. A further study can consider assessing the level to which farmers are willing to use agricultural insurance and the type of agricultural insurance they prefer. Moreover, the study did not cover the impact having agricultural insurance could have on output since agricultural insurance is in its inception stage in less developed countries like Ghana. A future study to that effect would be valuable. In addition, it will be advantageous to have other studies on other approaches to pricing yield index insurance and multi-peril insurance.

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APPENDICES

Appendix I: Questionnaire

UNIVERSITY OF GAHANA

This study is conducted under University of Ghana. This study is about the agricultural risks farmers face, the risk management methods they use, whether they will willing to adopt agricultural insurance and how much they will be willing to pay for it. Your help in answering these questions is highly appreciated. Your responses will be treated confidential.

Biographical Data

1. Age: …………………. years
2. Gender: **(tick one)** Male / Female
3. Marital Status: **(tick one)** Married / Single / Divorced / Separated / Widowed
4. How many people are in your household? …………………… people
5. What is the highest level of formal education you have had? **(tick one)**

   (a) Not at all (b) Primary (c) JHS (d) SHS (e) Tertiary
6. Do you farm? **(tick one)** Yes / No
7. How many years have you been farming on your own? ………… years

Farm Structural Characteristics

1. Where is your farm located? District: ………………………………................
2. What is the size (area) of your farm? In total (acres): ………………………
3. Area of land devoted to crops (acres): ……………………………………..
4. What kind of crops do you grow? **(tick all applicable)**

(a) Cereals (b) Tubers (c) Vegetables (d) Others

5. Which crop(s) specifically? …………………………………………………………….

6. What has been your farm yield for each of the past five years?

Year	Area (acres)	Farm Income (GH¢)
2011		
2012		
2013		
2014		
2015		

7. What form of land ownership do you hold? **(tick one)**

   (a) Personally owned (b) Rented/Leaseed (c) Use family farmland

Risk and Risk Management

1. Tick the kinds of risk that affects you agricultural activities? **(tick as many as affect you)**

   (a) Production related risks (c) Institutional/Decision-making related risk

   (b) Price/Marketing risk

2. What of these do you consider most risky? **(tick one)**

   (c) Production related risks (c) Institutional/Decision-making related risk

   (d) Price/Marketing risk

3. Which kind(s) of production related risk is affecting your farm yields and incomes?

   (a) Drought (b) Flood (c) Bush fire (d) Storm (e) Others…………………...

4. Which of the above **(in Question 2)** is most prevalent? …………………………………...

5. How do you manage the production related risks to reduce yield/income variability? **(tick all applicable)**

   (a) Mixed-cropping
   (b) Seasonal migrations
   (c) Growing resistant varieties
   (d) Avoiding the use of risky technologies
   (e) Store crop and spread sales over the year or longer time
   (f) Others……………………………………………………………………………...
   (g) Mixed farming
   (h) Irrigation
   (i) New crop varieties
   (j) Timing of planting

6. Have you ever received government support when an adverse weather event occurred? **(tick one)** Yes / No

7. Do you engaged in any economic activity besides farming? **(tick one)** Yes / No

   If **yes**, mention the kind of activity (ies) ……………………………………………..…

Insurance arrangements

1. Do you currently have an agricultural insurance policy? **(tick one)** Yes / No

   If **yes**,

   (i) Which kind of crop insurance policy?

   (a) Index Insurance (b) Traditional Indemnity Insurance

   (ii) What amount are you insured for?

   In GH¢ terms: ………………

   (iii) How much do you pay each year/planting season for the insurance (average)?

   In GH¢ terms: ………………

   As a percentage of the sum insured: ………………

   If **no**, why not? **(please explain)**

(a) Too expensive

(b) Not necessary

(c) I use other risk management techniques

(d) Others …………………………………………………………………………

2. Are you willing to buy/adopt Agricultural Insurance? **(tick one)** Yes / No

3. How willing are you to use Agricultural Insurance?

(a) Very willing (b) Not so willing (a) Not willing

4. If you were to insure your expected farm income for this year of GH¢ 1000.00, what is the highest premium you would be willing to pay for insurance?

In GH¢ terms: ………………

As a percentage of the sum insured: ………………

Appendix II: Computation of pure premium

VARIABLE IN THE PURE PREMIUM MODEL			VALUE
Rainfall trigger level **(T)**			2.5 mm
Range of values below trigger, **L**			0 to 2.5 mm
Number of possible outcomes from 0 to 2.5 mm			26
Time **(t)**	Crop growth months	4	0.333333
	Number of months in a year	12	
Interest rate **(r)** (BoG T.Bill rate as at March 2017)			0.175103
$\mathbf{e^{r*t}}$			0.943303
SI per day	Sum insured **(SI)** GH¢ (for scenario 1)	1000	GH¢ 8.333333
	Sum insured **(SI)** GH¢ (for scenario 1)	100	GH¢ 0.833333
	Crop growth days **(CGP)**	120	
Probability	Total percentage	100	0.038462
	Number of possible outcomes	26	
Trigger days **(TD)**			10

Scenario 1: Computation of pure premium with a sum insured of GH¢ 1000.00

Occurrences	Rainfall Trigger	Possible Rainfall per day	Proportion of loss in rainfall	Probability	SI per day	Expectations (EXP)
	(T)	(L)	(T-L)/T	P	SI/CGD	P(T-L)/T *SI/CGD
1	2.5	0	1	0.038462	8.333333	0.320512821
2	2.5	0.1	0.96	0.038462	8.333333	0.307692308
3	2.5	0.2	0.92	0.038462	8.333333	0.294871795
4	2.5	0.3	0.88	0.038462	8.333333	0.282051282
5	2.5	0.4	0.84	0.038462	8.333333	0.269230769
6	2.5	0.5	0.8	0.038462	8.333333	0.256410256
7	2.5	0.6	0.76	0.038462	8.333333	0.243589744
8	2.5	0.7	0.72	0.038462	8.333333	0.230769231
9	2.5	0.8	0.68	0.038462	8.333333	0.217948718
10	2.5	0.9	0.64	0.038462	8.333333	0.205128205
11	2.5	1	0.6	0.038462	8.333333	0.192307692
12	2.5	1.1	0.56	0.038462	8.333333	0.179487179
13	2.5	1.2	0.52	0.038462	8.333333	0.166666667
14	2.5	1.3	0.48	0.038462	8.333333	0.153846154
15	2.5	1.4	0.44	0.038462	8.333333	0.141025641
16	2.5	1.5	0.4	0.038462	8.333333	0.128205128
17	2.5	1.6	0.36	0.038462	8.333333	0.115384615
18	2.5	1.7	0.32	0.038462	8.333333	0.102564103
19	2.5	1.8	0.28	0.038462	8.333333	0.08974359
20	2.5	1.9	0.24	0.038462	8.333333	0.076923077
21	2.5	2	0.2	0.038462	8.333333	0.064102564
22	2.5	2.1	0.16	0.038462	8.333333	0.051282051
23	2.5	2.2	0.12	0.038462	8.333333	0.038461538
24	2.5	2.3	0.08	0.038462	8.333333	0.025641026
25	2.5	2.4	0.04	0.038462	8.333333	0.012820513
26	2.5	2.5	0	0.038462	8.333333	0
					Σ(EXP)	**4.166666667**

e^(r*t) * Σ(EXP) **3.930429427**

Pure premium= [e^(r*t) * Σ(EXP)]*trigger days **39.30429427**

Premium as a percentage of SI **0.039304** **4%**

Scenario 2: Computation of pure premium with a sum insured of GH¢ 100.00

Occurrences	Rainfall Trigger	Possible Rainfall per day	Proportion of loss in rainfall	Probability	SI per day	Expectations (EXP)
	(T)	(L)	(T-L)/T	P	SI/CGD	P(T-L)/T *SI/CGD
1	2.5	0	1	0.038462	0.833333	0.032051282
2	2.5	0.1	0.96	0.038462	0.833333	0.030769231
3	2.5	0.2	0.92	0.038462	0.833333	0.029487179
4	2.5	0.3	0.88	0.038462	0.833333	0.028205128
5	2.5	0.4	0.84	0.038462	0.833333	0.026923077
6	2.5	0.5	0.8	0.038462	0.833333	0.025641026
7	2.5	0.6	0.76	0.038462	0.833333	0.024358974
8	2.5	0.7	0.72	0.038462	0.833333	0.023076923
9	2.5	0.8	0.68	0.038462	0.833333	0.021794872
10	2.5	0.9	0.64	0.038462	0.833333	0.020512821
11	2.5	1	0.6	0.038462	0.833333	0.019230769
12	2.5	1.1	0.56	0.038462	0.833333	0.017948718
13	2.5	1.2	0.52	0.038462	0.833333	0.016666667
14	2.5	1.3	0.48	0.038462	0.833333	0.015384615
15	2.5	1.4	0.44	0.038462	0.833333	0.014102564
16	2.5	1.5	0.4	0.038462	0.833333	0.012820513
17	2.5	1.6	0.36	0.038462	0.833333	0.011538462
18	2.5	1.7	0.32	0.038462	0.833333	0.01025641
19	2.5	1.8	0.28	0.038462	0.833333	0.008974359
20	2.5	1.9	0.24	0.038462	0.833333	0.007692308
21	2.5	2	0.2	0.038462	0.833333	0.006410256
22	2.5	2.1	0.16	0.038462	0.833333	0.005128205
23	2.5	2.2	0.12	0.038462	0.833333	0.003846154
24	2.5	2.3	0.08	0.038462	0.833333	0.002564103
25	2.5	2.4	0.04	0.038462	0.833333	0.001282051
26	2.5	2.5	0	0.038462	0.833333	0
					Σ(EXP)	**0.416666667**

e^(r*t) * Σ(EXP)		**0.393042943**
Pure premium= [e^(r*t) * Σ(EXP)]*trigger days		**3.930429427**
Premium as a percentage of SI	**0.039304**	**4%**