Enhancing Sustainable Access to Capital For Farmers in Ghana Through Indexed Insurance

By The Katie School of Insurance- Illinois State University

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ABSTRACT

As a consequence of climate change, agriculture in many parts of the world has become a riskier business activity. Given the dependence on agriculture in developing countries, this increased risk has a potentially dramatic effect on the lives of people throughout the developing world especially as it relates to their financial inclusion and sustainable access to capital. Perhaps one of the most insidious consequences is the effect that this has on the willingness of lenders to make loans to farmers. This study aims to address this important issue. We focus on analyzing data which could be used to develop financial instruments, such as an indexed-based insurance product which could potentially help enhance sustainable capital for farmers in northern Ghana. We analyze relationships between crop prices and production estimates and also between rainfall per crop gestation period (planting – harvesting) and crop yields. We make recommendations on how this information could be used to help mitigate the financial risks to farmers in Ghana. Most of the focus in our paper is on rainfall and exploring the potential for drought loss mitigation through a weather index based on rainfall and crop yield. This study concludes by describing limitations and challenges that must be overcome in order to develop such risk management tools.

Key Words: Sustainability; Financial Inclusion; Microinsurance; Indexed-Insurance, Agricultural Risk Management

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INTRODUCTION

Farming is a major source of income for many people in developing countries. In Ghana it represents 36 percent of the country's GDP [1]and is the main source of income for 60 percent of the population. Agricultural production depends on a number of factors including economic, political, technological, as well as factors such as disease, fires, and certainly weather. Rainfall and temperature have a significant effect on agriculture, especially crops. Although every part of the world has its own weather patterns, and managing the risks associated with these patterns has always been a part of life as a farmer, recent changes in weather cycles resulting from increasing climate change have increased the risk profile for farming.

Weather risk impacts the poor directly by destroying their assets (crop, livestock) and thus, pushing them into poverty traps from which they have little means of recovery. Besides the direct impacts, weather shock effects indirectly by changing the behavior of the rural poor: knowing prospective consequences of shocks, people may go to extraordinary lengths to manage risk exposure, for example by selecting low-risk, low-return asset and activity portfolios that reduce the risk of greater suffering , but limit growth potential and investment incentives. The problem is exacerbated by the reaction of financial institutions, which may restrict lending to farmers to minimize exposure to

[1] Earth Trends Country Profiles. http://earthtrends.wri.org 2003 p. 1

weather risk, and households try to minimize their consumption expenditures following the weather shock by withdrawing kids from school, sale of assets, and reducing nutrient intake. Those measures have opportunity costs that hinder economic growth (Barnett et al., 2007).

Farmers in economically developed countries such as the United States, often manage such risks through crop insurance, which is substantially subsidized (as much as 90 percent) by their governments. However, government subsidized crop insurance is not available for most farmers in developing countries, especially not for small farmers, whose income, farm size, and remote location make traditional crop insurance products unworkable. These smaller farmers therefore respond to losses in ways that affect their future livelihoods such as selling off valuable assets, or removing their children from school and hiring them out to others for work. They may also be unable to pay back loans in a timely manner, which makes rural banks and even microfinance institutions reluctant to provide them with the capital they need to purchase high-yield seeds, and other inputs that increase their yields.

This risk also makes the farmer less willing to take chances on new farming techniques that could move them from subsistence to commercial farming. The reluctance of financial institutions to provide capital to farmers becomes more pronounced as their awareness of climate change (discussed later in this paper) increases and alters the perceived, if not actual, risk of farming. This aversion to making agricultural loans is unlikely to abate without some mechanism for either the farmers or the financial institutions to manage the financial consequences of weather risk.

For developing countries that rely greatly on agriculture, the inability of farmers to obtain adequate capital and manage their risks makes it difficult to sustain economic growth. Studies show that insurance is correlated to economic development (Hussels, 2005, Outrevill, 1990) and the connection between lending and the ability of the borrower (or lender) to manage risks is one obvious factor for this correlation. For this reason, it is imperative to find ways to manage agricultural risks to enable farmers to obtain more capital and invest in farming practices that will progress them and their respective countries.

Given its significance on agricultural production, managing the financial risks associated with weather damages, especially weather catastrophes, holds great promise for farmers and those who loan money to farmers. One risk management tool that has been piloted in a few developing countries is an indexed-based insurance product. An advantage of the indexed insurance product over traditional insurance is that it eliminates the administrative costs of underwriting and claim verification required in traditional insurance, and reduces the moral hazard that is associated with individual loss indemnification.

This project examines the potential for an indexed-based insurance product in Ghana. The initial focus is on a product for northern Ghana, especially for managing risks of agricultural losses to maize, rice, and groundnuts. Although the initial focus is limited to northern Ghana, and these particular crops, the implications of this research are more far-reaching.

MOTIVATION, RATIONALE, and OBJECTIVES

As mentioned previously, agriculture is the backbone of many African economies and will continue to be so into the foreseeable future. In addition to being a vital source of food, the economies of many African nations rely on agricultural production, and instabilities in agricultural production drain resources, thwart growth and much-needed private investment. Extreme weather events impede development of agricultural production and place food security in developing countries at risk. According to a British Council research briefing [2]unpredictable rains and variability in planting seasons are causing Ghanaians' crop yields to decline. Some rural Ghanaians consider migration to urban areas to be the only option left to them to address this unpredictability that has vexed farmers

[2] BBC World Service Trust and British Council , Climate Trends in Ghana. Research Briefing. September 2009. http://africatalksclimate.com/sites/default/files/content/files/ghana_web.pdf pp. 1-3

and those who rely on agriculture for their livelihood.[3] The interrelation of climate change with other factors is complex and still evolving but the growing evidence that climate change, influenced by carbon emissions from developed countries, places tremendous stress on lesser developed countries that are least equipped to manage the change.

Currently very few pre-event risk mitigation solutions exist. Traditional insurance has high transaction costs, adverse selection, poor distribution, and other challenges which have increased the costs and reduced the availability of protection. Furthermore, post-event response in the form of emergency aid, debt forgiveness, and grants are at risk following recent economic crises, and such public capital does not usually help create independent private solutions and can be inequitable and untimely.

One possible solution is an indexed-based insurance product based on local weather indices (like rainfall) that are correlated with local crop yields and economic losses. (These products are discussed in detail later in this article). Unlike individual indemnification insurance mechanisms, which have high administrative costs, moral hazards, and adverse selection, this type of financial product yields payouts based on pre-determined indices (such as the amount of rainfall in a particular time and location) which historically is correlated with economic loss and humanitarian need . This rainfall correlation would likely be expected in a country like Ghana which relies on adequate rainfall more than other countries in the world or even other Sub-Saharan countries as only 0.2 percent of farmer land in Ghana is irrigated.[4] This type of protection could provide greater economic stability for agricultural production and the economies of countries relying on agriculture. (Roth and McCord 2008).

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[3] All climate change impacts described in 'Climate Change in Ghana' are fully sourced from the following references:
UNFCCC (November 2007), *Ghana's Experience at Integrating Climate Change Adaptation into National Planning*
Drunen M A. Van, R. Lasage, and C. Dorland (Cabi Publishing 2006), *Climate Change in Developing Countries: Results from the Netherlands Climate Change Studies Assistance Programme*

[4] Earth Trends Country Profiles, http://earthtrends.wri.org, 2003.p.1

The primary goal of this project is to collect and analyze weather event, crop loss, and other health and economic data in Ghana. This information and analysis could be used to develop a weather-indexed financial product that would mitigate agricultural loses.

Managing this risk can open the door to enhanced credit for farming operations. If the risk of default on loans can be reduced by either mitigating the economic consequences for individual farmers from crop loss or by mitigating the exposure to credit default risk for financial institutions, then lenders may be more willing to provide loans to farmers or agricultural cooperatives. Helping to reduce the exposure to risk could help farmers, especially more risk-averse farmers, by enabling them to increase their incomes by taking more reasonable risk.

One hoped-for outcome could be to help attract new capital, both local and foreign, to this market, by providing more information to both farmers and other purchasers to build demand, and to prospective insurers, reinsurers, and other financial institutions. The information resulting from this study should enable institutions to better aggregate and pool low probability, high severity crop loss. This information could help develop a market for crop risk transfer at high quantities by closing the gap between the insurer's willingness to accept and potential purchasers' willingness to pay for this risk transference.

Ghana was chosen for a variety of reasons but mainly because it holds the elements necessary for the successful development of risk management techniques including insurance. Once such techniques and insurance are developed in Ghana, then it would have more potential to be replicated and used in other, arguably more challenging countries where food security is of an even greater concern.

Ghana has experienced two decades of sound and persistent growth and belongs to a group of very few African countries with a record of positive per capita GDP growth over the past 20 or more years. Ghana is also on the path to become the first Sub-Saharan African country to achieve the first Millennium Goal (MDG1) of halving poverty and hunger before the targeted year of 2015. On the other hand, Ghana is still an agriculture-based economy. As mentioned earlier, agriculture in Ghana it represents 36 percent of the country's GDP [5]and is the main source of income for 60 percent of the population. The country's recent development is characterized by balanced growth at the aggregate economic level, with agriculture continuing to form the backbone of the economy (McKay and Aryeetey, 2004).

Agricultural growth in Ghana has been more rapid than growth in the non-agricultural sectors in recent years, expanding by an average annual rate of 5.5 percent, compared to 5.2 percent for the economy as a whole (Bogetic et al., 2007)

Ghana's stable government, yet vulnerable agricultural economy, makes it a good country for an indexed insurance product. Stabilizing agricultural income could help Ghana's neighboring countries, as well as African countries in other regions that may currently be less attractive to foreign private capital. (Collier 2007). Ghana is a country that is politically stable, has relatively easy access to data, and favorable regulation. A well-designed risk management system could allow Ghana to act as a gateway to Africa, for underwriters who are not currently participating in Africa.

The goal of this project was to collect, organize and analyze data on weather, crop yield, crop production, crop prices, and other relevant factors that affect agricultural production and agricultural income in Ghana, and begin to explore the potential for providing more capital to farmers through risk mitigation strategies implicated in this research. Possible products that could be derived from this research include indexed based insurance, a weather (rainfall)-indexed derivative, or yield indexed product, based on district wide crop yields, that could be used by farmers or financial institutions

LITERATURE REVIEW

[5] Earth Trends Country Profiles. http://earthtrends.wri.org 2003 p. 1

The following summarizes extant literature on the use of index insurance, especially weather index insurance in mitigating agricultural risk. It concludes with a discussion on the challenges faced in the use of such products in developing countries.

Need for Additional Risk Management Techniques For Agricultural Losses

One common risk management technique to address agricultural loss is insurance. Agricultural risks associated with weather-related events are often addressed by agricultural insurance (such as crop and livestock insurance), flood insurance, and property and casualty insurance for natural disasters such as hurricanes and earthquakes.

In developed countries, especially Western countries, agricultural insurance is commonly available. However, traditional agricultural insurance, like crop insurance is not readily available in developing countries for the following reasons:

- Traditional agricultural insurance usually requires government support, because correlated risks create the potential for large financial losses that private industry is unwilling to accept. This government support is often lacking in developing countries. Without government support the cost of insurance is likely unfeasible for small farmers.
- The cost of the insurance can be economically unfeasible for insurers because of the smaller farm lots and lower limits of liability (and subsequent lower premiums). The loss adjustment costs related to proving a loss can easily be larger than the premium for the risks. Moreover, it is costly to control moral hazard and adverse selection, especially for small-scale firms.
- Crop insurance models and data used to develop these models used in North America, Europe and Japan are not applicable, or even available for many developing countries
- The supply of agricultural risk insurance is underdeveloped in the financial and insurance sectors, has high start-up costs, a weak regulatory and legal environment, and a lack of contract enforcement.

For all of these reasons, and others, another risk management technique, index insurance, holds promise especially for agricultural risks in developing countries.

The Basics of Index Insurance

The main difference between index insurance and traditional agriculture insurance is that loss estimates for the former are based on an index or proxy for loss rather than upon the individual loss of each policyholder as is the case with the latter. Index insurance is favored over other types of insurance for the following reasons:

1. It addresses correlated risks (e.g. floods and droughts).
2. It reduces the risks of moral hazard and adverse selection.
3. It works better in areas of higher vulnerability to weather risk especially drought risk where there is a high percentage of non-irrigated agriculture
4. It is easier to administer, because contracts are standard and there is no individual loss-adjustment.
5. It has lower transaction costs, since monitoring costs are greatly reduced and there no need for farm-level underwriting.
6. Beyond agriculture, index insurance can also be used to provide indemnities for disaster relief or to compensate other industries that can suffer from extreme variations in the weather (e.g. earthquake).

Challenges in Using Index Insurance

Index insurance may not be an appropriate tool in some circumstances where there is some variance between the index and individual losses. This potential mismatch is called *basis risk*. Basis risk occurs when realized losses don't correlate well with the index.

There are three types of basis risk: spatial basis risk (difference in outcomes between the physical places where a loss event occurs and where the index is measured), temporal basis risk (due to the timing of the loss event, the consequences of lack of rainfall may be worse), loss specific basis risk (losses are poorly related to the index). Careful consideration of contract design and better data may help mitigate the incidence of basis risk.

Structuring Index Insurance Contracts to Reduce Basis Risk

When designing an index insurance product it is important to minimize basis risk by finding indexes strongly correlated to the risk. Conventional wisdom suggests that a weather index requires long-term accurate data on crop yields and index measure (e.g., rainfall). (NOTE: This wisdom is currently being challenged because of the dynamic effect of climate change and question of relevance of decades of data that may no longer reflect current weather patterns.) An example of traditional requirements from one reinsurer, PartnerRe, is presented in below:

- More than thirty years of data;
- Limited missing values and outliers;
- Less that 1% of weather data missing;
- Data integrity verified;
- Reliable settlement mechanism; (Indemnity amount is readily discernable)
- Integrity of recording procedures.

Index insurance has often been used to address catastrophic risks like hurricanes or earthquakes where the trigger may be windspeed at landfall, or Richter scale measures in specific geographic areas. For catastrophic risk coverage the overall risk profile of producers in a region must be considered in segmenting risks in order to apply the insurance product that best matches the characteristics of the risk. For example, index insurance contracts have a finite range of values over which losses will be paid. The threshold and limit mark the boundaries of payment which also limits the risk exposure of the company. This range is referred to as a layer of risk. The following are typical layers (also known as tranches):

- Layer for the most severe events: it can be covered by a government social program.
- Middle layer includes risks that are likely to occur less frequent but cause larger losses: it can be covered by insurance.
- Layer for the frequent but less severe risks: the risks likely to be less correlated and catastrophic. It can be self-insured through savings, credit and informal means.

The main reason for the layers of risks is that index threshold ranges and payment limits in index insurance are based on the study of severity and frequency of risk events.

The Supply Chain of Index Insurance

Generally, the participants in the index insurance supply chain are similar to participants in any other insurance product supply chain:

- Reinsurers
- Insurers
- Policyholders at various levels: **Micro level** (individuals and groups of individuals), **Meso Level** (institutions and groups of institutions), and **Macro level** (government and aid agencies)

Delivery models for index insurance

Index insurance has different delivery models depending on the categories of policyholders:

1. **Micro level**: index insurance has been offered to individuals directly and linked to credit (e.g., India, Malawi). These are often, but not always, linked to loans that have been taken out by individuals. The index insurance involves the insurer working with the microfinance institution or rural lender to provide insurance. Some stand-alone policies may be offered directly to a individual but such delivery can be more challenging. Government or donors may also provide risk financing to the individual directly.
2. **Meso level**: At the meso level insurance is sold to intermediaries, like financial institutions, who absorb the aggregated risk exposure of their clients. An example would be an insurer that offers index insurance to a bank or microfinance institution or cooperative. The policyholder may also be a donor organization, or non governmental organization (NGO) that wants to reduce its exposure to catastrophic needs.

3. **Macro level:** At the macro level, a government or international organizations might use index insurance as reinsurance for a disaster relief fund activities (e.g., Mexico, Ethiopia and Caribbean Catastrophe Risk Insurance Facility). CAT bonds could also be used in this manner just as the Mexican government is using them.

The common delivery issues are:

- Lower transaction costs for serving low income markets makes distribution difficult;
- High transaction costs such as education and marketing to clients in remote areas,
- Need to earn client trust with a product that is new and may not be well understood.

Recommendations for the use of index insurance include:

- Indentifying high severity risks and create an index insurance to provide ex ante financing for major catastrophes
- Getting the government involved, and finding the appropriate role for government
- Linking the insurance to the banking or value chain activity
- Allowing the market to develop index insurance products for small holders and more sophisticated insurance products for larger holders.

Index Risk Products: Derivatives or Insurance ?

Although derivatives and insurance products have the similar commercial and economic features, from the legal and regulatory perspectives, they are viewed as different products, and may be regulated and marketed differently.

Elements of an Insurance Product

Despite many differences between jurisdictions in how insurance is defined, certain core elements are found in the definition of an insurance contract such as:

- The insured pays a sum of money (premium) to the other party (insurer);
- In return for premium, insurer agrees to accept the risk of an uncertain event occurring at a future time;
- The insured must have an interest in the subject matter of insurance
- The insurer agrees to indemnify loss;

- The insurance contract has a specified period (the term).

Legal Differences Between an Insurance Contract and a Derivative

The terms of derivative contract include the payment of a sum of money from one party to the other, the transfer of risk and stipulation of a definite contract term. There are two legal differences:

- The typical requirement in an insurance contract is that the insured person has an "insurable interest" in the property insured ; and
- An insurance contract is designed to indemnify or compensate for loss.

A derivative does not require that a loss occurs or that even a loss is anticipated to occur. Although derivatives may be used to hedge against losses, this is not required. In a sense, a derivative contract resembles a gambling arrangement. Derivatives are usually tradable, whereas insurance is not.

The insurance industry is highly regulated to reduce systematic risk and to protect policyholders, many of whom are unsophisticated buyers. The regulatory position with respect to derivatives is more complicated. First, the regulation framework of many jurisdictions has not yet developed. The lack of a clear legal and regulatory framework introduces a considerable uncertainty. Second, there is no consistency in regulation of derivatives across countries. Derivates may be subject to regulation as a security or as an investment.

Agricultural Index Insurance in Developed Countries

The idea of index insurance is not new and was introduced as 1920, by an Indian scholar and refined later by American scholars. Sweden offered area-yield insurance in the 1950s. Area-yield insurance was added to the portfolio of insurance products for the US crop insurance program with a pilot program in 1993.

In the U.S., area-yield products often as heavily subsidized as traditional agricultural insurance products. The advantage of index insurance over traditional insurance depends on the homogeneity of the area. Barnett et al. (2005) find that index insurance performs better that multiple peril crop insurance in more homogenous production regions and for certain crops such as sugar and beets.

Weather Index Basics

As mentioned earlier most of the focus in our paper is on rainfall and exploring the potential for drought loss mitigation in northern Ghana. For that reason the following information regarding weather index financial products is presented.

One type of index insurance product is weather index insurance. A weather index measures a specific weather variable like rainfall or temperature at a specific weather station over a defined period of time. Several examples of this type of insurance exist in North America. For instance, in Canada, most weather-based insurance programs are cost-shared forty percent by producers and sixty percent by the government. The most popular products are annual crop weather-based insurance program (protects annual crops in the event of significant precipitation shortfalls and early fall frost), Forage Rainfall insurance program (protects grazing acres against below-average seasonal precipitation) and Corn Heat Unit Pilot Program (insures feed and grain corn farmers against a lack of heat during the growing season).

A growing body of research explores the topic of weather indexed insurance and the promise it holds of developing countries. Jerry R. Skees and Benjamin Collier's article "The Potential of Weather Index Insurance for Spurring a Green Revolution in Africa" outlines the potential of index-based weather insurance products for contributing to a green revolution in Africa. They developed a conceptual framework that links poverty, risk, and missing financial markets. The weather risks that affect most African nations are drought and flooding. Index insurance for drought is currently much further developed than index insurance for other perils.

Key Lessons From Developing Countries:

- Weather risk products are challenging for developing countries, because the products require sophisticated markets and regulation.
- Developing countries need improvements in the legal and regulatory environment, including contract law and enforcement.
- Lack of good data systems and data collection.
- Need for educational efforts about the use of weather insurance.
- Product development problems exist because extensive private investment required to develop new index products and markets is not economically justified, because these products can be easily copied and replicated by others that did not have to incur the development costs.

Weather index insurance policies specify a threshold and a limit that establishes the range of values over which indemnity payments will be made. If the insurance policy protects against unusual high realizations of the weather variable, for example excess rainfall or extremely hot temperatures, an indemnity is made whenever the realized value of the index exceeds the threshold. The limit is set higher than the threshold and the indemnity increases incrementally as the realized value of the index approaches the limit. No additional indemnity is paid for realized values of the index that exceed the limit. Conversely, if the policy protects against unusually low realizations of the weather variable like drought or extremely cold temperatures an indemnity is made whenever the realized value of the index is less than the threshold and the limit is set lower than the threshold.

The Advantages and Disadvantages of Weather Indexed Insurance

Weather indexed insurance has a number of advantages and disadvantages over traditional insurance, such as crop insurance.

Advantages

One advantage of weather index insurance is that indemnity is based on a trigger and not on the actual loss of a policyholder. This means that an indexed based product has an advantage in having reduced underwriting and claims administration costs. This is especially important in developing countries where limits and premiums are often low and claim administration, including loss determination, is high. Weather index insurance is not as vulnerable to the asymmetric information problems of adverse selection and moral hazard, which exists with traditional insurance. This keeps operating costs affordable and reduces potential moral hazard as policyholders have no better information than the insurer about the underlying index, and no way to control it.

Another advantage is that weather indexed insurance, like traditional insurance, can still help mitigate poverty and enhance capital development. In an article focused on innovations in risk transfer for natural disasters in lower income countries and titled "Weather Index Insurance for Agriculture and Rural Areas in Lower income Countries", Barry Barnett and Olivier Mahul argued that transferring risk can catalyze investment and economic growth, thus contributing to poverty reduction in rural areas of lower income countries. Index insurance products can serve as the first step in developing more advanced weather insurance products and improving access to broader rural financial services in lower-income countries. It also addresses the potential implications of index insurance for lower-income countries where rural and agricultural financial markets are largely underdeveloped.

Correlated risks from weather events can be a major constraint to financial services. The banking systems of most countries are not designed to absorb natural disaster risk. Natural disaster risk must be transferred into a global market to be diversified into a global portfolio of insurance risks. Thus, insurance markets can be the missing link for stronger development of rural finance. Weather insurance products could also be used by the financial institutions themselves to protect their portfolios against excessive loss due to defaults associated with extreme weather events. This protection should also improve institutions' willingness to provide credit to agricultural enterprises and rural households. Using weather insurance to manage the risk of catastrophic weather events should stimulate economic development by improving stability and opportunities for growth in the agricultural and financial sectors.

Another possible use of weather insurance is to improve government and donor response to natural disasters by providing quick access to resources for disaster relief and recovery needs. Natural disasters can depress economic output, damage infrastructure, and increase fiscal demands on government and donor organizations. Weather insurance can provide easier access to capital while foreign aid is being sought.

Limitations and Challenges in Using Weather Index Insurance

Weather index insurance also has significant limitations. Some of the noted limitations include:

- It only protects against losses caused by extreme occurrences of the underlying weather variable and is only effective when basis risk can be reduced to an acceptable level.
- Purchasers must utilize other strategies to protect against the financial impacts of loss events that are not covered by the index insurance product.
- Start-up costs for weather index insurance can be quite high and, once developed, the insurance products have characteristics of a "public good" which affects willingness of investors to develop such a product, and
- Significant basis risk (the risk that loss payment does not correlate well with actual loss of individual policyholder) exists, affecting the desirability and suitability of the product

Studies by USAID proved that development of index insurance products requires careful dialogue with government policy makers and regulators. A feasibility study is needed to determine whether index insurance would be appropriate, beneficial and economical.

RESEARCH SITE(s)

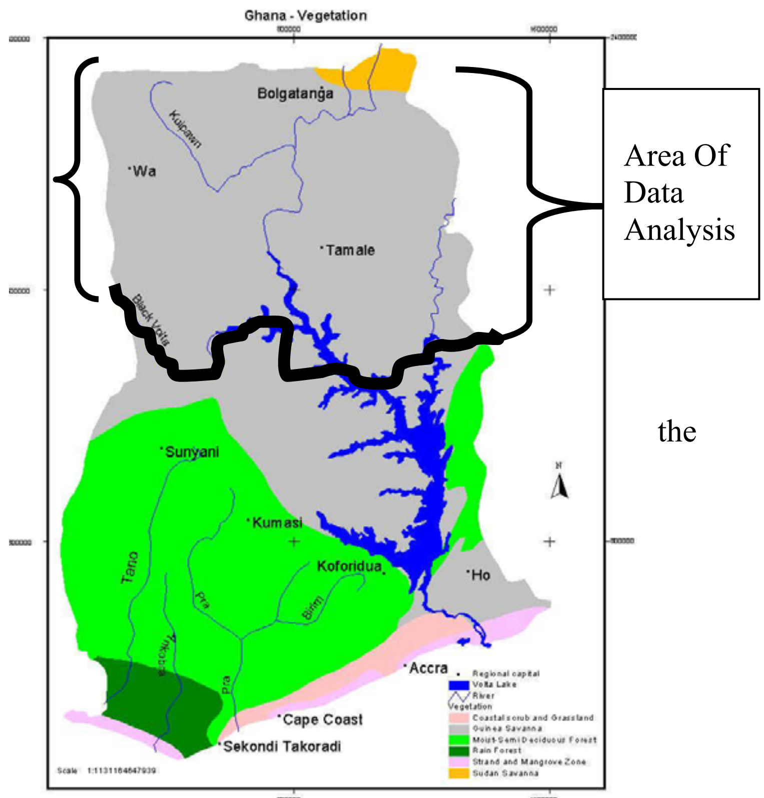
Ghana produces a variety of crops in various climatic zones which range from dry savanna to wet forest. Agricultural crops including yams, grains, cocoa, oil palms, groundnuts, and timber, form the base of Ghana's economy. This research is focused mainly on the northern part of Ghana where there is substantial farming activity. The northern region of Ghana is considered the major bread basket of the country, and is also the most susceptible to the vagaries of the weather, especially the lack of rainfall. Unfortunately past agricultural growth and development has been accompanied by increased income inequality, and poverty abatement is lagging in Northern Ghana (Al Hassan and Diao, 2007).

This northern part of Ghana is made up of three main regions; Upper West Region, the Upper East Region and the Northern Region. The largest of these is the Northern Region which incidentally is the largest region in Ghana, covering a land area of about 70,383 square kilometers. However, it has the lowest population density of all ten regions in the country *(PPMED, Ghana, 1991)* with 80% of its people dependent on farming. The major food crops grown here are yam, millet, rice, maize, sorghum, soybeans, groundnut and cassava. Tamale is the administrative capital of the Northern Region and the biggest town in Northern Ghana.

Although Ghana's central and Southern regions have weather cycles consisting of two rainy seasons and a dry season. The northern region experiences only one rainy season (traditionally April – September) and a dry season (traditionally November – April). This one rainy season lends itself to a rainfall insurance index that would be less complicated than one in the central or southern regions which have two rainy seasons. During the dry season, there are also harmattan winds (dry desert winds) which blow from the northeast from December to March, lowering the humidity with hot days and cool nights. However, like most climates, there is some variability, more so in recent years. Annual rainfall is about 1,100 mm (about 43 in) with a range from about 800 mm to about 1,500 mm. In the Northern region, the Ghana Meteorological Agency (GMA) reported a 10.2% change in the cumulative rainfall between the 30-year average and that for 2009. Those changes for the Upper East and Upper West regions were -3.5% and -34.5% respectively. All together, the percentage change in rainfall for the northern sector of Ghana was -8.6%.

Average monthly rainfalls over the past 4 decades in the three northern regions has changed. The Upper East Region has a fairly steady rainy season but the Northern Region and Upper Western regions have trended toward a more variable "rainy season" by about one month on average.

The vegetation (see Ghana Vegetation map insert to the right) is classified as savannah woodland, with vast areas of grassland, characterized by drought-resistant trees such as the acacia, baobab, shea nut, dawadawa, mango, neem and mahogany. The area north of the dark line in the map insert to the right is the sector on which this project focuses.



The soil in this area is mostly silt or loam, thus having the tendency to get waterlogged during the rainy season but drying up in the dry season. This, however, works well for the farmers since they grow various types of crops: each with its own soil preference. For example, during the rainy season, rice is a preferred crop since it fares very well on marshy land. Yam, on the other hand, is better cultivated when the land is dried out. Although the type of vegetation supports agricultural production quite well, a major hurdle for farmers is maintaining the soil fertility of the land throughout the various farming cycles.

GHANA PROJECT DATA SOURCES USED

Both primary and secondary data were collected and studied for this project. The primary data involved meeting with and interviewing potential major stakeholders of the indexed-insurance and microinsurance mechanism (or known locally as a scheme) to understand their motivations, gauge the viability of the scheme and explore potential strategies for implementation. The results of this study are discussed later in this section.

Secondary data was collected on Rainfall, Crop yields, Crop prices and Soil types. Data was collected from The Ministry of Food & Agriculture, which is the main government arm responsible for formulating and implementing agricultural policy in Ghana. The Statistics, Research and Information Directorate (SRID) and Policy Planning Monitoring and Evaluation Division (PPMED) are two of the five directorates through which the ministry carries out its functions. According to information on the Ministry's website, the SRID has as some of its objectives "to initiate and formulate relevant policies/programs for creation of timely, accurate and relevant agricultural statistical database to support decision making" and "to conduct agricultural surveys and censuses covering major agricultural commodities". The PPMED, on the other hand, is responsible for undertaking monitoring and evaluation of programs and projects under the Ministry.

The statistical service department is an independent government department that is responsible for the collection, compilation, analysis, publication and dissemination of official statistics in Ghana for general and administrative purposes. The Meteorological agency is also the official government entity responsible for collection meteorological data in Ghana.

Ghana Crop and Rainfall Data Collected

Rainfall data was obtained from 27 weather stations around the country with 4 in the northern Region (Tamale, Bole, Salaga and Damango) and this consisted of daily rainfall estimates in mm from 1988 to 2007.

Exhibit 1 provides the life cycles of the selected crops while Exhibit 2 provides the maximum, minimum and average rainfall in mm for each crops life cycle for the various years.

Exhibit 1: Life cycles of the selected crops

Crop	Planting date	Time of harvest	Gestation
Maize	End of March- End of April (major season)	August- September (major crop) December- January (minor crop)	105 days (early maturing) 120 days or more (late maturing)
Rice	April-May	Late October- November	4-5 months

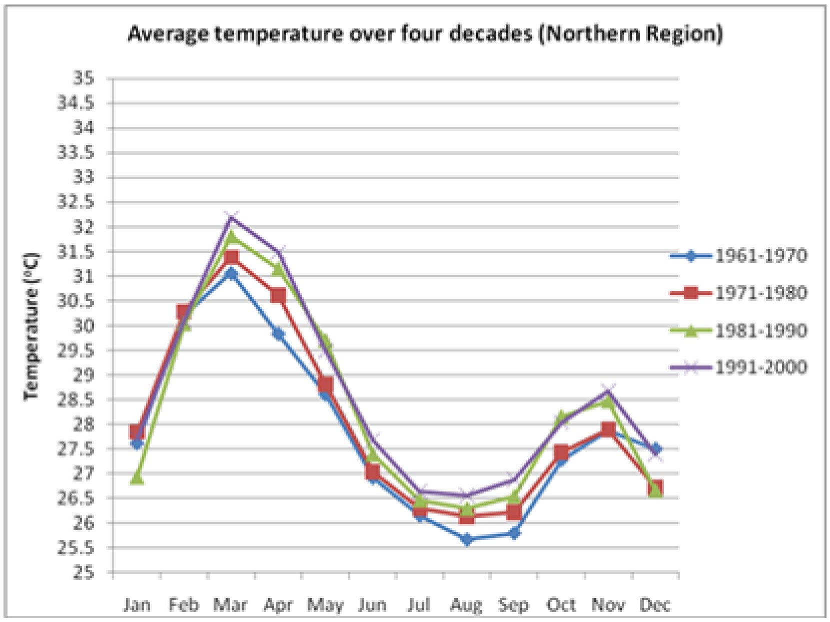
Assumptions and Limitations

In collecting the data, several assumptions were made, some due to limitations that we came across. Firstly, to be able to design and price an insurance contract based on a weather index, the data for that index must be sufficient. The data used in this research spanned a period of about twenty four years; this would have been sufficient for assessing correlations if the rainfall patterns were consistent. Due to the variability encountered, a longer time period, of about forty years of data, is preferred. However, the project reality is that the data beyond what was obtained is currently only available in paper form and has yet to be converted to digital form. This project did not have resources for acquiring that data and making that conversion.

Although the data was obtained through all the appropriate government channels and was validated, it is important to keep in mind the potential problem of data being entered incorrectly when it is converted from paper to digital form . For the purpose of this paper, minimal data input error is going to be assumed.

Another limitation is using only a rainfall trigger when temperature data does exist. Unfortunately, temperature data by district is not easily accessible. However, regional data does exist, and the temperature data from the Northern Region as indicated in Exhibit 2, shows temperatures have advanced steadily each decade with the latest period showing about a one degree temperature difference over a 40-year time period for the months of March through December.

Exhibit 2- Average Temperature Change- Northern Ghana (1961-2000)



It was also assumed that the weather stations the rainfall data was collected from were secure and this may not be true, especially for data from Rainfall Stations. This is not likely an issue currently but this is something that should be considered if a weather-index insurance product is developed because this lack of a secure data creates a potential moral hazard. Finally, crop production estimates are not only influenced by rainfall. They are affected by economic factors, morbidity and mortality rates, rural to urban migration (which happens to be very prevalent in Ghana and causes farmers to lose labor for their farms and this can cause a drop in the production estimates). Unfortunately, data on these factors could not be obtained; either because there is no data, or that the data is so incomplete that it makes any useful comparisons difficult.

Challenges in Collecting Crop and Rainfall Data

The following problems were encountered in collecting data on crop yields and production and rainfall.

- Delays in supply of data. We began the process of collecting data in March of 2009. By late May we had only begun to collect the first few rainfall and crop data.
- Several missing observations in some of the data supplied. This missing data will be described later in this paper.
- Loss of data by national data collection agency.
- Changing districts and delays in obtaining supplementary information. This redistricting makes comparisons of districts difficult. For example, districts of Ghana were re-organized in 1988/1989 in an attempt to decentralize the government and to combat the rampant corruption amongst officials. The reform of the late 1980s subdivided the regions of Ghana into 110 districts, where local district assemblies should deal with the local administration. By 2006, an additional 28 districts were created by splitting some of the original 110, bringing their number up to 138. In February 2008, there were more districts created and some were upgraded to municipal status. This brought the final number to 170 districts in Ghana. There are still only 10 regions.
- Delays in supply of information on current data collection practices, e.g. names of markets in some regions, estimation of area under cultivation for different crops.

Rainfall Data Types and Location

Data on rainfall for selected towns was obtained from the Ghana Meteorological Agency. Rainfall data is recorded at the weather stations in all ten regions mainly Ashanti, Brong Ahafo, Central, Eastern, Greater Accra, Upper East, Upper West, Volta and Western regions. There are four types of stations in each region namely Synoptic, Climatic, Agro-meteorological and Rainfall. Synoptic stations collect observations and measurements hourly on all parameters namely rainfall, evaporation, humidity, temperature etc. Climatic Stations are similar to Synoptic stations except that data is collected every three hours on all parameters. Agro-meteorological Stations collects data every three hours, basically on agricultural related parameters such as rainfall, temperature, evaporation, wind speed and direction, precipitation, solar radiation and relative humidity. Rainfall Stations data are collected on rainfall once in twenty-four hours, usually at 09:00 GMT. Rainfall is the only parameter measured at these stations. These stations are often staffed by part time workers and are considered by some experts to be less reliable. To ensure widespread distribution of stations throughout the country, the following strategies were adopted in collecting the data:

- Apply the principle of stratification (by size) to determine the number of stations for each region.
- Select at least two stations from each region.

Although data was collected from across Ghana, the data analyzed in this first study is from the Northern part of Ghana. The following exhibit illustrates the type of location and type of station the data was collected from.

Exhibit 3- Location and Type of Weather Station

Location Where Rainfall Data Collected	Weather Station Type
Tamale	Synoptic
Bole	Synoptic
Salaga	Agro-Meteorological
Damongo	Climatic
Walewale	Climatic
Gushiegu	Rainfall
Bimbilla	Rainfall
Chereponi	Rainfall
Yendi	Synoptic
Savelugu	Rainfall

Crop Data

Crop yield and prices were obtained from The Statistics, Research and Information Directorate (SRID) and Policy Planning Monitoring and Evaluation Division (PPMED) both of the Ministry of Food & Agriculture. Crop data consisted of crop life cycles (planting and harvesting times), crop production estimates, crop yield and crop prices (wholesale for rural and urban areas) for various districts. Estimation of yield was conducted using objective measurement techniques. Randomly located square plots were marked out in the field by an enumerator. The square is pegged and lined. Farmers were asked to work on these plots as in other fields on the farm. Produce from these plots were weighed at the time of harvesting by the field worker / enumerator and used as the basis for estimating the yield. The crops inside the plot were harvested by the enumerator at the time the holder harvests the rest of the field. The total production of food crops was determined by estimating the area under cultivation for each crop and the yield rate. The product of these two components was an estimate for the total production of the crop.

Crop production data was from 1985-2007. For the 1985-1991 time period the SRID collected data on a regional basis. As mentioned earlier Ghana has ten regions. The data analysis becomes a bit more challenging moving into later years. The specific challenges are detailed at the end of this section but the issue relates to the fact that data is categorized by districts and Ghana has added a number of districts in recent years, growing nationwide from 100 to 170 districts in less than a 10 year time period. For this study the time period of 1992-2007 included SRID data by district in northern Ghana. Fortunately, the northern area of Ghana has only changed from 18 to 20 districts.

Crop price data was also collected. The price data covered the period 1999-2008 (excluding 2001 when data was missing). Wholesale price data was collected on market days usually twice a week. These are averaged to obtain the weekly prices. Weekly prices are also averaged to obtain monthly prices. A simple average of urban and rural prices was computed to obtain a single price for each crop in each region. Regional prices are then averaged to obtain the national price.

An analysis of this crop and rainfall data and the correlations among various factors was completed and the results of this analysis are found later in this paper.

Primary Data

In collecting and analyzing data, the ultimate goal is to be able to provide the foundation to develop a risk transfer technique that would improve the lives of lower income people in Ghana, especially those who rely on agriculture. Although it is well beyond the scope of this initial project to measure and assess changes in capital flows to farmers from financial institutions as the climate has changed. It is also beyond the scope of this project to assess and measure the market potential for risk transfer techniques, or even one risk transfer product, it is reasonable, and within the scope of this project, to conduct a preliminary analysis in order to explore whether there is any potential for a market to develop, or any willingness to consider any risk transfer techniques.

Although the collection of crop and rainfall data was focused on the potential for developing an indexed based financial risk transfer product, the collection of primary data was much more broadly focused and included gathering information about the potential for other risk transfer techniques. Specifically the risk transfer techniques explored were:

- Index-based insurance for farmers or financial institutions,
- The perception of risk by key financial institutions and how that risk affects capital flows
- Microinsurance products for farmers and market vendors in faming communities,
- Non-insurance risk pooling mechanisms for farmers.

With this in mind, data collection involved exploring the general potential market for various risk transfer techniques for a variety of potential stakeholders.

With the above ends in mind, the primary data collection phase involved travelling to Ghana and meeting with farmers, government officials, cooperatives, NGO's, insurance companies, development agencies, researchers, banks and other stakeholders in order to solicit their perspectives, and "points of pain", learn from their experiences, and gain further insights.

As part of this study, we engaged rural banks and microfinance institutions in the northern region as they represent the main source of capital for farmers. These institutions represent both potential purchases for an insurance product to help mitigate their risk of credit loss from their portfolio of farm loans, and also potential distributers of an insurance product to their farm customers. The purpose of talking to managers at these institutions was to gain insight into the financial behavior of the farmers and understand their risks that this insurance product could potentially address. We also met with managers at the APEX bank which is the bank in Accra that is responsible for all the rural banks in Ghana to determine their perspective on the need to manage the credit losses from agricultural loans made by rural banks.

If such insurance products were to be developed they would need regulatory approval. To gain an understanding of the insurance regulatory environment in Ghana, discussions were held with the Deputy Commissioner of the National Insurance Commission. The National Insurance Commission of Ghana is the major regulator of insurance in Ghana. In addition discussions were held with potential underwriters to assess their appetite for providing or distributing microinsurance or indexed-based insurance. As part of this effort, discussions were held with Starlife Assurance, Life Insurance Company, and SIC.

In assessing the technical support available to assist with research we met with the president of the Ghana Society of Actuaries, and faculty from the University of Ghana in Accra and from Kwame Ncrumbah University of Science and Technology (KNUST) in Kumasi. We also sought to verify the needs and issues for such products through meetings with the Ministry of Agriculture (the government arm responsible for agriculture policy in Ghana) at their northern region office in Tamale.

These various stakeholders provided insightful information that proved to be valuable in our analysis and in the recommendations that we eventually make.

Mortality and Morbidity Data

The initial research design included collecting mortality and morbidity data for Ghana to analyze correlations between crop yields and morbidity and/or mortality. The collection of this data was abandoned in favor of using limited project resources to collect more crop data, when it was learned that morbidity data is collected mainly in urban areas, that would be less likely to be affected by crop yields in rural areas, and mortality rates were not categorized by age groups or causal factors making it difficult to determine if people were dying at birth, dying due to old age, or dying from accidents or diseases. Anecdotally, we did not find a correlation with mortality and crop yield in talking with farmers and financial institutions, instead the consequences of poor yield seemed to be more economic in nature. We believe that these limitations made the data less valuable for our study.

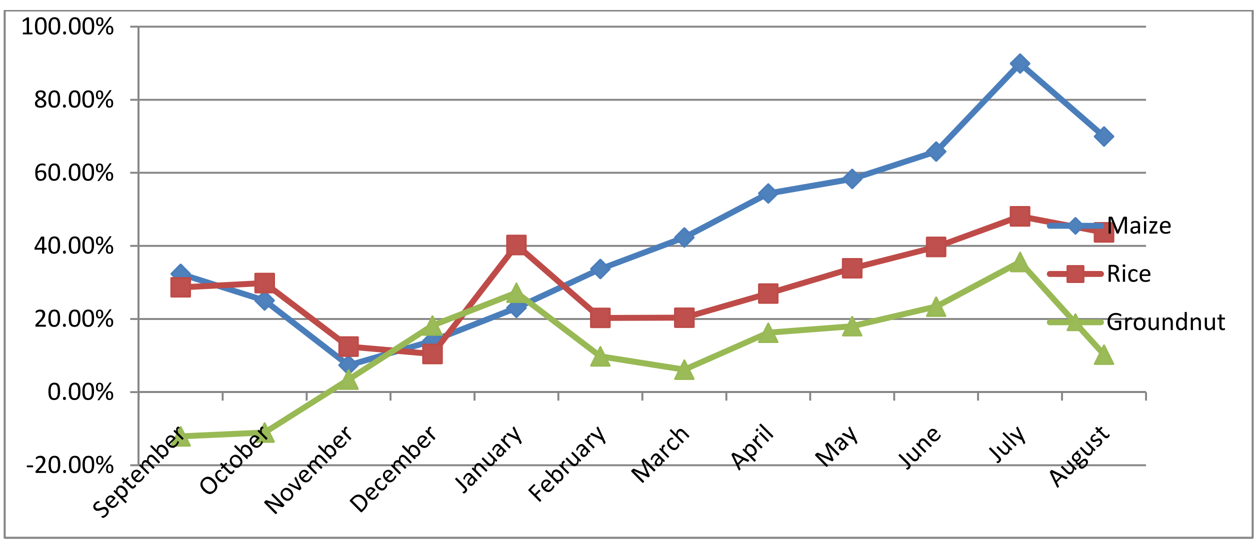
CROP AND RAINFALL DATA ANALYSIS

An analysis of data was conducted on yields, production estimates for groundnuts, rice, and maize as these are the cash crops that farmers were raise. These crops are used in a variety of ways and are most likely the crops which would correlate with food security. Rainfall from the Bole, Savelugu, Chereponi and Tamale districts in the northern region was analyzed as these districts had the most complete data. (See Appendix Item E for location of these districts.) Wholesale prices for both rural and urban areas for the crops were obtained from data from the Northern region as a whole. The average cumulative rainfall based on each crop's life cycle (period between planting and harvesting) was estimated for each year. This had to be calculated separately for each crop since their life cycles are different. An analysis was made to determine if there was a correlation between rainfall (between traditional planting and harvesting time) and crop yield for specific crops mentioned above. In addition, an analysis of crop prices was made to determine how crop prices fared with respect to crop production and crop yield in a given district.

Analysis Results

The lack of statistically significant correlations between rainfall and crop yields was a surprising but important finding. This has implications on the potential for an effective weather index insurance tied to rainfall which will be discussed at the end of this article. The relationship between crop price and crop yield was also interesting as there was not always an hypothesized negative correlation, even for local yield and crops with mainly local markets. Based on interviews in our primary research we expected to see price fluctuations within the year, with low prices immediately after harvest and high prices typically found in the summer the following year as illustrated in Exhibit 4. For example a nearly 90 percent average increase from October to the following July was seen in the price of maize. This increase was anecdotally cited by the microfinance institutions interviewed in the primary research phase of this study and the reason that storage facilities were seen as so valuable.

Exhibit 4- Average Monthly Price Fluctuations from Harvest Time (Maize, Rice, Groundnuts)



Price inflation was also observed. From 1999 to 2008 wholesale prices for all three crops rice, maize, and groundnuts have been steadily increasing as described in Table 1. The greatest change was found in the rural price of groundnut. This could be due to the fact that, most of groundnut distribution for the market is done by middlemen who increase the cost of the groundnut produced. Mean values for the crops are distorted due to extreme values at the tail ends of the price distributions (for example, minimum price for maize in rural areas is GH¢3.70 in 1999 to GH¢44.13 in 2008).

Table 1: Increases in Northern Region Crop Prices

	Min	Max
RiceRural	11.29	71.70
RiceUrban	10.14	71.31
MaizeRural	3.70	44.13
MaizeUrban	3.67	42.31
GnutRural	9.25	83.04
GnutUrban	9.48	72.21

Note: Descriptive Statistics for wholesale crop prices in the northern region. This is for both rural and urban areas. The unit for crop prices is the GH¢ (GH₵). 1 GH₵ = $1.40 in 2009.

Bole District

As seen in Table 2, no significant correlations were found between the crop yields and wholesale prices. Also, there were no significant correlations between rainfall and maize and groundnut but at a 5% significance level, rice was positively correlated to rainfall at 0.625.

In Bole, rice yields showed significant dips in 1997, 2001 and 2005. The year 2005 did not affect only rice yields, but maize as well; yields dropped from 2Mt/Ha to 0.93Mt/Ha. (see fig 1) This was largely due to late start of rains and low cumulative rainfall of about 967mm compared to that of 2003 of 1032mm. Also, crop area for maize decreased drastically from 1200Ha in 2004 to 239Ha in 2005. According to the Ministry of Food and Agriculture, Ghana, this decrease in cropping area was because farmers were unsure about the weather conditions for the year. Average cumulative rains for all three crops during their crop cycle was negatively skewed ; -0.46, -0.58 and -0.32 for maize, rice and groundnut respectively (See Table 3). This shows that initial rains during the crop cycles were on the low side. This may mean that the sowing times for crops were delayed to later months.

Table 2: Bole- Correlation Between Yields and Price and Yields and Rainfall

	Rice RuralPrice	Rice UrbanPrice	Maize RuralPrice	Maize UrbanPrice	Gnut RuralPrice	Gnut UrbanPrice	Rainfall Maize	Rainfall Rice	Rainfall G'nut
Maize Yield	0.196	0.211	0.137	0.171	-0.082	0.111	0.296	0.351	0.134
Rice Yield	0.323	0.329	0.309	0.325	0.215	0.278	0.129	.625*	.519*
Gnut Yield	0.49	0.521	0.383	0.433	0.477	0.328	.629*	.525*	0.331

Correlation between Rice Yield and Rainfall was significant at 0.05 for Bole district

Figure 1 – Crop Yields for Bole

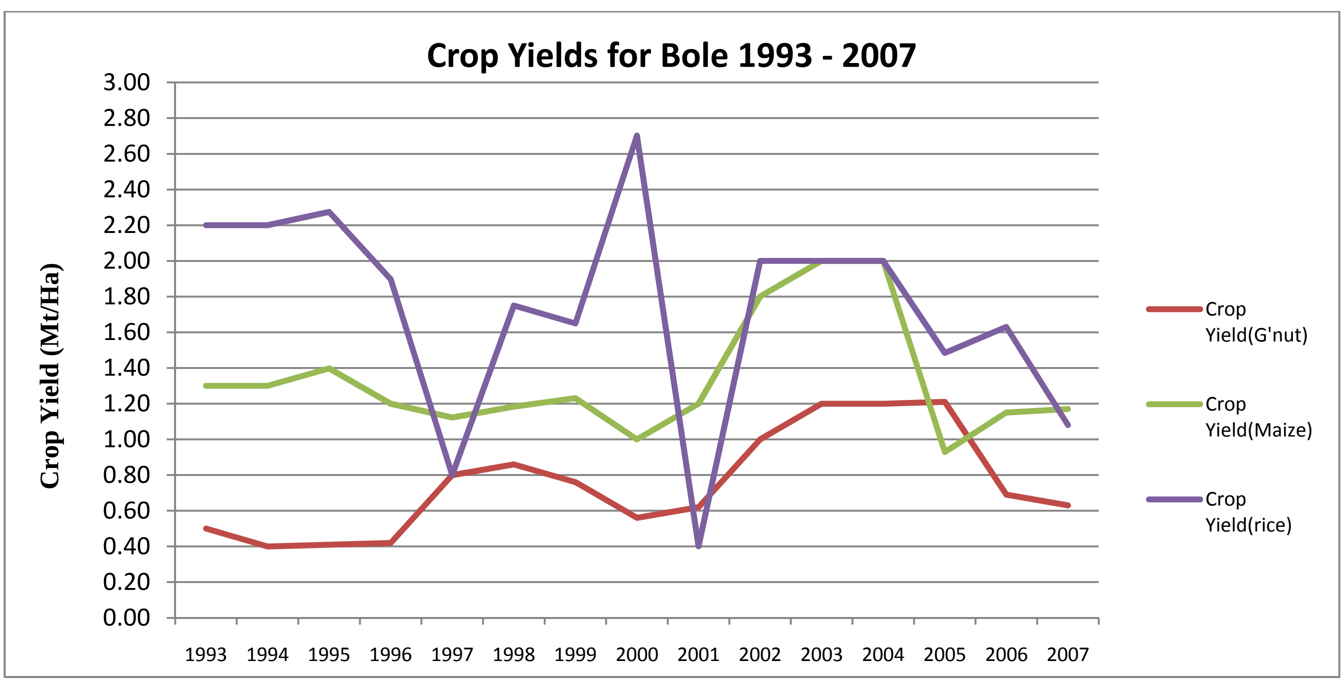


Table 3: Bole Descriptives (Yield and Rainfall)

	Range	Min	Max	Mean	Std. Error	Std. Deviation	Variance	Skewness
CropYldMaize	1.07	0.93	2.00	1.33	0.09	0.33	0.11	1.26
CropYldRice	2.30	0.40	2.70	1.74	0.16	0.60	0.36	-0.84
CropYldGnut	0.81	0.40	1.21	0.75	0.07	0.29	0.08	0.51
AvgRainMaize	56.47	115.90	172.37	150.67	4.35	16.84	283.54	-0.46
AvgRainRice	56.51	117.22	173.73	152.29	4.50	17.41	303.25	-0.58
AvgRainGnut	45.56	126.70	172.26	152.25	3.85	14.89	221.86	-0.32

Note: Descriptive Statistics for crop yield and average rainfall for maize, rice and groundnut in the Bole district. Average rainfall refers to the average cumulative rainfall for the period of the crop's life cycle. Rainfall is measured in millimeters (mm). Yield for each crop is measured in Metric Tons per Hectare (Mt/Ha). 1 hectare = 2.471 acres

Salvelugu District

Yield correlations for crops in the Salvelugu district are shown in Table 4. Although there was no significant correlation between yield and rainfall, there were significant positive correlations between maize yield and prices. It was unexpected to find that as more maize was being produced, prices for maize were also increasing, suggesting an interesting demand curve for that crop . The Savelugu district had a decrease in yield for maize, rice and groundnut in the year 1997. Yields picked up the following year only to fall again in 2001 and again in 2005 (Fig 2). Rice and maize yields were extremely varied with minimum and maximum yields for rice being 0.72Mt/Ha and 3.49Mt/Ha respectively while that of maize was 0.51Mt/Ha and 1.40Mt/Ha. Yields for groundnut and were low for the year 2005 (fig 2), the same situation seen in some of the Northern districts.

Table 4: Savelugu –Correlations Between Yields Prices and Rainfall

	Rice RuralPrice	Rice UrbanPrice	Maize RuralPrice	Maize UrbanPrice	Gnut RuralPrice	Gnut UrbanPrice	Rainfall Maize	Rainfall Rice	Rainfall G'nut
Maize Yield	.890**	.907**	.897**	.888**	.764*	.870**	0.361	0.417	0.452
Rice Yield	-0.507	-0.469	-0.378	-0.359	-0.531	-0.491	0.166	0.173	0.156
G'nut Yield	0.036	0.028	0.044	0.026	-0.195	0.056	0.211	0.201	0.143

Correlations between rainfall and yield were not statistically significant. There were however price and yield correlations as indicated above.

Figure 2 - Crop Yield for Savelugu

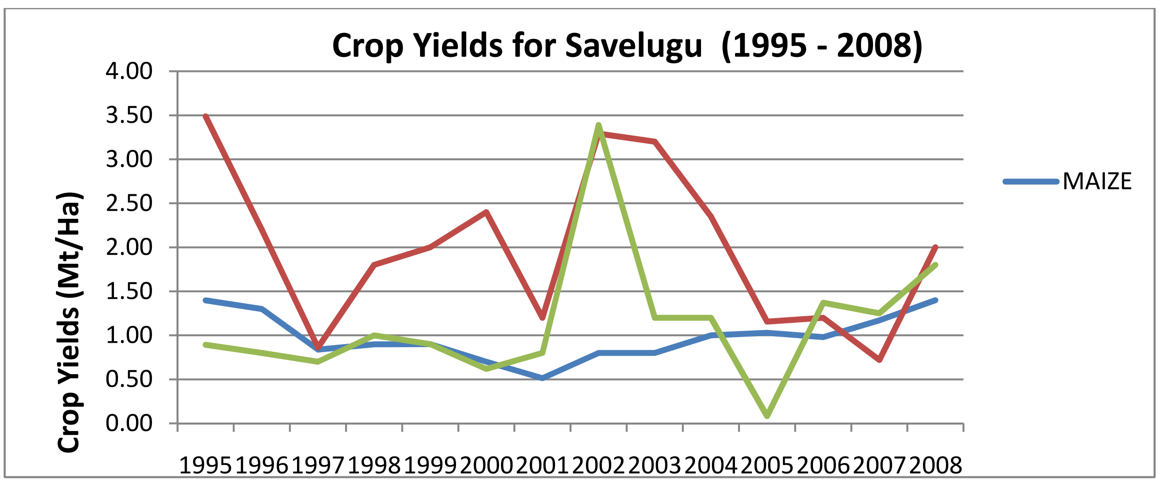


Table 5: Savelugu Descriptives (Yield and Rainfall)

	Range	Min	Max	Mean	Std. Error	Std. Dev	Variance	Skewness
MaizeYld	0.89	0.51	1.40	0.99	0.07	0.27	0.07	0.08
RiceYld	2.77	0.72	3.49	1.90	0.24	0.87	0.75	0.48
GnutYld	3.31	0.08	3.39	1.14	0.22	0.79	0.63	2.02
AvgRainMaize	104.22	91.23	195.45	149.37	7.99	28.81	830.30	-0.33
AvgRainRice	119.45	88.23	207.68	149.97	8.82	31.81	1011.73	0.10
AvgRainGnut	112.81	105.75	218.56	158.26	8.83	31.84	1013.90	0.47

Note: Descriptive Statistics for crop yield and average rainfall for maize, rice and groundnut in the Savelugu district. Average rainfall refers to the average cumulative rainfall for the period of the crop's life cycle. Rainfall is measured in millimeters (mm). Yield for each crop is measured in Metric Tons per Hectare (Mt/Ha). 1 hectare = 2.471 acres

Cheriponi District

In the Chereponi district, there were also no significant results for correlations between the yields of any of the three crops and rainfall (Table 6) and no significant correlations were found between rice or groundnuts and their rural and urban prices. However, like the Savelugu district, maize yields showed very high positive correlations with wholesale prices for both rural and urban areas

(specifically: -0.786, $p \leq 0.05$ and 0.800, $p \leq 0.01$). Figure 3 indicates that rice showed the most variability in this district and although all three crops had yields plummeting in years 2001 and 2007, they are now on an increasing trend.

Table 6 : Chereponi Correlations Between Yield Prices and Rainfall

	Rice RuralPrice	Rice UrbanPrice	Maize RuralPrice	Maize UrbanPrice	Gnut RuralPrice	Gnut UrbanPrice	Rainfall Maize	Rainfall Rice	Rainfall G'nut
Maize Yield	.693*	.739*	.786*	.800**	0.644	.677*	0.014		

Rice Yield	0.189	0.224	0.319	0.315	0.191	0.237		0.169	
GnutYield	0.641	0.663	0.657	0.65	0.431	0.65			0.105

Correlations between rainfall and yield were not statistically significant

Figure 3 – Crop Yields for Chereponi

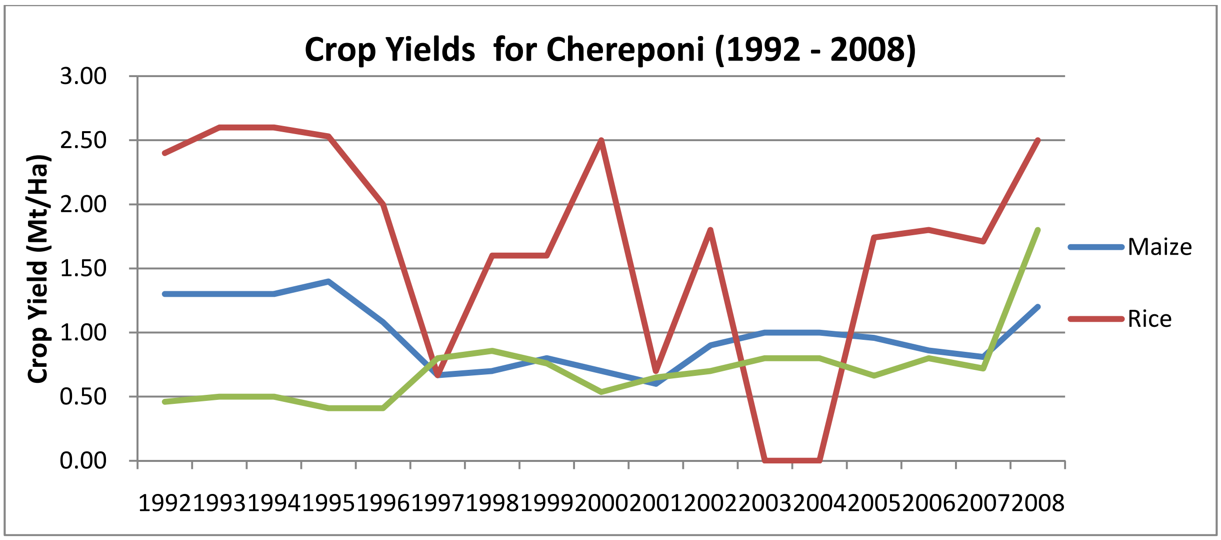


Table 7: Chereponi Descriptives (Yield and Rainfall)

	Range	Min	Max	Mean	Std. Error	Std. Deviation	Variance	Skewness
MaizeYld	0.80	0.60	1.40	0.98	0.06	0.25	0.06	0.25
RiceYld	2.60	0.00	2.60	1.80	0.19	0.78	0.60	-1.02

GnutYld	1.39	0.41	1.80	0.72	0.08	0.32	0.10	2.62
AvgRainMaize	112.20	96.30	208.50	163.29	8.15	28.24	797.67	-1.04
AvgRainRice	82.60	123.10	205.70	169.39	7.27	25.19	634.47	-0.53
AvgRainGnut	108.30	126.00	234.30	181.73	9.49	32.86	1079.90	0.17

Note: Descriptive Statistics for crop yield and average rainfall for maize, rice and groundnut in the Chereponi district. Average rainfall refers to the average cumulative rainfall for the period of the crop's life cycle. Rainfall is measured in millimeters (mm). Yield for each crop is measured in Metric Tons per Hectare (Mt/Ha). 1 hectare = 2.471 acres

Tamale District

From Table 8, the only significant correlations were between maize yields and wholesale prices. All other results from Tamale, the administrative capital of the northern region, were not statistically significant. Apart from a peak yield of 8.00Mt/Ha in 2001, yields for groundnut generally decreased across the years (fig 4). The other two cereal crops did not fare very well either with maximum yields for maize and rice being 1.60Mt/Ha and 2.73Mt/Ha respectively (See Table 9). This could be due to the declining area for crop production in the Tamale district caused by rapidly increasing population.

Table 8: Tamale- Correlations Between Yield, Price and Rainfall

	Rice RuralPrice	Rice UrbanPrice	Maize RuralPrice	Maize UrbanPrice	Gnut RuralPrice	Gnut UrbanPrice	Rainfall Maize	Rainfall Rice	Rainfall G'nut
Maize Yield	.911**	.907**	.879**	.899**	.899**	.895**	0.112	0.17	0.215
Rice Yield	0.679	0.685	0.555	0.603	0.473	0.608	-0.325	-0.054	-0.045
Gnut Yield	0.74	0.735	0.601	0.651	0.436	0.641	-0.203	-0.433	-0.409

Figure 4 – Crop Yield for Tamale

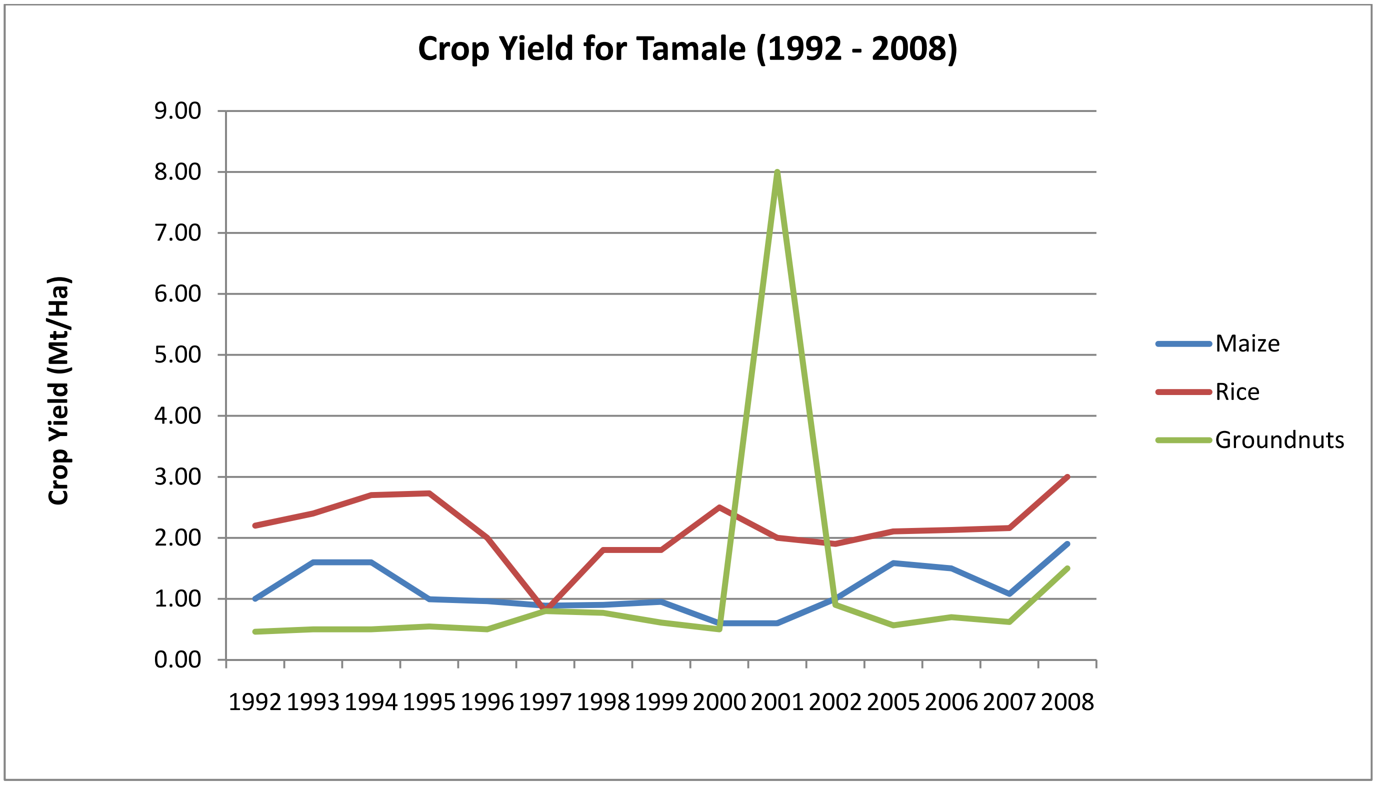


Table 9: Tamale Descriptives (Yield and Rainfall)

	Range	Min	Max	Mean	Std. Error	Std. Deviation	Variance	Skewness
MaizeYld	1.00	0.60	1.60	1.09	0.09	0.35	0.12	0.44
RiceYld	1.93	0.80	2.73	2.09	0.13	0.48	0.23	-1.33
GnutYld	7.54	0.46	8.00	1.14	0.53	1.98	3.92	3.71
MaizeAvgRain	92.30	100.45	192.75	145.85	6.23	23.30	543.01	0.12
RiceAvgRain	111.53	98.83	210.37	149.90	7.07	26.46	699.98	0.20
GnutAvgRain	120.16	104.92	225.08	156.21	7.57	28.33	802.36	0.55

Note: Descriptive Statistics for crop yield and average rainfall for maize, rice and groundnut in the Tamale district. Average rainfall refers to the average cumulative rainfall for the period of the crop's life cycle. Rainfall is measured in millimeters (mm). Yield for each crop is measured in Metric Tons per Hectare (Mt/Ha). 1 hectare = 2.471 acres

DISCUSSION AND CONCLUSIONS

As mentioned earlier, this project is a small part of a much larger endeavor by researchers from around the world, in studying the potential for agricultural risk management tools that can mitigate the financial impact of weather related events on farmers, especially those in developing countries like Ghana. In that context it is important to discuss the project limitations, summarize some of the key findings of this study, and identify key questions uncovered from this study that still need to be answered.

Limitations and Challenges of the Study

In working with the data, several limitations were encountered in this study. These limitations are not unusual for researchers working in developing countries, and in fact Ghana has, on a comparative basis fewer problems than other countries. However, it is important to note these limitations especially in considering the conclusions, and the potential areas that need to be researched.

One of the first issues encountered was in obtaining the data. Collecting data is an expensive endeavor and choices were inevitably made in order to best prioritize the data to be obtained. This involved opting for northern region data in lieu of data in other parts of the country. This choice was made because the northern region experiences only one rainy season and drought insurance seemed like a more viable possibility. Furthermore, only limited amount of data is available, and collection of data should continue and expand, so that better and more reliable inferences can be made in future research.

The availability data in electronic form and the labor involved in obtaining it was an additional challenge. Most of the data that is over twenty years old is currently hard copy in paper files. For the data which has been converted to electronic format, computer viruses have destroyed some of the data, resulting sometimes in one full year of missing electronic data. Paper copies of data do exist, electronic data could be reentered, and the government is regularly updating and converting to digital form. However, currently only about 15 years of data is available electronically. Oftentimes the data is housed on individual computers in an office and is not networked to a larger data source. This often means that data must be acquired individually from each computer. This is a time consuming and labor intensive process, and requires an in-country researcher to gather the data. (Note: The Statistics Division of the Food and Agric Department of Ghana is working to fill in the missing spots and correct inconsistencies in order to have better data to work with and the people we met were helpful and enthusiastic in trying to help we obtain the most up-to-date data).

Although obtaining and converting older hard copy data to digital data may appear to be a likely remedy, the correlations may still prove to be weak, especially given the changes that have occurred in recent years as to the timing of rainfall and planting for various crops. Any correlations that would be found would have to be carefully scrutinized in order to determine if they are likely to reflect the current environment of changing climate conditions.

Matching sets of data is required for understanding correlations between variable. The unavailability of matching sets of data and missing crop and rainfall data for several periods impedes the calculation of these correlations in many districts. (Data security varies widely by source as well. As mentioned earlier Rainfall stations staffed by volunteers have less security the other types of meteorological stations.) The frequent political redistricting was another challenge because data is recorded by district, but new districts have been added, and without some way to hold the district data constant, it is difficult to find matching data sets to determine correlations. We chose some of the districts which had not undergone re-districting, and therefore permitted comparability of data over time.

A lot the data is not normal and may be required to be normalized before conducting data analysis of correlations. Other sophisticated forms of data analysis may also be required. That is an area that we continue to work with and consider with the research team and explore with researchers working with similar data issues on projects in other countries.

Although the districts we analyzed seemed relatively small, the lack of correlation between rainfall and crop yields for the district could occur for a number of reasons. Rainfall-crop yield correlations may be affected by factors such as:

- The location of a rainfall collection station from the center of the district
- The size and topography of a district,
- The microclimates that exist within a district, and
- The existence of weather bands that bisect a district.

A more detailed, in-country analysis would be required to assess those factors. A potential solution may be to add more rainfall collection sites within a district.

Despite the challenges, this area of research is rich with opportunity for making valuable contributions to the lives of those living in developing countries.

Summary of Findings

The lack of correlation between rainfall and crop yield was surprising. There are a number of possible explanations for this which could be examined in further research, but this study may also point to the need to develop an insurance product that has some other trigger or combination of triggers that would more closely correlated to crop yield and thus the actual crop losses that famers in a given district may incur. Some of the direct findings of this study, include:

- An overall lack of statistically reliable correlations between rainfall and crop yields for maize, rice, and groundnuts for three key districts in northern Ghana.
- Correlations between prices and crop yields were sometimes positive
- Strong seasonal fluctuation of prices for crops

One potential product they may be considered is an area yield index. These have an advantage over farm yield insurance products in that they do not have the moral hazard or high administrative costs of a farm yield product, yet may have lower basis risk than a weather index product like drought insurance. Area yield insurance products are some of the oldest forms of an index for agricultural loss, and may have hold promise if the yield for a district correlates well with losses for farmers, or possibly defaults on farm loans to financial institutions for that district.

The seasonal price fluctuations indicate a benefit to farmers for crop storage facilities, which is what we had learned anecdotally from our interviews with microfinance institutions. This potential solution could prove to have the greater impact on farmers' income and for enhanced access to capital from financial institutions than any risk management tool. Assessing the differences in income and agricultural risk making decisions based on a farmer's access to storage could prove valuable.

Some of the indirect findings of this study based on interviews conducted include:

- An interest by financial institutions making loans to farmers to better mitigate the risk of loan defaults,
- An interest by financial institutions to purchase an insurance product that would help mitigate the financial risk of loan defaults
- An interest by financial institutions to make more loans to farmers if the risk can be better mitigated
- An interest in exploring other forms of financial risk management for farmers such as risk retention groups.

With respect to the formation of village risk retention group, one Paramount Chief offered to provide his 70,000 villagers as a pilot for such a program. The structure and formation and involvement with local chiefs could provide an opportunity to offer a non-insurance risk management solution that would more closely reflect the ways in which farmers have traditionally managed their risk. Such a program would require extensive field research and in-country program coordination.

Addition Research Suggested

In addition to the possible research projects described above a number of research questions stem from this study. Perhaps the most promising potential is for research on an area index by district. Such an index may more accurately reflect the default risk for financial institutions making loans in a particular district. It might also more closely reflect the losses of an individual farmer, while at the same time provide the benefits of an index insurance product over an indemnity based insurance product. Other questions also arose from this study which further research could help explain. The following are key questions stemming from this study:

- Why is there such little or no correlation between rainfall and crop yield, in an area where drought is a risk and there is little irrigation?
- How might additional historical data affect these correlations?
- At what point is the historical data no longer predictive of current agricultural yields given changes in farming practices and changes in climate and weather patterns?
- Are there other risk management tools which may be more appropriate and useful than rainfall insurance, in managing agricultural risk in Ghana?
- To what extent does the location of a district's meteorological station represent the meteorological data for the entire district?
- If rainfall, or lack of rainfall, does not explain crop yield what factors do (government agriculture subsidies for inputs, economic conditions, flow of capital from financial institutions, etc)?
- If basis risk for individual farmers is high, is index insurance an appropriate risk management tool for the individual farmer?

- If financial institutions were able to purchase an index insurance product, would they use this tool to provide more capital to farmers?

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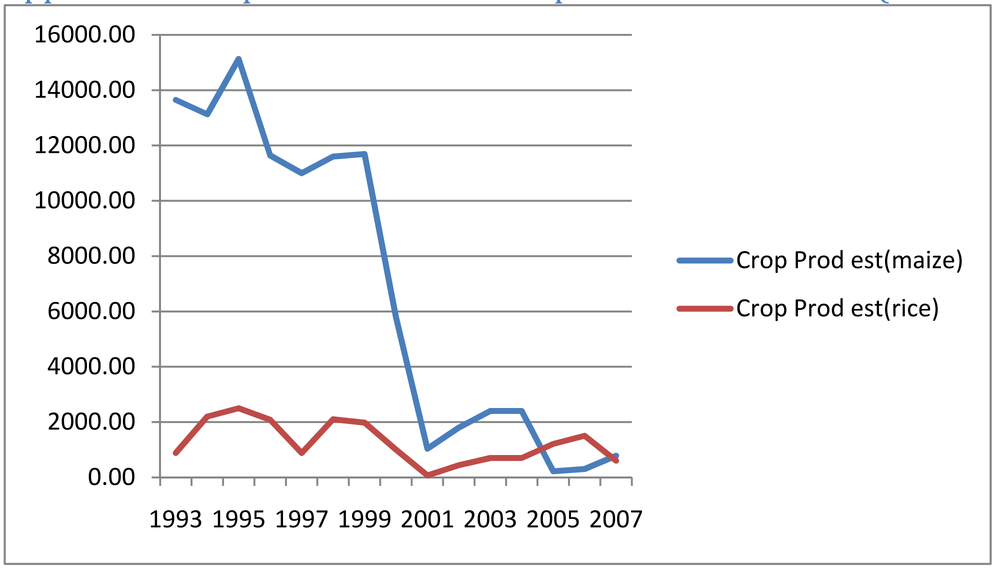
Appendix

A: Crop Yield, Production and Cumulative rainfall/period data set

Year	Crop Yield(Maize)	Crop Yield(rice)	Crop Prod est(maize)	Crop Prod est(rice)	avg cumm rainfall(maize)	avg cumm rainfall (rice)
1993	1.30	2.20	13650.00	880.00	888.30	972.90
1994	1.30	2.20	13130.00	2200.00	695.40	955.90
1995	1.40	2.27	15130.00	2500.00	816.30	935.30
1996	1.20	1.90	11640.00	2085.00	846.50	956.10
1997	1.12	0.80	11000.00	880.00	959.30	1003.40
1998	1.18	1.75	11600.00	2100.00	797.90	881.30
1999	1.23	1.65	11693.00	1980.00	1005.40	1079.10
2000	1.00	2.70	5800.00	1000.00	1000.10	1092.10
2001	1.20	0.40	1039.00	69.00	800.40	848.30
2002	1.80	2.00	1800.00	440.00	1034.20	1103.00
2003	2.00	2.00	2400.00	700.00	1032.40	1134.70
2004	2.00	2.00	2400.00	700.00	946.60	1042.40
2005	0.93	1.48	222.00	1208.00	967.40	1119.00
2006	1.15	1.63	302.45	1502.86	927.60	951.10
2007	1.17	1.08	779.69	604.80	842.90	929.60

Appendix B: Graph of Maize and Rice production estimates (1993 – 2007)



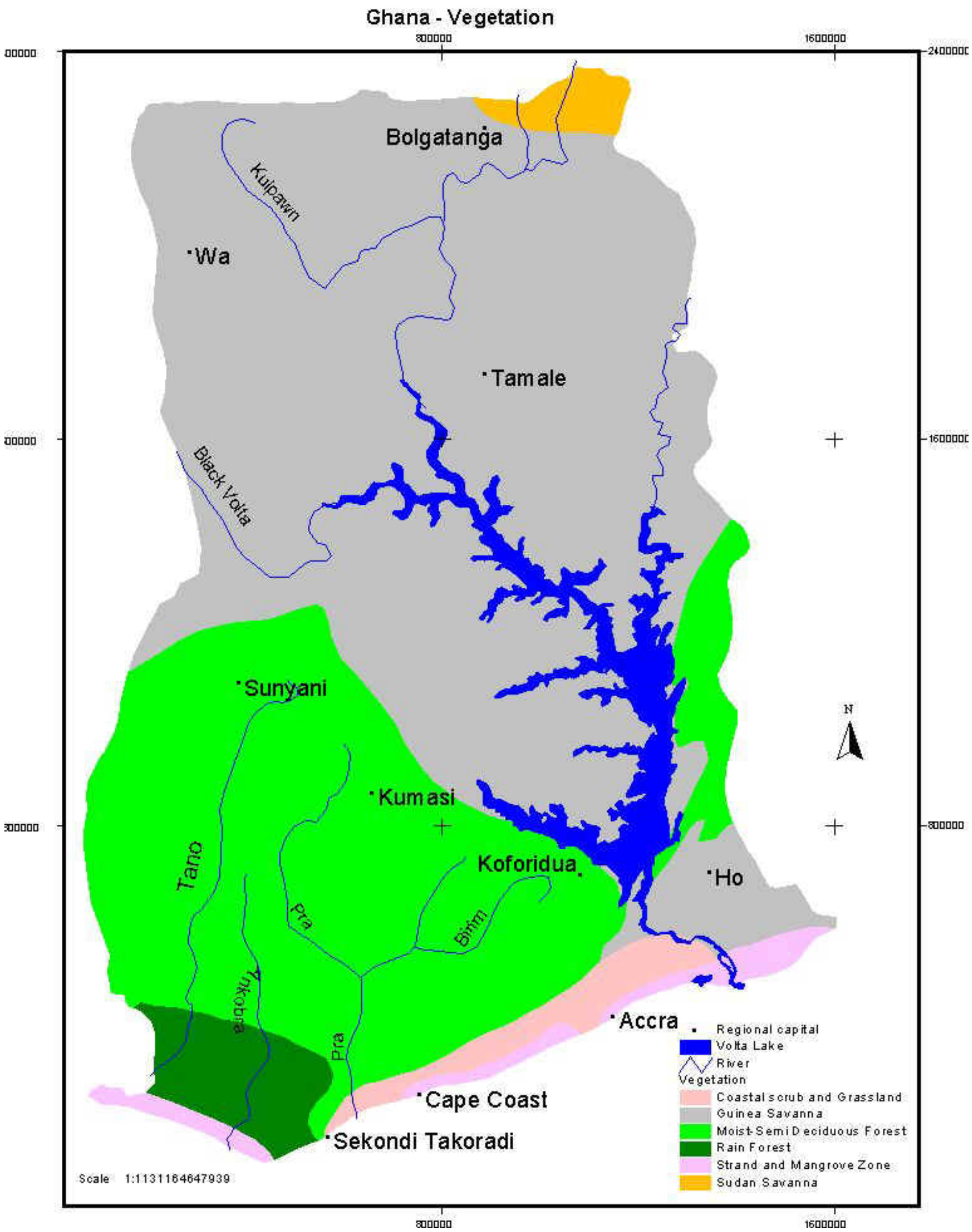
Appendix C:

Ghana - National Consumer Price Index and Inflation Rates (2005 – 2009)

Link:

http://www.statsghana.gov.gh/docfiles/CPIRelease_pdf/national_cpi_&_inflation_rates.pdf

Appendix D. Maps of Northern Ghana



Appendix E. Map of Northern Districts

Districts of Northern Ghana.

The Northern Region of Ghana contains 20 districts. 18 are ordinary districts in addition to 1 municipal and 1 metropolitan districts.:

- Bole District
- Bunkpurugu-Yunyoo District
- Central Gonja District
- Chereponi District
- East Gonja District
- East Mamprusi District
- Gushiegu District
- Karaga District
- Kpandai District
- Nanumba North District
- Nanumba South District
- Saboba District
- Savelugu-Nanton District
- Sawla-Tuna-Kalba District
- Tamale Metropolitan District
- Tolon-Kumbungu District
- West Gonja District
- West Mamprusi District
- Yendi Municipal District
- Zabzugu-Tatale District

LOCAL CLASSIFICATION OF SOIL TYPES OF GHANA