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Feasibility Study on Agricultural Index Insurance for Rice Producers in Battambang, Cambodia

Author
Gregerson, Katheryn

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Feasibility Study on Agricultural Index Insurance for Rice Producers in Battambang, Cambodia

By

KATHERYN GREGERSON
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Approved:

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Stephen Boucher, Chair

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Michael Carter

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Chea Leangsrun

Committee in Charge

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Abstract

Rice production in Cambodia faces increasing challenges due to climate variability, with frequent droughts and floods threatening yields and exacerbating food insecurity. This thesis investigates the feasibility of introducing rainfall-based index insurance as a risk management tool for rice producers in Battambang, Cambodia. The study evaluates the potential welfare benefits of six different index insurance contracts using the Relative Insurance Benefit (RIB) methodology, which compares the economic benefits of index insurance to those under perfect yield insurance and no insurance scenarios. Using CHIRPS rainfall data and yield data from a recall survey, resulting low RIB measures are explained based on variability in rice yields attributable to rainfall, the relationship between self-reported weather experiences to those detected by the index insurance contracts, and how indemnity events depict the basis risk involved in these products. Drawing from focus group discussions and key stakeholder interviews, the study considers additional feasibility factors such as farmer access to information and the role of trust in the agri-insurance sector of Cambodia. The findings suggest that while index insurance offers potential benefits to rice producers, significant challenges remain, particularly when a high quality, rainfall-based index insurance contract that improves farmer welfare is the end goal. Recommendations are provided to guide future efforts in developing and scaling up index insurance in Cambodia, with an emphasis on improving the accuracy of rainfall-based indices and enhancing farmers' trust in these products.

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1. CHAPTER 1: INTRODUCTION

Fundamental to Cambodia's economy, the agricultural sector contributes to 22.8% of Cambodia's gross domestic product (World Bank, 2021). Rice accounts for 50% of the value of agricultural output (ADB, 2021) and employs over 3 million people, arguably making it the most important food industry in Cambodia (IFC, 2015). While rice yields have improved over the past three decades, climate change threatens rice production, leading to reduced yields and increased food insecurity. Due to Cambodia's tropical climate with both monsoon and dry seasons, it consistently ranks in the top three countries most affected by weather-related losses in Southeast Asia (Kreft et al., 2015).

Climate change impacts are the most prevalent near the Mekong River, where most Cambodians live and where most of the country's rice is grown (Chinvanno et al., 2006). Smallholder rice producers in this region are particularly vulnerable, as they are at the mercy of unpredictable rainfall patterns and ever-shifting water levels of the Tonle Sap Lake. A longer dry season and shorter wet season with higher rainfall has specifically impacted rice producers in the Battambang province, otherwise known as the "rice bowl" of Cambodia (Srean et al., 2018). These drought and flooding events negatively impact households by creating uncertainty in crop yield, with some sources predicting that rice yield could decrease by 30 kg per hectare by 2025 (Bairagi et al., 2020). In turn, this severely reduces post-harvest profits.

Significant adaptation efforts are required in order to manage and recover from high yield loss and decreased revenue streams. Currently, Cambodian rice producers have extremely low adaptation rates to these weather-related risks. While adopting stress-resistant rice varieties, integrated pest management practices, and weather advisories has been emphasized, uptake has been minimal (Bairagi et al., 2020). Further adaptive strategies are needed in order to ensure the survival of this integral sector.

As a proven risk management tool, agricultural crop insurance has been introduced as a solution to helping smallholder rice producers adapt to the threatening climate change patterns they face. The Royal Government of Cambodia has shown interest in supporting insurance schemes as an "adaptive social protection approach that could reduce climate-risk and disaster burdens on society" (Cambodia Climate Change Strategic Plan, 2014). However, previous crop insurance schemes have faced a lack of weather data, low education amongst farmers, and a lack of profitability for private insurers as large barriers to success (Chamroeunrith & Sokhorng, 2019). These challenges have discouraged private insurance companies from providing conventional crop insurance contracts to producers.

While it is true that rice producers have a low awareness of crop insurance as a risk management tool, Wang et al. (2022) found that rice producers highly value and are interested in learning more about insurance products. In this landscape, index insurance arises as a promising alternative solution for insurance providers and users alike, as it reduces moral hazard and significantly lowers costs for both parties. Rather than requiring costly loss verification, index insurance utilizes an indicator of losses, such as yield, rainfall, or vegetation measurement, as an index to trigger payouts. As a global leader in the development, research, and impact evaluation of index insurance contracts, the Feed the Future Innovation Lab for Markets, Risk, and Resilience (MRR) at UC Davis has found that index insurance has the potential to reduce producers' reliance on costly coping mechanisms and promote resilience through enhancing their investments in more productive and profitable inputs and opportunities (Carter & Chiu, 2022).

However, index insurance does face the challenge of basis risk, or the risk that producers' actual losses do not correlate well with the indexed measurements, resulting in the potential for producers to be worse off as a result of purchasing the insurance (Kramer et al., 2022).

Another consideration to be made when introducing index insurance is how gender dynamics may impact insurance demand and uptake. According to the FAO Cambodia Gender Profile, women are often in charge of seedling care, weed control, and transplanting when it comes to rice production. They are also responsible for communicating with middlemen and hiring external labor. Management of these farming activities is increasingly landing on women, as men are migrating to cities and to Thailand for waged employment (FAO, 2023). The same report indicates that men typically make decisions related to cropping systems, seed selection, and input usage, along with investment ideas related to expanding production. However, women manage household spending and income and are often consulted by men prior to financial decisions being made (FAO, 2023).

However, the gendered dimensions behind insurance adoption and decision-making are not well documented. For example, given their primary responsibility of meeting their families' food and nutritional needs, women may perceive the threat of drought differently and thus may have different demand for insurance compared to men. In Kenya, a research project transformed livestock-based index insurance into gender-inclusive insurance. To do so, they reframed the insurance product around women's unique and indirect risks and sold insurance units by the number of household members who might be at risk if a disaster strikes. Through a randomized control trial, they found this reframing to significantly increase demand for index insurance (Arteaga et al., 2023). More research on these gendered dimensions of risk perceptions and insurance demand in Cambodia is necessary to ensure that a new index insurance product can be designed to be as inclusive as possible.

1.1 Literature Review

In this section, we review the literature regarding the impacts of rainfall on rice yield in Cambodia, as well as the benefits and challenges of utilizing index insurance as a tool to manage and transfer those risks.

1.1.1 Rainfall Impact on Rice Yield

Over the last decade, rice yield in Cambodia have been steadily increasing. However, lower yields are apparent in provinces that are water-stressed, either due to too much or too little rainfall (Abhishek et al., 2021). Since over 85% of national rice production is dependent on rainfall, climate change leaves rice producers extremely vulnerable to drought and flooding (Kim et al., 2018). It can be difficult to quantify the direct impact of rainfall on rice yield, as there are many other variations at play in farming systems and livelihood activities. However, several papers have sought to depict this impact through learning from farmers themselves and using novel remote sensing and satellite technologies.

To specifically quantify the impact of drought on rice yield and food security in Cambodia, Sok et al. (2022) analyzed precipitation and vegetation indices. Focused on the Tonle Sap basin, they found November to be the most common month for drought. Importantly, they also showed that drought duration had a stronger impact on rice yield than drought severity and intensity (Sok et al., 2022). To further depict this, a study done by Poulton et al. (2016) utilized the APSIM farming systems model to project that in Southeast Cambodia from 1978-2011, a 10% reduction in rainfall resulted in average rice yields declining by about 26%.

On the other hand, flooding typically occurs in Cambodia from May to October, during the monsoon season. Looking specifically at plots where producers grow short-duration (< 115 days to mature) rice in the early wet season, Okazumi et al. (2014) estimates that flood damage occurs when the depth of water in paddy plots is greater than 50 cm during the rice-growing period. Using a similar "flood" definition of 20-60 cm depth of rainfall, Chi et al. (2011) found that floods can decrease yields anywhere from 20-100% if producers do not re-sow or adjust their cropping calendars. These drastic decreases in yield due to both drought and flooding often result in diminished household food consumption and lower farm profits.

In order to manage and adapt to these changing climatic conditions, studies (Kim et al., 2018; Bairagi et al., 2020) have indicated that several strategies may be feasible. These include irrigation, adjustment of planting dates, adopting drought/flood-resistant rice varieties, and accessing weather advisories. While these sound promising, rice producers in Cambodia often lack access to their benefits. For example, irrigation infrastructure is scarce, especially in the Battambang province. Drought/flood-resistant rice varieties are being developed within IRRI Cambodia and Cambodian Agricultural Research and Development Institute (CARDI) but are rarely distributed to farmers. If they are distributed, they are often given to "lead farmers" who are already operating at a larger scale. There are new apps being developed to provide farmers with weather advisories and other crop information (i.e., Tonle Sap App). However, these apps require farmers to have a smart phone and are often only publicized to farmers who have taken out loans with certain microfinance institutions. Due to these constraints, researchers and the development community have turned towards agricultural index insurance in recent years as a potential risk transfer tool that may be a more feasible option for rice producers in Cambodia.

1.1.2 Index Insurance Overview and Benefits

An effectively structured crop insurance program can be pivotal in helping farmers manage risks, bolster the resilience of agricultural households, and encourage greater investment in higher-risk, more productive inputs and technologies. Index insurance, a broad category of crop insurance, has garnered considerable interest in recent years, particularly in low- and middle-income countries (Miranda and Farrin, 2012; Barnett et al., 2006).

Instead of basing payouts on actual losses, index insurance compensates the farmer based on estimated losses. These losses are determined by evaluating an external index that, if designed well, is highly correlated with farmers' yields. If the index value exceeds (or falls below) a contractually defined threshold called the trigger or strike-point, then all insured farmers within the insurance zone receive an indemnity payout. The insurance zone is the spatial area at which the index is measured and is typically an administrative unit with clearly defined borders such as a village or county.[1] Because indemnity payouts are based on an external index instead of the individual farmer's losses, index insurance is best suited to protect farmers against covariate risk – or the risk to average yield in the insurance zone. As a result, and as will be discussed further below, the quality of an index insurance contract will depend on both how much of the total risk faced by farmers is in the form of covariate risk (i.e., variability in average yield in the insurance zone) versus idiosyncratic risk as well as the degree to which the selected index predicts, or is correlated with, average yield in the insurance zone.

Table 1.1 categorizes indices into three general classes and summarizes their benefits and costs.

[1] While much of the index insurance literature has focused on the choice of index, recent research suggests that the design of insurance zones is also critical to the quality of index insurance contracts (Estefania-Salazar et al, 2024).

Table 1.1: Three Classes of Indices for Index Insurance Contracts			
	Directly Measured Area Yield Indices	**Indirectly Measured Area Yield via Remote-Sensing**	**Weather Indices**
Definition	Direct estimate of average yield within an insurance zone via crop cuts.	Use of remote sensing data measuring vegetative growth, such as NDVI, and/or weather outcomes, such as temperature and rainfall, to predict average yield in an insurance zone.	Rely on weather data (i.e., rainfall, temperature, etc.) gathered from weather stations or satellites to determine what impact that weather event may have on yield.
Benefits	*Most recommended option:* 1. Direct measure (instead of prediction) of yield. 2. Captures risk from all types of disasters (more than just one named peril).	*Second best option:* • Indirectly estimates average yield by modeling the relationship between remotely sensed variables and average yield. • High potential for innovation around new types of remote sensing technologies and big-data modeling techniques.	*Last resort, not recommended:* 1. Often the easiest for farmers to understand, but still exhibits the most basis risk.
Constraints	• Expensive, as it requires crop cuttings to estimate average yield. • Difficult to get long enough historical yield data in order to price contracts.	1. Still need yield data to develop a high-quality index. 2. Satellites that use optical sensors may default in certain conditions.	• Only captures risk related to a singular, named peril such as drought. • Does not estimate yield. • Lack of weather stations and inaccurate weather predictions.

Index insurance is cheaper and more objective than traditional insurance because it eliminates the need for highly costly on-farm loss measurement and claims assessment and removes challenges arising from adverse selection and moral hazard (Miranda and Farrin, 2012). It is important to note, however, that the cost of developing index insurance contracts can vary significantly depending on the class of index selected (as discussed in the table above).

Various studies have provided evidence of the positive impact of index insurance on farming households' resilience, productivity, and incomes. For example, research done in Kenya by Janzen and Carter (2019) found that index insurance reduced households' reliance on costly ex-post coping mechanisms following a severe drought. Specifically, index insurance reduced poorer households' use cutting food consumption following a drought by 49 percentage points, while the insurance reduced wealthier households' reliance on selling assets following a drought by 96 percentage points.

Without access to formal insurance, farm households attempt to smooth income and consumption through inefficient measures. When a weather event severely decreases a farmer's yield or completely destroys a farmer's crop, they often use self-insurance mechanisms such as depleting household savings or assets, adjusting household labor supply, receiving transfers from community members, reducing food consumption, or taking children out of school in order to maintain consumption levels in the face of this loss of income (Janzen and Carter, 2019; Morduch, 1995). Uninsured risks, such as drought and flooding, also have important adverse ex-ante impacts as they prevent farmers from investing in productivity-enhancing but risky inputs and technologies that would result in higher incomes long-term (Boucher et al., 2021).

Through research on index insurance, the Feed the Future Innovation Lab for Markets, Risk and Resilience has coined the term "Resilience+" to describe a "virtuous circle" where families can use index insurance to 1) manage risk with minimal compromise to future wellbeing, and 2) invest in more productive agricultural assets that actually improve future wellbeing (Carter, 2020). However, learning, experience, and trust in the insurance product are critical for driving investments that generate Resilience+. The next section explores these and other challenges facing the adoption and scale-up of index insurance.

1.1.3 Index Insurance Challenges

While there are many proven benefits to the adoption of index insurance, take-up has been low across the globe. There are both supply-side (insurance designers and providers) and demand-side (farmers) challenges.

On the supply-side, likely the most prevalent constraint is basis risk, which arises when risks faced by households are not the same risks that are measured by the index (Carter et al., 2017). Basis risk takes two forms. Positive basis risk, also called a "false positive" event, occurs when the index is triggered and thus the household receives a payout, even though they did not experience a yield loss. Negative basis risk, also called a "false negative" event, occurs when the index is not triggered and thus the household does not receive a payout even though the household did experience a shock resulting in a yield loss (Carter et al., 2017).

As described above, at best an index insurance contract can fully insure farmers against covariate risk – i.e., risk to average yield in the insurance zone. Basis risk can thus be driven by two sources. First, the greater is the degree of idiosyncratic/individual risk relative to covariate risk, the larger will be basis risk. For example, if the primary driver of risk in an insurance zone is pest damage which, in turn, is high variable across households, then idiosyncratic risk and basis risk will be high. If, instead, the primary source of risk is drought which simultaneously affects all farmers in the insurance zone then covariate risk will be relatively more important and, as long as the index accurately predicts average yields, basis risk will be low.

From the farmer's point of view, the quality of an index insurance product decreases as basis risk increases. This is because basis risk results in farmers receiving payouts when they least need them and preventing payouts when they most need them. As a result, the higher is basis risk, the lower is the ability of the insurance contract to smooth or stabilize farmers' consumption. We will return to this point when we describe our measure of index quality in the next section.

One constraint to minimizing basis risk is that of poor-quality index, yield, and agronomic data for the area to be insured. To ensure the proper triggering of payouts, satellite and/or weather station data must be reliable and available in precise measurements that are gathered at the right resolution and frequency. This is especially relevant in Cambodia, where weather stations are sparse and farmers lack trust in the accuracy of their measurements (Lay et al., 2023). Basing index measurements off of reliable yield and agronomic data is also essential to minimize basis risk.

On the demand-side, farmers face financial, knowledge, and resource constraints when determining whether or not to adopt index insurance. A primary barrier for farmers is low financial literacy and lack of awareness around the concept of insurance more generally (Wang et al., 2022). Other farmers may not be risk averse enough to seek out risk management strategies. If farmers are aware and interested in exploring the concept of crop insurance, many face credit and liquidity constraints. Accessing funds early in the growing season to commit towards an insurance product is not feasible for many households. Even if households can access these funds, the cost of index insurance can be extremely high, especially without government subsidies. The premium for a weather index crop insurance (WICI) product offered in Cambodia in 2021 was $10 USD per hectare, with a 50% government subsidy (Lay et al., 2023). A $5 USD premium per hectare is a substantial gamble for low-income households who do not understand the full benefits of having crop insurance.

These constraints set aside; farmers must also trust in the insurance provider in order to adopt the insurance product. Without the step of on-farm loss verification, farmers miss out on valuable relationship-building and contact with insurance representatives. Cai et al. (2016) found that in China, an essential element of building trust is the first-hand witness of payouts to oneself or a neighbor. If index insurance payouts do not happen frequently, households may never develop or lose trust in the provider and drop out of the insurance scheme, thus harming the trust of neighbors as well.

1.2 Cambodian Context and Research Partner

Here, a snapshot of current government, donor-funded, and private sector programs working with index insurance is presented, along with research gaps and context on the research partnership with the Center of Excellence for Sustainable Agricultural Intensification and Nutrition (CE SAIN).

Several research studies have focused on the benefits and constraints of index insurance, specifically for rice in Cambodia. An emphasis has been placed on farmer demand and willingness-to-pay (Fiala and Wende, 2016; Lay et al., 2023; Wang et al., 2022), noting that while farmers are generally interested in crop insurance, demand is dampened by a lack of trust in the provider, high prices, and low levels of risk aversion. They find that farmers are more willing to pay for index insurance if they are married or have larger farm sizes, while they are less willing to pay if they have more children. Lay et al. (2023) interviewed 232 respondents in the Battambang province to understand their willingness to pay for WICI with a $5 USD premium per hectare. 45.7% of respondents were willing to purchase the product, a more promising result than past studies.

A study done by Falco et al. in 2016, looked at the ex-post investment decisions of farmers in Cambodia who adopted index insurance. They find that investment in risky, but profitable inputs increases when index insurance is present in the market. However, these investments depend on farmers' initial wealth status and ability to assess the likelihood and intensity of shocks. These results line up well with the idea of Resilience+ discussed above.

While the above research has raised awareness around the topic of index insurance in Cambodia, significant research gaps remain. No index insurance products have yet successfully scaled up across the country. In this environment, it is necessary to take a step back and walk through the necessary steps for determining whether an index insurance product could be of sufficiently high quality to improve the welfare for rice producers in Cambodia. By combining recalled yield data from a targeted area in the Battambang province with farmers' perceptions and key stakeholders' input, this feasibility study measures the risk involved in rice production, conducts an ex-ante analysis of the quality of a number of potential index insurance products, and communicates additional considerations to make prior to introducing an index insurance product to rice producers in Battambang.

To accomplish these research goals, the Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) was selected as a local partner. CE SAIN is a quasi-research and extension wing of the Royal University of Agriculture (RUA) in Cambodia that was established in 2016 as a platform for disseminating promising agricultural innovations and technologies to farmers. CE SAIN works closely alongside the Royal University of Agriculture (RUA) and USAID Feed the Future Innovation Labs to promote sustainable agricultural intensification and nutrition through related teaching, research, and extension activities. A rapidly expanding center, CE SAIN has its head office on RUA's campus in Phnom Penh, as well as

Agricultural Technology Parks across seven provinces. CE SAIN has collaborated with over 20 different US institutions and has promoted more than 28 agricultural technologies to farmers.

CE SAIN was selected as a research partner due to an interest in expanding their expertise into more market-based approaches, their strong farmer network throughout the Battambang province, and ability to source enumerators and other staff personnel. They are a well-respected research entity and have vast connections with key stakeholders focused on index insurance initiatives in Cambodia.

1.3 Research Objectives

The focus of this research is to analyze the feasibility and quality of two specific rainfall-based index insurance contracts for rice producers in Battambang, Cambodia. This analysis will first tell us if index insurance could be a welfare-improving risk management solution for rice producers in Battambang. It will provide information on producers' understanding of index insurance and an overview of the opportunities and constraints facing the scale up of index insurance in Cambodia. Findings from this study may guide the development and marketing of future indexed products in Cambodia, ensuring that contracts are high-quality and well-perceived by rice producers. Additionally, this study may help to inform the wider development community on important considerations to make when introducing and designing index insurance contracts across the globe, wherever rice is grown.

1.4 Thesis Structure

Starting in Chapter 2, this thesis identifies the most appropriate ex-ante quality measure for index insurance contracts, Relative Insurance Benefit. Before performing the RIB analysis, we discuss the data required for analysis, how that data was collected through a yield recall survey, and examine the riskiness involved in rice production in Battambang. A descriptive analysis of the farmers in our study area is also provided. Chapter 3 then discusses the contracts to be analyzed.

In Chapter 4, the RIB methodology and results are presented. Chapter 5 then discusses those results, diving deeper into the true impact of rainfall on yield and how basis risk impacts the RIB measure.

Chapter 6 of this thesis diverges slightly from the previous chapters to focus on additional feasibility considerations for index insurance for rice in Battambang. The chapter walks through how these considerations were researched, first describing the context, data collection, and the two methodologies used – Focus Group Discussions and Key Stakeholder Interviews. Results and discussion based on findings from each methodology are presented. The thesis concludes with suggested topics for future research.

2. CHAPTER 2: DATA AND DESCRIPTIVE STATISTICS

2.1 Motivation

This section walks through an ex-ante quality analysis of six different rainfall-based index insurance contracts. An "ex-ante" analysis is done before a product is implemented or fully operational. Here, this type of analysis helps us understand how much basis risk is involved in each contract. The higher the basis risk, the less risk protection provided by the contract and thus, the lower the welfare gain for farmers. This is a method that can and should be used by insurance companies and governments alike. Insurance companies should conduct this type of analysis in order to see which contracts provide the most value to farmers. Governments should conduct ex-ante analyses to see where their scarce budget, if any budget, should be directed. Both insurance providers and governments have a stake in selecting the highest quality contracts for farmers, and at a minimum, they do not want to introduce contracts that could potentially harm farmers.

2.2 Literature Review – Index Insurance Quality

Since the quality of index insurance products is so important, there have been several methods developed to analyze the contracts for quality. Some of these methods rely on measures that look at the probability distribution of wealth, and the impact of insurance on the lower tail of this distribution (Morsink et al., 2016; Bucheli et al., 2021). The lower "left" tail represents instances where a household experiences severe financial losses, perhaps as a result of catastrophic weather events that impact crop yield. While this is important to understand when assessing the quality of index insurance, we are lacking a focus on the upper "right" tail of the wealth probability distribution. Here, we see instances of false positives, or times when the index insurance contract pays the farmer when the farmer did not experience significant losses. This also plays a role in the overall ability of the contract to be welfare-enhancing (Kenduiywo et al., 2021) because, even though the farmer benefits from these payouts, they come at the cost of raising the insurance premium. In addition, the measures mentioned above do not provide an evaluation of how a candidate index insurance contract would impact the welfare of farmers.

For this study, we chose a methodology, Relative Insurance Benefit (RIB), to evaluate index insurance quality that overcomes these limitations and provides a measure of impact of index insurance on farmer welfare. The following section provides an overview of the RIB methodology and concepts.

2.3 Relative Insurance Benefit (RIB) Methodology: General

The Relative Insurance Benefit (RIB) measures improvements in farmer welfare derived from an index insurance contract relative to a hypothetical contract that perfectly measures losses. To measure the RIB, we first define three different insurance scenarios – Perfect Insurance, No Insurance, and the Index Insurance contract for which we want to analyze quality. We then calculate the certainty equivalent for each of these contracts. Using certainty equivalents is a benefit of the RIB method, as it is a numeric welfare measure representing the amount of riskless (certain) income that delivers the same level of utility as the expected utility associated with a risky activity. The certainty equivalents are used to determine the RIB as follows:

$$RIB^R = \frac{CE^R - CE^N}{CE^P - CE^N}$$

In the equation above, CE^R is the certainty equivalent of the index insurance contract under consideration. CE^N is the certainty equivalent of the scenario in which farmers have no insurance, and CE^P is the certainty equivalent of the scenario in which farmers have access to a hypothetical perfect insurance contract in which individual yield losses are perfectly measured and indemnified.

The denominator of the above equation represents the increase in farmer welfare resulting from offering a perfect yield insurance contract compared to a no-insurance scenario. The numerator does that same for index insurance. The RIB thus takes on its maximal value of one when the index contract offers economic benefits that are equal to the perfect contract. When none of the benefits of insurance are achieved, it takes on the value of zero, and it becomes negative if the insured are worse off than having no insurance at all. Therefore, a desirable RIB is as close to one as possible. A negative RIB implies that the contract would make farmers worse off compared to being uninsured. This could happen if basis risk is very high.

An RIB can be derived for any potential index insurance contract. In this way, the RIB is a powerful measure for guiding policy makers and insurance providers in the selection of the "best" index insurance contract. It also helps to determine if contracts surpass a minimum level of quality, for example, contracts with a negative RIB would make farmers worse off than having no insurance at all; and therefore, should not be offered.

2.4 Yield Data Required for Analysis

In addition to CHIRPS data, rice yield data available from the past five to 10 years is necessary to understand what a Perfect Yield Insurance contract, and what No Insurance, would look like for rice producers in the Battambang province. Existing yield data collected by the Cambodian government was not disaggregated by village and not available for the past five years, so a yield recall survey was required.

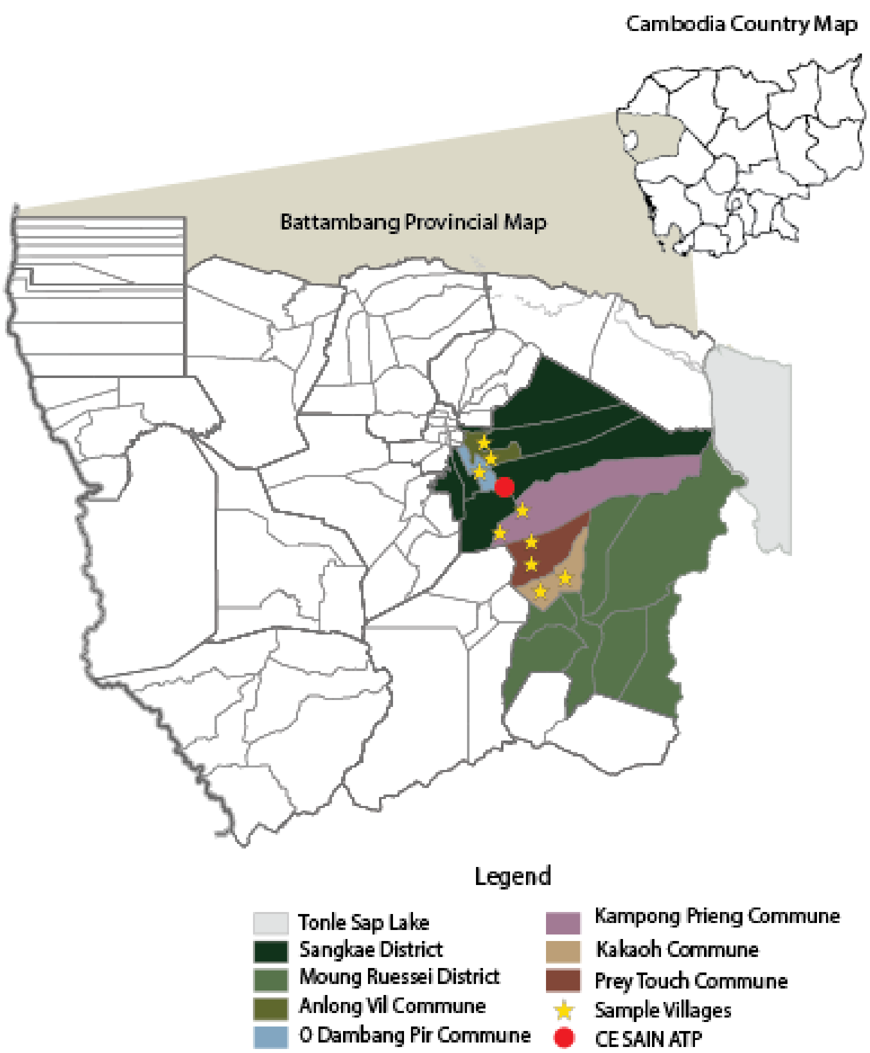
2.5 Sampling Setting Selection

The Battambang province of Cambodia, or the country's "rice bowl", accounts for over 10% of total wet season rice production in the country, equivalent to 670,000 tons of rice annually (USAID, 2010). The province is located to the west of the Tonle Sap Lake, which has unpredictable flooding patterns throughout the summer monsoon season. However, Battambang boasts highly fertile soils and sufficient amounts of rainfall to support strong rice production (USAID, 2010). Battambang was selected as the study area in order to focus on the local rice producers who are vital to Cambodia's overall rice production and who are facing increasingly serious drought and flooding events.

Within Battambang, the yield recall surveys were administered within the Sangkae and Moung Ruessei districts. CE SAIN operates an Agricultural Technology Park (ATP) in the Sangkae district of Battambang. This ATP showcases innovative agricultural technologies to farmers by hosting farmer field days, maintaining demonstration plots, and conducting extension-like outreach to surrounding farmers. Due to the nature of this work, ATP staff are closely connected with village chiefs and farmers in study districts.

The five communes and nine villages included in the study (*Figure 2.1*) were further selected based on 1) number of rice-producing households, 2) proximity to the ATP for logistical purposes, and 3) ability to source village chief contact information through the ATP. In Moung Ruessei, the Kakaoh commune and villages of Srae Ou and Toul Prum Mouy were specifically selected due to their participation in ADB's weather indexed crop insurance (WICI) pilot program in partnership with Forte.

Figure 2.1 Sample Area Map



2.6 Questionnaire Design

The yield recall survey covered a range of topics including producer demographics, rice production timing, rice production in the cropping seasons 2018-2022, and familiarity with crop insurance. The questionnaire is included as Appendix A.

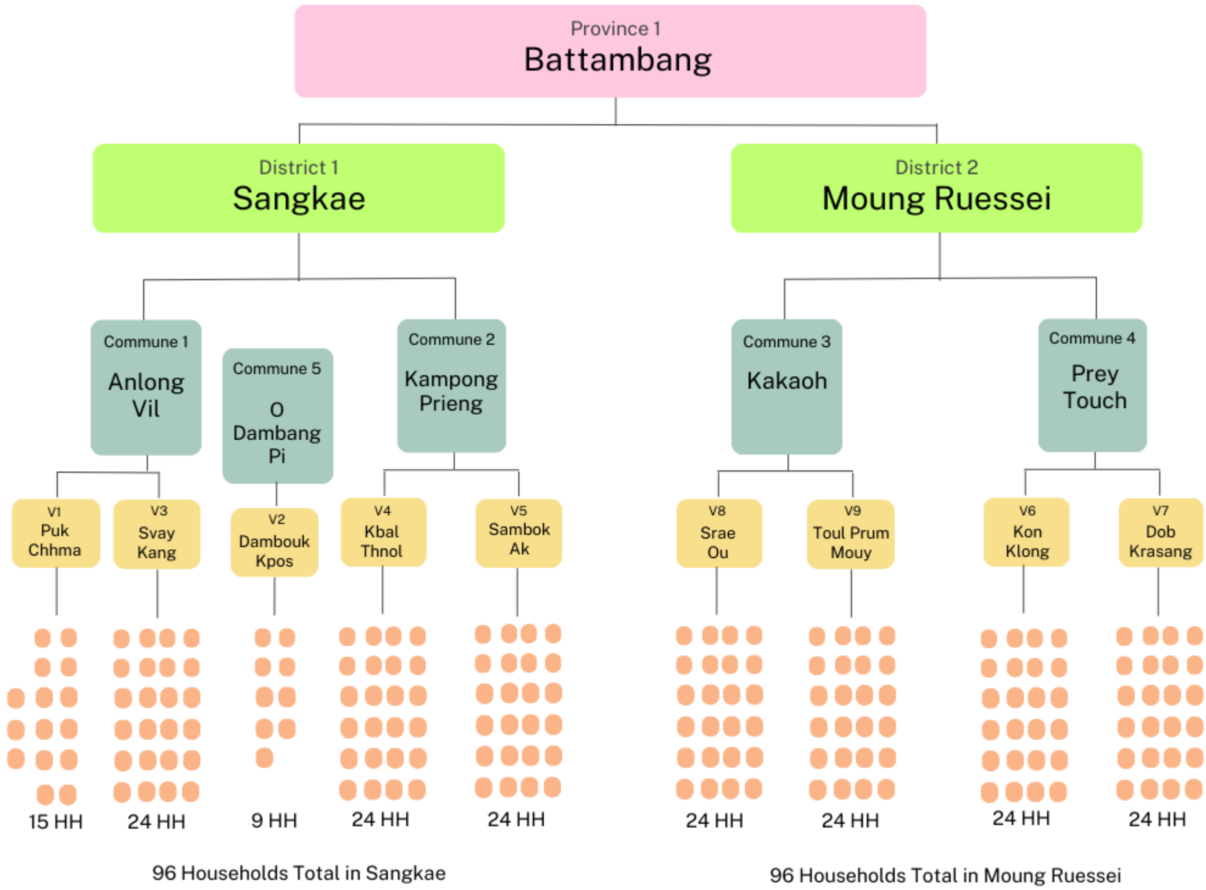
The questionnaire was piloted by the researcher, two enumerators, and ATP staff in Sangkae district with 10 rice producers. The questionnaire was then updated based on farmers' input and notes taken by enumerators. It was also determined that surveys would be administered on paper, then later entered into the KoboToolBox data collection system on tablets. This improved quality in recording of answers and saved time.

Eight total enumerators participated in a full-day training prior to administration of the official yield recall survey. They also attended four hours of "knowledge transfer sessions" where they learned about the economic theory behind index insurance and how it can serve as a promising risk management tool in some contexts. These trainings improved the overall reliability and validity of the data by equipping enumerators with background information.

2.7 Sampling Design and Administration

As described in *Figure 2.2*, a total of 192 households were surveyed across nine villages. Prior to administering the surveys, the data collection team interviewed each Village Chief. These 30-minute interviews enabled the team to have permission to speak with village members, to map out homes of rice producers in each village, to get a first-hand account of the weather events and yields in each village, and to learn about community events that might help farmers better recall their yields. The Village Chief Interview Questionnaire is included as Appendix B.

Figure 2.2 Sampling Plan



The sampling strategy for the yield recall survey was done using spatial random sampling and single-visit recall data collection. The questionnaire required producers to recall yields from three different seasons in each of the past five years. Enumerators sampled throughout each village by skipping three households in between each surveyed household. A depiction of this strategy is included as Appendix C. Data collection took a total of four days. Surveys were cross-checked by enumerators at the end of each day and uploaded to KoboToolBox on tablets the day after data collection was completed.

2.8 Descriptive Analysis

This section describes the demographics of rice producers in our sample and their general rice production practices. Table 2.1 provides basic information on age, gender, rice area and rice yields for sample farmers for each of the nine sample villages. Rice farmers in Cambodia can plant up to three rice crops per year. Tables 2.2 and 2.3 provide a description of the timing of each of these seasons and the frequencies of participation in each season by sample farmers.

2.8.1 Sangkae district, Battambang province

In 2015, the estimated poverty rate in Sangkae was 19.5% (Open Development Cambodia, 2015), which is higher than the national average of 16.6% (Oxford Poverty and Human Development Initiative [OPHI], 2023). Community members must rely on subsistence agriculture, primarily rice production for their livelihoods. In recent years, more and more males are migrating to Thailand to find work and send remittances back to their families.

As seen in Table 2.1, three communes and five villages were sampled from Sangkae. In the sampled villages, the number of households ranged from 243 to 700. Surveyed producers have been growing rice for an average of 20.4 years, and the average total land size for these producers is 3.92 ha.

The average annual precipitation in Sangkae from 2013-2023 was 1,462 mm per year (Funk et al., 2014). Rainfall amounts are largest from May to September during the summer monsoon season. For the purposes of this study, this is considered the “early wet season”. The “late wet season” runs from October to January, with the “dry season” running from November to February. This is summarized in Table 2.3. Of the 96 rice producers surveyed in Sangkae, 36.46% are able to grow rice in both the early and late wet seasons. Only 3.13% of the surveyed producers grow rice in the dry season. This number is small due to the lack of irrigation infrastructure in this district.

2.8.2 Moung Ruessei district, Battambang province

In 2015, the estimated poverty rate in Moung Ruessei was 24.07% (Open Development Cambodia, 2015), which is much higher than Sangkae's rate and the national average. Residents in Moung Ruessei rely on rice production and out-migration to Thailand, as well as migration towards urban centers to find work.

Table 2.1 presents the two communes and four villages that were sampled in Moung Ruessei. The number of households in sampled villages ranged from 300 to 581. Surveyed producers have been growing rice for an average of 22.5 years, and the average total land size for these producers is 5.06 ha.

The average annual precipitation in Moung Ruessei from 2013-2023 was 1,724 mm per year (Funk et al., 2014). Of the 96 rice producers surveyed in Moung Ruessei, 52.08% are able to grow rice in both the early and late wet seasons. This higher percentage of rice production in multiple growing seasons is likely to due to more irrigation infrastructure and access in Moung Ruessei compared to Sangkae. 9.38% of the surveyed producers grow rice in the dry season, further depicting this difference in water availability (*Table 2.3*).

Table 2.1 Descriptive Statistics of Sample Farmers

District	Commune	Village	# of HH	# of HH Interview-ed	% Female	% Male	Avg Age	Avg. Yrs Growing Rice	Avg. Land Size (ha)	Avg. Yield (kg/ha)
Sangkae	Anlong Vil	Puk Chhma	243	14	43	57	48	22	3.26	2,364
		Svay Kang	270	25	72	28	49	23	3.21	2,574

Table 2.1 Descriptive Statistics of Sample Farmers

District	Commune	Village	# of HH	# of HH Interview-ed	% Female	% Male	Avg Age	Avg. Yrs Growing Rice	Avg. Land Size (ha)	Avg. Yield (kg/ha)
	Kampong Prieng	Kbal Thnol	416	24	75	25	41	18	4.47	2,931
		Sambok Ak	700	24	46	54	46	22	4.75	3,909
	O Dambang Pir	Dambouk Kpos	NA	9	78	22	46	17	3.92	2,054
Sangkae Totals			1,629	96	62.8	37.2	46	20.4	3.92	2,919
Moung Ruessei	Kakaoh	Srae Ou	581	24	58	42	49	26	4.79	1,785
		Toul Prum Mouy	455	24	71	29	47	27	4.26	1,826
	Prey Touch	Dob Krasang	300	24	63	37	45	19	7.00	2,831
		Kon Klung	500	24	67	33	44	18	4.18	3,298
Moung Ruessei Totals			1,836	96	64.75	35.25	46	22.5	5.06	2,437
Overall Totals	5	9	3,465	192	63.78	36.23	46	21.45	4.49	2,672

Table 2.2 Most Common Planting and Harvesting Months

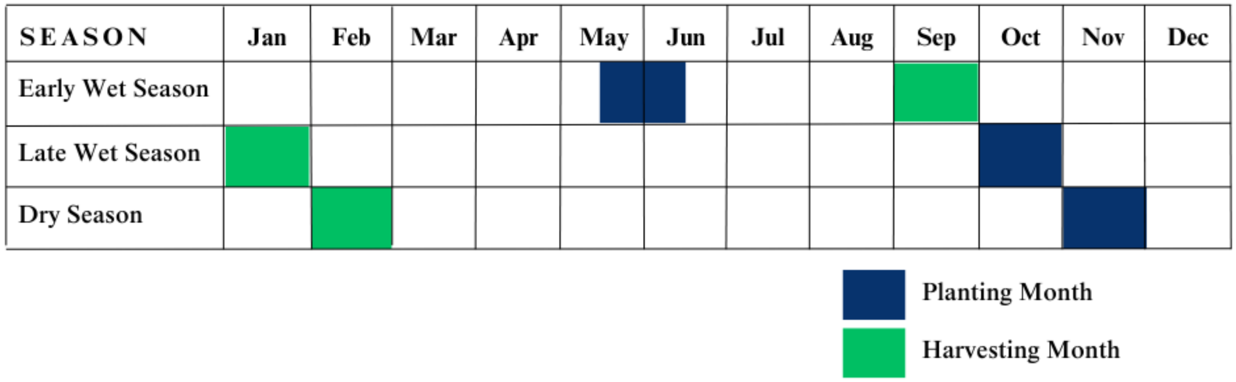


Table 2.3 Seasonal Planting Patterns of Sample Farmers

	Percentage (%) of farmers that planted in:			
District	**Early Wet Season Only**	**Early Wet Season and Dry Season Only**	**Early Wet Season and Late Wet Season Only**	**All Seasons**
Sangkae	44.8%	15.6%	36.5%	3.1%
Moung Ruessei	21.9%	16.7%	52.1%	9.4%

Due to the above planting season realities, we choose to focus solely on the Early Wet Season for the implementation of the RIB quality measure. It is important to note that 95.31% of farmers planted during the Early Wet Season in all five years (2018-2022), 4.17% planted in four of the five years, and 0.52% planted in only three of the five years. Given that part of our analysis will rely on the mean historical yield for each farmer, our RIB analysis will only include those farmers who planted in all five years.

2.9 Yield Risk

To answer the research question of how risky rice production is in Battambang, the term "risk" must first be defined. Here, risk is defined as uncontrollable, stochastic shocks that negatively impact producers' yields and for which they do not have effective responses (Jensen and Barrett, 2017). While variation in yields across farmers and over time can be partly explained by risk, there are many other non-stochastic factors that explain yield variation including access to differential access to finance and inputs, variable soil quality and farming ability, and different input and output prices. In what follows, we decompose the total variation into these stochastic (i.e., risk) and non-stochastic components.

When zooming in to focus solely on risk, we can categorize it into two types: idiosyncratic risks and covariate risks. Idiosyncratic risks are those that are unique to an individual household and are relatively independent. On the other hand, covariate risks are shared risks that simultaneously affect all households in a village (Boucher and Delpierre, 2013). This distinction is important, as index insurance is typically designed to mitigate covariate risks.

2.9.1 Average Yield

When thinking about these risks, it is useful to first understand how yield varies in our study area. Table 2.4 presents a first look at the degree of variation across space by presenting the area weighted and unweighted mean yields at different administrative levels. The first row shows that, when pooling across all farmers and all years, the average yield of all sample farmers in Battambang was 2,672 kg/ha, while the area-weighted average yield was 2,703 kg/ha. We observe that there are minimal differences between the area-weighted average yield and unweighted average yield numbers. This is likely because rice producers' best plots are similar in size, or their best plots differ in size, but the size of land does not impact rice productivity. On the other hand, there is large heterogeneity in average rice yields across geographical locations. For example, at the district level, average yields in Sangkae (3,021 kg/ha) are roughly 20% higher than in Moung Ruessei (2,430 kg/ha). This difference is driven largely by high productivity found in the Kampong Prieng commune (3,512 kg/ha). The lowest yields are found in the Kakaoh commune (1,773 kg/ha), which is within the Moung Ruessei district.

Table 2.4 Average Rice Yields by Administrative Level

Administrative Level	Location	Area-Weighted Average Yield (kg/ha)	Unweighted Average Yield (kg/ha)
Province	Battambang	2,704	2,672
District	Sangkae	3,022	2,919
	Moung Ruessei	2,430	2,437
Commune	Anlong Vil	2,325	2,427
	O Dambang Pi	1,873	2,254
	Kampong Prieng	3,512	3,418
	Kakaoh	1,773	1,793
	Prey Touch	2,907	3,047
Village	V1 – Puk Chhma	2,532	2,364
	V2 – Dambouk Kpos	1,845	2,054
	V3 – Svay Kang	2,301	2,574
	V4 – Kbal Thnol	3,093	2,931
	V5 – Sambok Ak	3,953	3,909
	V6 – Kon Klung	3,413	3,298
	V7 – Dob Krasang	2,557	2,831
	V8 – Srae Ou	1,823	1,785
	V9 – Tuol Prum Mouy	1,733	1,826

2.9.2 Coefficient of Variation Analysis

To begin to quantify yield variability and different types of risks faced by rice producers, we calculate the coefficient of variation (CV) of yields for several different groupings. We use the CV instead of the standard deviation since the standard deviation is proportional to the mean and its magnitude depends on the variable being analyzed (Sarker, 2012). The CV standardizes variation across variables by dividing the standard deviation by the mean and expressing it as a percentage. The CV is unitless due to the fact that the standard deviation and average have the same units. This allows different variables with different units to be compared to one another (Madhu, 2019).

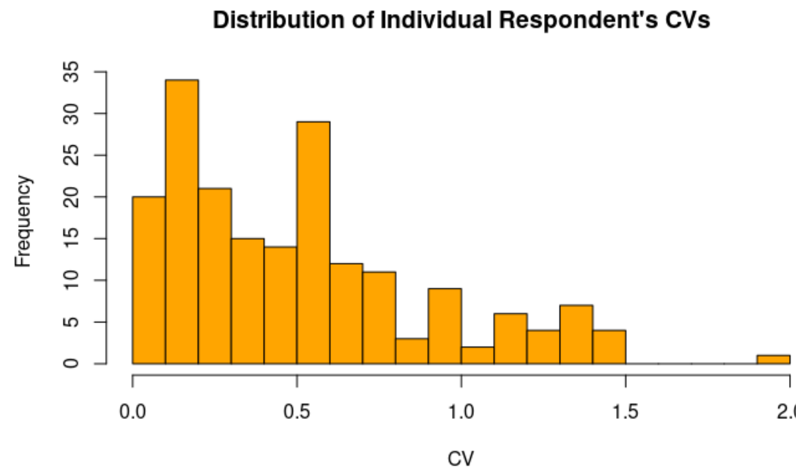
In this study, we calculate the CV for three different groupings. In the first, we compute the CV for all plot-level yield observations pooled across farmers, years, and location within the specified level of spatial disaggregation (i.e., province, district, commune, village). The CV in grouping 1 provides an indication of the magnitude of yield variation in rice production in our sample. This number captures both: 1) the risks faced by rice producers, and 2) all other non-stochastic factors that may impact production, as discussed above. The following equation was used:

$$CV^1 = \frac{\sigma_A}{\bar{Y}_A}$$

Where CV^1 is the coefficient of variation for grouping 1. σ_A is the standard deviation of plot-level yield observations pooled across farmers, years, and location within level of spatial disaggregation, A. $\bar{Y}_A$ is the mean of plot-level yield observations pooled across farmers, years, and location within level of spatial disaggregation, A.

In the second grouping, we calculate a separate CV for each of the 192 farmers based on their 5-year yield history. We then report the average of those CVs within each level of spatial disaggregation. The CV in grouping 2 captures each respondent's individual variation in yields from 2018-2022. If we assume that each producer's own ability, soil quality, access to inputs, etc. stays the same over those five years, then this CV captures each farmer's specific yield risk and does not capture the other non-stochastic factors that may impact production. We expect this mean CV to be smaller than in the first grouping, as it does not include variation that might be due to differences across farmers. While the mean CV is a valuable number to compare across groupings, it is important to also note the distribution of each individual respondent's CV. *Figure 2.3* shows a left-skewed pattern, indicating a higher frequency of CVs below 0.6 than above 0.6.

Figure 2.3 Distribution of Individual Respondent CVs



The equation used for grouping 2 can be expressed as:

$$CV^2 = \frac{\sum_{i=1}^{N_A} \frac{\sigma_i}{\overline{Y}_i}}{N_A}$$

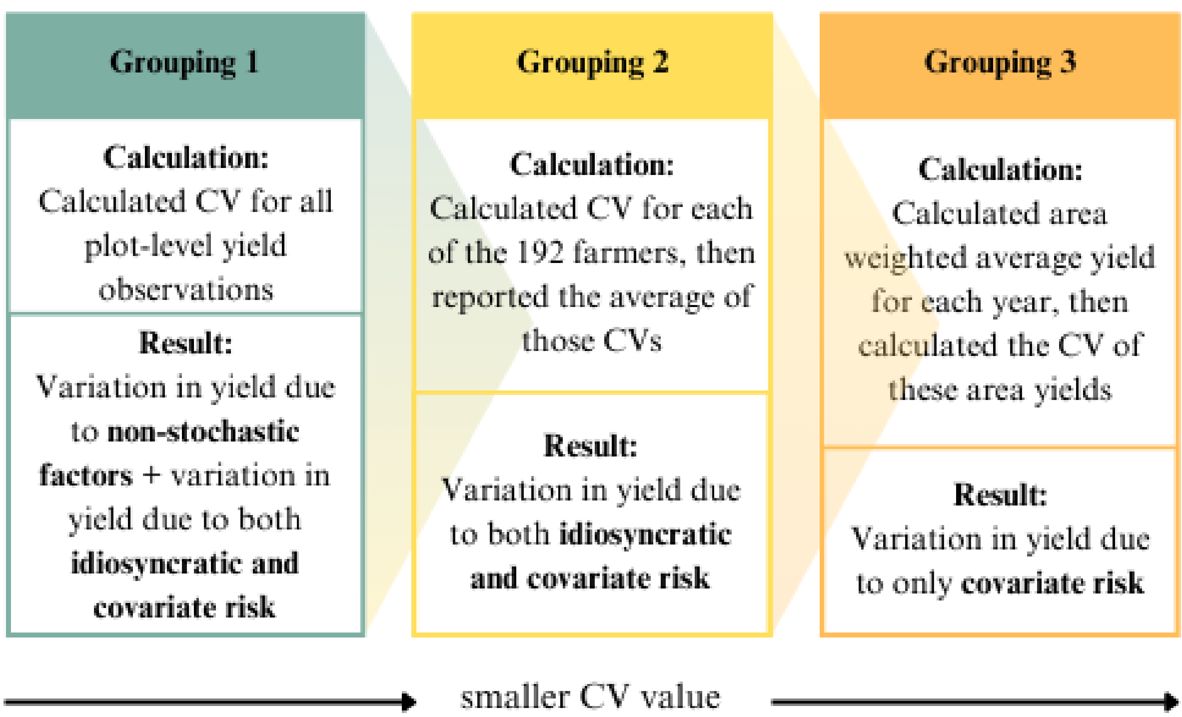
For the third grouping, we calculate the CV of the average yield within the spatial unit of disaggregation. From here, we will refer to the average yield within the spatial unit of disaggregation as area yield. To do so, we first calculate the area yield for each year (2018-2022), within each spatial level of disaggregation by calculating the area weighted average yield of sample plots within each spatial level of disaggregation. Then, we calculate the CV of these area yields across the five years. The CV in grouping 3 is the number most index insurance providers are interested in when designing contracts. This is because it is intended to primarily capture covariate risks that affect yields consistently across farmers within each spatial level of disaggregation. Following the above process, we are able to focus solely on the magnitude of variation in average yields over time, and not on the magnitude of variation in individual yields that are likely caused by idiosyncratic shocks. We expect this CV number to be smaller than in both groupings 1 and 2, as it does not include variation in yields due to differences across farmers and does not include idiosyncratic risk. The following equation was used for grouping 3:

$$CV^3 = \sigma_A \sum_{t=1}^{N} \frac{\bar{Y}_{At}}{N}$$

Where CV^3 is the coefficient of variation for grouping 3. *N* is the number of years for which we are calculating the area weighted average yield. $\bar{Y}_{At}$ is the area yield in spatial level of disaggregation, *A*, in year *t*. It is calculated as the area-weighted average yield for all plots within A. σ_A is the standard deviation of $\bar{Y}_{At}$ calculated over the five years of the yield recall survey.

The CV for all three groupings was calculated at the provincial, district, communal, and village levels. *Figure 2.4* provides a streamlined explanation of these three CV groupings.

Figure 2.4 Coefficient of Variation Calculations and Results



As we calculate the CV at smaller and smaller levels of spatial disaggregation (province → district → commune → village), we anticipate that the portion of risk due to covariate factors will increase, causing the CV value for grouping 3 to be higher. Producers within smaller levels of spatial disaggregation are more likely to experience similar shocks compared to producers across larger areas. Due to this phenomenon, it makes sense for index insurance contracts to be designed for the level of spatial disaggregation that has the highest covariate risks.

Table 2.5 presents the CV values for the three different groupings.

2.9.3 Coefficient of Variation Results

Table 2.5 Coefficient of Variation – Three Groupings

Administrative Area	Location	Grouping 1 CV	Grouping 2 CV	Grouping 3 CV
Province	Battambang	0.632	0.508	0.108
District	Sangkae	0.571	0.416	0.075
	Moung Ruessei	0.689	0.600	0.160
Commune	Anlong Vil	0.569	0.363	0.092
	O Dambang Pi	0.393	0.345	0.404
	Kampong Prieng	0.526	0.471	0.122
	Kakaoh	0.818	0.746	0.296
	Prey Touch	0.539	0.460	0.161
Village	V1 – Puk Chhma	0.566	0.374	0.073
	V2 – Dambouk Kpos	0.500	0.365	0.154
	V3 – Svay Kang	0.559	0.354	0.125
	V4 – Kbal Thnol	0.605	0.534	0.232
	V5 – Sambok Ak	0.433	0.407	0.119
	V6 – Kon Klung	0.436	0.352	0.171
	V7 – Dob Krasang	0.644	0.586	0.188
	V8 – Srae Ou	0.780	0.686	0.205
	V9 – Tuol Prum Mouy	0.831	0.776	0.418

These CV numbers generally line up with our expectations, with grouping 1 having the highest CV, grouping 2 having a smaller CV than grouping 1, and grouping 3 having the smallest CV. As noted, this indicates that grouping 1 is capturing non-stochastic factors that impact rice yield, as well as both covariate and idiosyncratic yield risk. The CV in grouping 2 is smaller, as it only captures covariate and idiosyncratic yield risk. Finally, the CV in grouping 3 is the smallest, as it generally captures only covariate yield risk.

Heterogeneity of CV across geographic locations is evident, as we see Moung Ruessei displaying generally higher CVs, or higher levels of yield variability. The Kakaoh commune has the highest CV numbers and the lowest average yields.

We can also observe a pattern in the CV numbers as we move from the provincial level down to the village level. As predicted, the CV numbers in grouping 3, which capture covariate yield risk, generally increase as we move to smaller levels of spatial disaggregation. This phenomenon is due to the fact that producers who live in a smaller level of spatial disaggregation (a village) are more likely to share the same types of yield risk. However, across larger levels of spatial disaggregation (districts), their yield variations may have more to do with idiosyncratic shocks than covariate shocks, as they are spread farther apart.

The CV calculations for grouping 1 were validated by comparing them against CVs of rice yields in Battambang province collected from the Accelerating the Adoption of Stress-Tolerant Varieties (ASTV) Project. Early wet season CV was 0.53 in 2016 and 0.38 in 2019 in Battambang. Our study's CVs are slightly higher, with average CV in the early wet season each year ranging from 0.53 to 0.77.

2.9.4 Limitations

A longer-term panel dataset of average rice yields in the Battambang province would be helpful, as two phenomena may be influencing our CV results. On one hand, larger number of significant weather events may have occurred within these five years than is normal for Battambang. If this is the case, our CV numbers likely overstate the true degree of yield risk and variability.

The opposite could also be true. Significant weather events may occur in Battambang, but they typically happen, for example, only once every 20 years. In this hypothetical case, it is a possibility that no significant weather events occurred within these five years. In this case, our CV values would understate the true degree of yield risk and variability.

In spite of the limitations listed above, calculating the CV in various groupings for this five-year panel dataset still provides a valuable estimate of rice yield variability and yield risk in Battambang. Zooming in on grouping 3, we are focused only on covariate risk, which aligns with the RIB analysis we will conduct next. By observing grouping 3, we see that covariate risk is a small percentage of the high overall yield risk. We also know that at best, index insurance contracts are able to insure against only covariate risks. Therefore, unless idiosyncratic risk is pooled well across the village, an index insurance contract in this context is likely to not work well. Because of this, we expect the RIB measures that follow to be quite low.

3. CHAPTER 3: INDEX INSURANCE CONTRACTS TO BE EVALUATED

Prior to calculating the RIB, we must first describe each of the contracts underlying the scenarios described above. The contracts include:

- A hypothetical Perfect Insurance contract that perfectly measures and compensates farmers for yield losses.
- SFSA Rainfall-based Index Insurance contract, for which we will analyze three different variations: 1) a contract that covers only drought, 2) a contract that covers only flooding, and 3) a contract that covers both drought *and* flooding.
- Locally Adjusted Rainfall-based Index Insurance contract, for which we will also analyze three different variations: 1) a contract that covers only drought, 2) a contract that covers only flooding, and 3) a contract that covers both drought *and* flooding.

3.1.1 SFSA Rainfall-based Index Insurance Contract

The SFSA Rainfall-based Index Insurance contract assessment is based on a "*Feasibility Study with Dry Run for Agricultural Input Insurance in Cambodia*", conducted by the Syngenta Foundation for Sustainable Agriculture (SFSA) from 2018 to 2020. Their study partly focused on the rice value chain in Battambang province and piloted a Weather Index Insurance product for rice producers. Their term sheet is applied equally to all study villages for the purposes of this research and is included as Table 3.1.

Table 3.1 SFSA Term Sheet for Weather Index Insurance for Rice in Battambang

Sowing Date	Cover Start Date	Cover End Date	Cover Duration
May 10	June 14	October 11	155 days

Phase Name	Vegetative Stage	Reproductive Stage	Ripening Stage
Phase Length (days)	55	35	30
Phase Start Date	June 14	August 8	September 12
Phase End Date	August 7	September 11	October 11
Deficit Rainfall Insurance (Drought) – stage-wise cumulative rainfall			
Trigger (mm)	250	175	Not Covered
Exit (mm)	150	105	
Payout per mm (USD)	0.94	1.79	
Sum Insured (USD)	94	125	
Excess Rainfall Insurance (Flooding) – Max cumulative rainfall during 3 consecutive days			
Trigger (mm)	120	100	50
Exit (mm)	220	200	150
Payout per mm (USD)	0.78	1.40	2.20
Sum Insured (USD)	78	140	220

As seen in Table 3.1, the rice season is divided into three fixed stages. Drought coverage is relevant for only the first two stages, and the index is the cumulative rainfall during each stage. The contract pays out if cumulative rainfall in the vegetative stage is less than 250 mm, and each millimeter deficit below those 250 mm is compensated by a payout of 0.94 USD per hectare insured. The maximum payout, or sum insured, is 94 USD, which corresponds to cumulative rainfall of 150 mm. A similar structure applies to the reproductive stage as shown in the term sheet.

Flood coverage is relevant across all three growth stages, and the index is the maximum rainfall during three consecutive days within each stage. The contract pays out if the maximum rainfall within the three days exceeds 120 mm in the vegetative stage. Each millimeter of excess rainfall is compensated at 0.78 USD with a maximum payout of 78 USD per hectare insured. This structure applies to the reproductive and ripening stages seen in the term sheet.

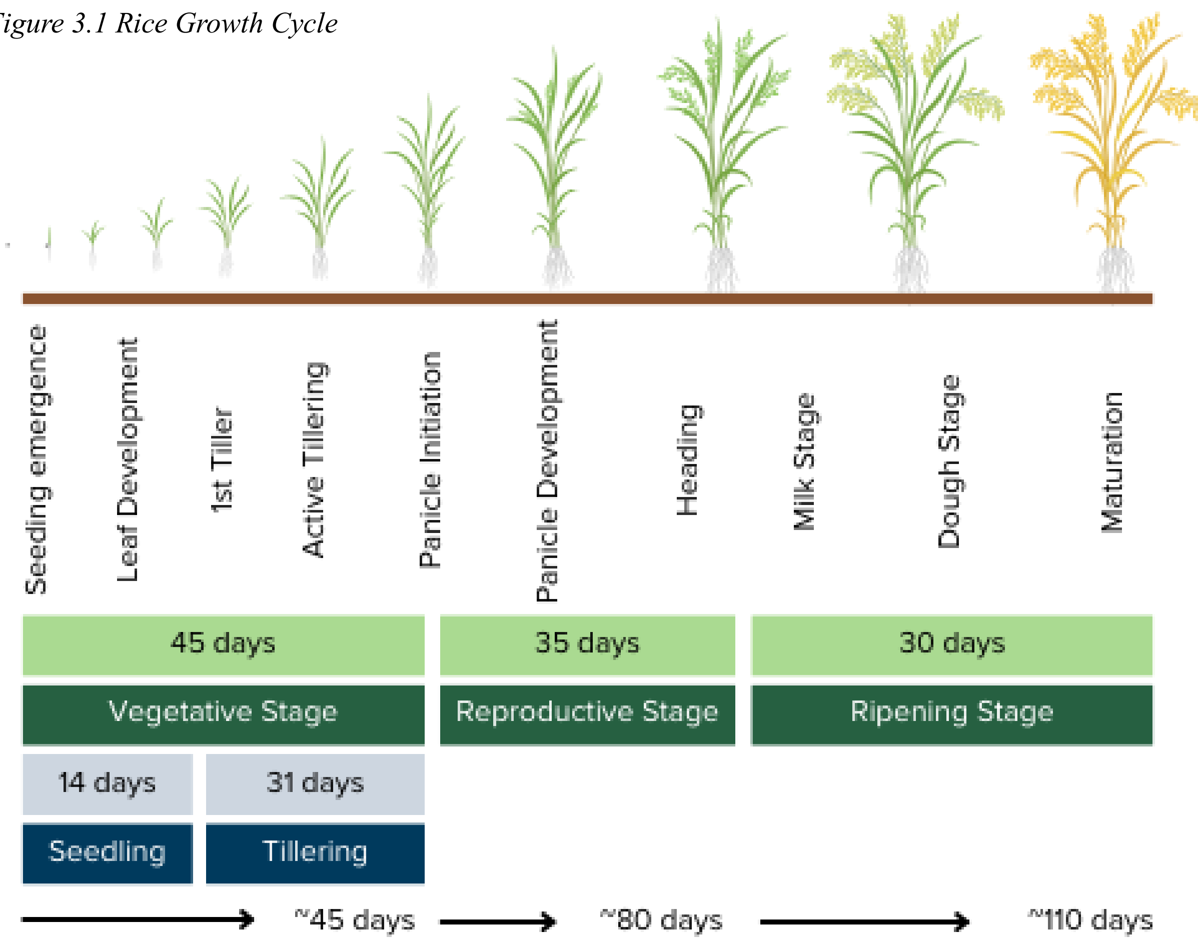
3.1.2 Locally Adjusted Rainfall-based Index Insurance Contract

The SFSA term sheet was then adjusted to reflect the nuances in our study. Several studies (Capistrano and Quilang, 2018; Bouman et al., 2007; Lansigan, 2015) as well as consultation with agronomists from the International Rice Research Institute (IRRI) were referenced for this adjustment. For example, the average planting date in the early wet season of our study was May 22. Since over 99% of our study's farmers direct-seed their rice (do not transplant their seeds), we have the cover start date coinciding with the planting date. It is also known that farmers in Battambang typically dry direct seed their rice (DDSR), meaning the field is not flooded at time of planting (Martin et al., 2020). Based on the yield recall survey data, most farmers plant a short-duration rice seed, with an average of 115 days to maturity. The most common variety of rice planted by surveyed rice producers is Sen Kra Oub (SKO-01).

The growth stages of Sen Kra Oub were determined based on a thorough literature review and confirmed with researchers at IRRI. As seen in *Figure 3.1*, Sen Kra Oub takes 106-110 days to reach maturity (Onwuchekwa-Henry et al., 2023). It is a non-photoperiod sensitive jasmine variety (Vergara and Chang, 1985). The vegetative growth stage of Sen Kra Oub can range from 41 - 50 days, with the reproductive stage lasting 35 days, and the ripening stage lasting 30 days (adapted from: Moldenhauer et al., 2013; Aguilar, 2019; Vergara and Chang, 1985). In our study, we estimated the vegetative growth stage to be 45 days, the reproductive stage to be 35 days, and the ripening stage to be 30 days.

Upon further consultation with the Philippine Crop Insurance Corporation (PCIC) and work on crop water requirements by Capistrano and Quilang (2018), we broke the vegetative stage down further into the seedling and tillering stages. If there is zero rainfall received during the seedling stage, or first 14 days after planting, the plant is likely to have close to zero yield potential (Capistrano and Quilang, 2018). Sufficient rainfall is also important in the following 31 days, classified here as the tillering stage.

Figure 3.1 Rice Growth Cycle



For deficit rainfall insurance, "drought" is defined by growth stage. Here, cumulative rainfall requirements for rice were based on the assumption that evaporative demand for crop growth per day is 6 millimeters (Lansigan, 2015). For excess rainfall insurance, "flooding" is defined by both growth stage and cumulative rainfall over three consecutive days. These triggers are summarized in the Adjusted Rainfall-Based Index Insurance Term Sheet - Table 3.2.

Table 3.2 Adjusted Rainfall-Based Index Insurance Term Sheet

Planting Date + Cover Start Date	Cover End Date	Cover Duration
May 22	September 9	110 days

Phase Name	Vegetative Stage		Reproductive Stage	Ripening Stage
	Seedling	Tillering		
Phase Length (days)	14	31	35	30
Phase Start Date	May 22	June 6	July 7	August 11
Phase End Date	June 5	July 6	August 10	September 9
Deficit Rainfall Insurance (Drought) – stage-wise cumulative rainfall below trigger				
Trigger (mm)	52	96	110	46
Exit (mm)	31.2	57.6	66	27.6
Payout per mm (USD)	1.7	1.7	1.8	2.2
Sum Insured (USD)	35	64	80	40
Excess Rainfall Insurance (Flooding) – rainfall above trigger in 3 consecutive days				
Trigger (mm)	100		100	75
Exit (mm)	166		166	125
Payout per mm (USD)	0.44		0.69	1.03
Sum Insured (USD)	68		106	205

Beyond the coverage dates and growth stage lengths, there is a key difference between the SFSA contract, and this adjusted contract. While the rainfall triggers for flooding coverage are fairly similar, the rainfall triggers for drought coverage are significantly lower in the adjusted contract. These lower drought triggers may result in less frequent and smaller payouts for farmers and will also bring down the premium for this contract. The RIB analysis we conduct will show whether these adjustments result in a better welfare outcome for farmers or not.

3.1.3 Sub-Contracts

As mentioned above, for both the SFSA Contract and the Adjusted Contract, three sub-contracts will be analyzed:

1. **Drought Only –** indemnity calculations are based only on the rainfall triggers under the drought category.
2. **Flooding Only –** indemnity calculations are based only on the rainfall triggers under the flooding category.
3. **Both Drought and Flooding –** indemnities are paid if rainfall is below the drought triggers *and* if rainfall is above the flooding triggers. The total indemnity is the sum of indemnities from both categories above.

3.2 Defining Insurance Zones

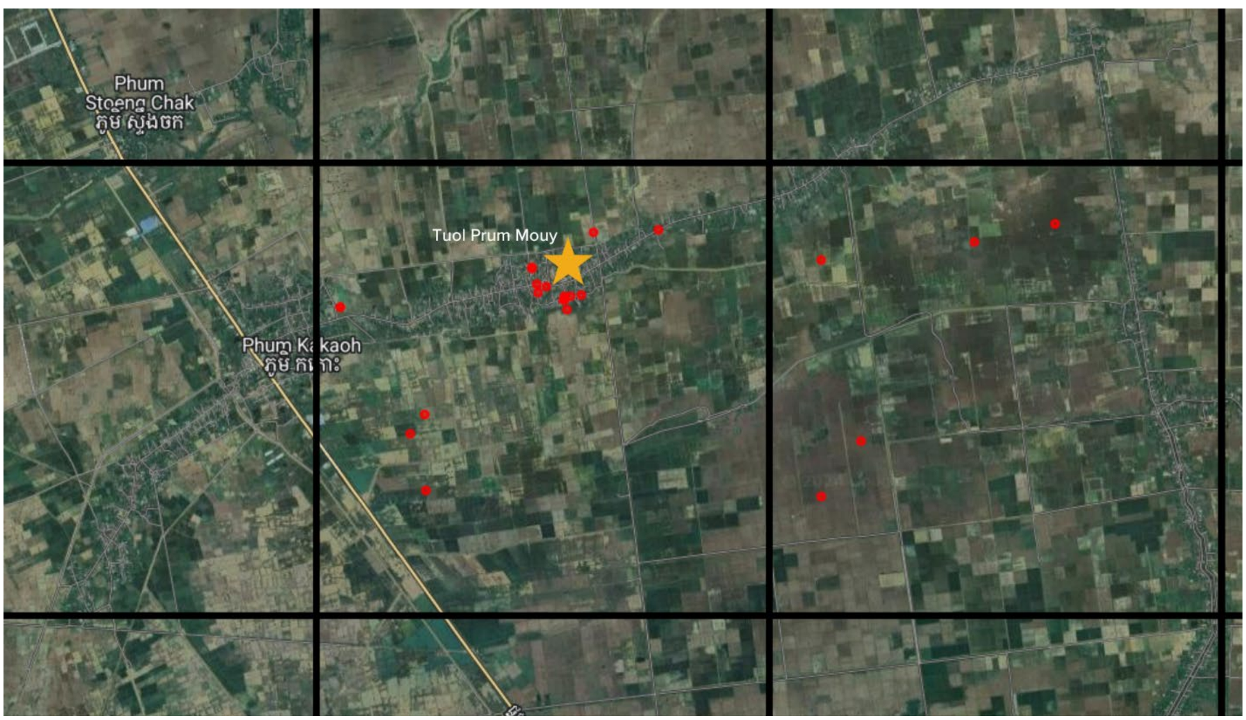
The zones for which we measure rainfall and calculate indemnity payouts need to be defined. This is an important step, as one way of improving the quality of index insurance contracts is by defining insurance zones with the smallest amount of variation between plots. While the original SFSA feasibility study defined insurance zones at the commune level, we choose to define them at the village level. This smaller spatial disaggregation impacts several aspects of the index insurance product, and these are discussed throughout the thesis.

3.3 Index Measurement – CHIRPS Data

One last consideration to be made when defining our contracts is what data source will be used to measure daily rainfall. We selected CHIRPS, which stands for the Climate Hazards center InfraRed Precipitation with Station data set. CHIRPS has been creating gridded rainfall time series at a 0.05-degree resolution since 1981 globally (Funk et al., 2014) and is a commonly used data source for weather-based index insurance contracts. Using publicly available CHIRPS data, we gathered daily rainfall data for each producer's GPS coordinates from January 1, 2018, to December 31, 2022. These daily rainfall reports were organized by date into the growing stages identified in each term sheet.

To understand rainfall experiences at the village level, we first identified all CHIRPS 5 x 5 km grids that were located within each village (as recorded by each producer's GPS coordinates), typically 1-3 grids. We then averaged rainfall reports across these grids for each village, in each growing stage, to compare against the triggers found in the term sheets. *Figure 3.2* provides an example of sample farmers found within two CHIRPS grids for Village 9, Tuol Prum Mouy.

Figure 3.2 Example Map – CHIRPS Grids for Village 9



4. CHAPTER 4: RIB METHODOLOGY: ADAPTED TO BATTAMBANG DATA

This section outlines the methodology used for an ex-ante quality analysis of the different index insurance contracts described above for rice producers in Battambang, as compared to a hypothetical Perfect Yield Insurance contract. To evaluate their fitness as insurance, and to provide a guide to choosing the contract that best protects the insured, we measure the Relative Insurance Benefit (RIB) metric for each contract, closely following the process outlined in Kenduiywo et al., 2021.

While we previously defined the index insurance contracts to be analyzed, we now need to define the price of each contract. In this study, we assume that farmers would pay the actuarially fair premium for each type of contract. The actuarially fair premium is set equal to the expected value of indemnity payments that a farmer would receive. As such, insurers would earn zero expected profits. We ignore transaction/administrative costs as well as any additional charges corresponding to pure profit. As will be explained in detail below, given the small number of time-series observations per household, we will essentially pool data from all sample farmers and assume that all farmers have access to the same actuarially fair contract.

4.1 Individual and Village Approach

We consider two approaches to calculate the RIB; each will have a different actuarially fair premium. The first approach, from now on referred to as the "Individual Approach", assumes that idiosyncratic risk is not pooled at all, so that any variation in an individual farmer's yield translates into variation in that farmer's consumption (and utility) in the absence of insurance. In this approach, the Perfect Yield insurance contract will perfectly insure against individual yield losses. We will thus use the overall sample distribution of individual yield losses to calculate the AFP for Perfect Yield insurance under this approach.

The second approach, from now on referred to as the "Village Approach", assumes that idiosyncratic risk is fully pooled across households in the sample, so that only variation in *average* village yield translates into variation in farmers' consumption. Alternatively, in this approach, we assume that our representative farmer's yield takes the value of average yield each year. We will thus use the distribution of average yield and yield losses to calculate the AFP for Perfect Yield insurance under this approach. Each approach is further explained below.

4.2 Actuarially Fair Premium Calculation – Individual Approach

4.2.1 Hypothetical Perfect Yield Insurance contract

As discussed above, the RIB compares the increase in farmer welfare resulting from an index insurance contract to the increase in welfare resulting from a perfect insurance contract in which the farmer's yield losses are perfectly measured and indemnified. We thus begin by describing the Perfect Insurance contract.

First, the long-term average yield for each farmer is calculated as:

$$\bar{y}_{iv} = \frac{\sum_{t=1}^{T} y_{ivt}}{T} \tag{1}$$

Where y_{ivt} is the yield of farmer *i* in village *v* in year *t*, and *T* is the total number of years for which we have data (which equals 5).

Then, a yield loss percentage, L_{ivt} is calculated for each farmer's yearly yield observation as follows:

$$L_{ivt} = \left(\frac{y_{ivt} - \bar{y}_{iv}}{\bar{y}_{iv}}\right) \times 100 \tag{2}$$

To simplify the analysis, we calculate the yield loss percentages for all farmers in the sample. For example, with 9 villages, roughly 24 farmers per village, and five yield loss percentages for each farmer, we would expect roughly 1,080 yield loss percentage values in the sample. However, this number is reduced down to 785, due to the exclusion of yield reports for farmers who did not plant rice in all five study years. We assume that this is the probability distribution function of percentage yield loss for the prototypical farmer for whom we will compute the RIB.

To further simplify the analysis, we assume that all farmers have identical mean yields (i.e., they are equally productive) which we set at the overall sample mean, $\bar{y}$, of 2,672 kg/ha.

This overall sample mean is scaled to become Standardized Individual Yield, SY_{ivt}, according to the yield loss percentage for each farmer's yearly yield observation, through the following equation:

$$SY_{ivt} = (\bar{y} \times L_{ivt}) + \bar{y} \tag{3}$$

From there, we need to calculate if each farmer should receive a payout in each year, and if so, how much of a payout they should receive. We assume that the Perfect Insurance contract compensates for any losses in excess of 10% yield loss relative to the farmer's mean (i.e. when $L_{ivt} < -10\%$), with yields being compensated at a price of 0.25 USD per kg. This contract guarantees a floor on income associated with a 10% yield loss minus the insurance premium.

This leads to the following indemnity function, I_{ivt}:

$$I_{ivt} = \begin{cases} 0 & if\ L_{ivt} > -10\% \\ 0.25 \times \left(0.90 \times SY_{ivt} - y_{ivt}\right) & if\ L_{ivt} \leq -10\% \end{cases} \tag{4}$$

Our assumptions, that farmers have the same mean yield, and their yield losses are drawn from the same distribution, simplify the analysis by allowing us to have the same premium for Perfect Yield insurance for all farmers in the sample. This premium, or the actuarially fair premium, AFP_I, is the average indemnity payout across all farmers in the sample, calculated as follows:

$$AFP_I = \frac{\sum_{i=1}^{n} I_{ivt}}{n} \tag{5}$$

Where I_{ivt} is the indemnity payout for each farmer i, in village v, in year t, and n is the number of yield observations for that village.

4.2.2 SFSA Rainfall-based Index Insurance contracts

To calculate the AFP for the SFSA contracts, a new indemnity function was used to first calculate the indemnity for each yield observation in each stage and then to determine the total indemnity for each yield observation. Since rainfall is measured at the village level, the indemnity for each yield observation depends only on the rainfall in that village in a given year, and not on the farmer's realized yield. For example, all farmers in Village 1 will receive the same indemnity in 2018.

For a contract that covers **only drought**, the indemnity function is:

$$I_{ist}^{D} = \begin{cases} 0 & if\ R_{ist} > T_s \\ P_s \times (T_s - R_{is})\ if\ exit < R_{ist} < T_s \\ P_s \times (T_s - exit) & if\ R_{ist} < exit \end{cases} \tag{6}$$

In the equation above, R_{ist} is the total rainfall for farmer i (which equals the total rainfall in the village that farmer resides in), in growing stage s, in year t. T_s is the rainfall trigger in growing stage s. $exit$ is defined in the above term sheet. P_s is the payout per mm in growing stage s. The values of the triggers, exits and payout per mm are given in the term sheets in Section 3.1.1.

If the village's rainfall in each stage is greater than the trigger, then farmers receive no indemnity. If it is less than the trigger, all farmers receive the same indemnity that brings them back up to the trigger level of mm in the USD equivalent. However, farmers cannot receive a payout any higher than the sum insured amount. The indemnities from each stage are added together to calculate the total indemnity, TI_{it}^{D}, for each farmer, in each year.

$$TI_{it}^{D} = \sum I_{ist}^{D} \tag{7}$$

Lastly, to calculate the AFP, we need the probability distribution of rainfall for each farmer, which is the same as the probability distribution of rainfall for the village each farmer resides in. This comes from the CHIRPS data collected, as described above. We use the empirical rainfall distribution in combination with the indemnity function to compute the AFP. Specifically, we assume this rainfall contract was available in the sample area from 2018-2022, and we calculate the indemnity that would have been paid to each farmer, in each year. The AFP is simply the average of indemnities over all 785 yield observations.

$$AFP_I = \frac{\sum_{i=1}^{n} TI_{it}^{D}}{n} \tag{8}$$

Where TI_{it}^{D} is the indemnity payout for each farmer *i*, in year *t*, and *n* is the number of yield observations in the sample.

The method for calculating the AFP for the contract that covers **only flooding** and the contract that covers **both drought *and* flooding** follows the same steps as above, utilizing the contract parameters found on the term sheet.

4.2.3 Locally Adjusted Rainfall-based Index Insurance contract

We used the same process as the above SFSA calculations to calculate the AFP for the adjusted rainfall-based index insurance contract. The only difference is in the length and timing of growing stages, which is depicted in the updated term sheet.

4.3 Actuarially Fair Premium Calculation – Village Approach

While idiosyncratic risk is not pooled at all in the individual approach, we assume that *all* idiosyncratic risk is pooled in the village approach. The same steps are repeated as above;

however, now our analysis is based on 45 observations, corresponding to average yield deviations at the village level. The idea is that, under the village approach, we assume that the prototypical farmer for whom we will calculate the RIB has yields equal to the average yield of farmers within the insurance zone, in our case the village.

To find these 45 yield deviations at the village level in each year, we reference the same 785 percentage yield loss values, L_{ivt}, found in Equation 2. For each village and each year, we next find the average percentage yield loss across all farmers within the village, using the following equation:

$$\bar{L}_{vt} = \frac{1}{n}\sum_{i=1}^{n} L_{ivt} \tag{9}$$

In equation 9, $\bar{L}_{vt}$ is the average percentage yield loss for village *v*, in year *t*, and *n* is the total number of yield observations (farmers) for village *v*, in year *t*. This results in 45 average percentage yield deviations (9 villages x 5 years).

From there, the AFP for Perfect Yield Insurance, for the SFSA rainfall-based index insurance contract, and for the adjusted rainfall-based index insurance contract is calculated following the exact same steps as above. The AFP for the village approach, AFP_V is simply the average of indemnities across the 45 village-level percentage yield deviations.

4.4 Actuarially Fair Premium Results

The AFPs for various contracts were calculated using both the individual approach and the village approach across the entire sample, offering insights into the cost of insurance coverage for different risk pooling scenarios. The results, presented in Table 4.1, reveal several key trends and differences across the insurance contracts.

Table 4.1 Actuarially Fair Premia (USD/ha insured)

Method	Perfect Insurance	SFSA Rainfall Contract			Adjusted Rainfall Contracted		
		Drought Only	Flood Only	Both	Drought Only	Flood Only	Both
Individual	106.32	111.25	37.84	149.08	0.40	0.41	0.81
Village	18.12	110.10	39.99	150.09	0.51	0.50	1.01

Perfect Insurance Contract: The AFP for Perfect Insurance is significantly higher under the individual approach compared to the village approach, with an AFP of 106.3218 versus 18.1239, respectively. Recall that, when calculating the AFP under the village approach, we pooled percentage yield loss values across farmers within each village in each year, and then averaged them so that the perfect insurance contract protects only against covariate risk – or risk associated with average village yields. As a result, under the village approach, the AFP for the perfect insurance contract will be significantly lower than under the individual approach if covariate risk represents only a small fraction of total risk. Our results suggest that this is indeed the case; namely that idiosyncratic risk is, in fact, significantly more important than covariate risk (at the village level) for rice farmers in our sample. This is consistent with our findings regarding the coefficients of variations under different groupings discussed earlier in this thesis. This finding also suggests that – since index insurance contracts are, at best, able to insure against covariate risk (but not idiosyncratic risk) – the index insurance contracts that we will examine are likely to provide relatively low risk management benefits to rice farmers.

SFSA Rainfall Contract: Under the SFSA Rainfall Contract, the AFPs vary depending on the type of coverage but will not vary significantly by individual versus village approach because the indemnities depend only on rainfall at the village level. For example, for the Drought Only contract, the AFP is less than 1% higher under the individual approach (111.2465) compared to the village approach (110.10). More importantly, these AFPs are extremely high, even higher than those for Perfect Insurance, indicating that drought – as defined under this policy -- is common for farmers in our sample. AFPs for the Flooding Only contract are much lower, roughly 40 USD per insured hectare and again, the difference between the individual and village approach AFP is very small. The AFPs for the contract that covers both Drought & Flooding are, as expected, higher, reflecting the increased risk associated with covering multiple hazards.

Adjusted Rainfall Contract: Compared to the SFSA contract, the AFPs for the adjusted contract are substantially lower, and are all less than or equal to 1 USD per insured hectare. This reflects both the low probability of drought and flooding based on the threshold values specified in these contracts as well as the lower payout per millimeter of deficit or excess rainfall. The extremely low AFPs suggest that this contract will rarely make a payout to farmers and, as a result, will likely be of little value for risk mitigation. Additional reflection on why these threshold values seem less relevant than expected based on consultation with local experts will be an important area of future work.

Comparison and Implications: The variability in AFPs across contracts underscores the need for tailored insurance solutions that align with the specific risk profiles and needs of the sample area. While the adjusted rainfall contract may offer more affordable premiums, it may not be designed to capture the true impact of weather risks.

Percentage of Sum Insured: Insurance companies are typically interested in the percentage of the sum insured that the AFP represents because it provides a direct measure of the financial risk they are covering relative to the maximum potential payout. A higher percentage of the sum insured indicates that the contract covers more risk, which translates into higher premiums. This higher premium compensates for the increased likelihood of payouts, ensuring that the insurer remains financially viable in the face of significant claims.

For our perfect insurance contract, the sum insured is calculated based on the value of 1 kg of rice at 0.25 USD, multiplied by the Standardized Yield of 2,672 kg/ha. This calculation results in a total sum insured of approximately 620 USD per farmer, derived from insuring up to 90% of the long-term average yield, which is estimated at 690 USD. The average AFP for our perfect yield insurance is around 62 USD, representing approximately 10% of the estimated sum insured. In the SFSA Drought Only case, the sum insured depends on the trigger and exit values as well as the payout per millimeter deficit in each stage. As described in the term sheet in Section 3.1.1, the total sum insured for the SFSA Drought Only contract was 216 USD. Since the average AFP for this contract was around 110 USD, this represents approximately 51% of sum insured. This higher AFP for the SFSA Drought Only contract suggests that drought presents a substantial risk to farmers, leading to higher premiums as a safeguard against the greater financial exposure for the insurer.

4.5 Constructing the Certainty Equivalents

As described above, the RIB uses the economic concept of certainty equivalent (CE) to evaluate the quality of a given index insurance contract. In particular, we will need to calculate the CE associated with three scenarios: 1) Farmers have no insurance, 2) Farmers have the perfect insurance contract described above and, 3) Farmers have one of the index insurance contracts described above. This section describes how we will calculate the CE associated with each scenario for a prototypical rice farmer. Our prototypical farmer, in turn, will either correspond to the Individual or Village method described above.

4.5.1 Certainty Equivalent Under Individual Approach

When taking the Individual Approach to calculate the CE, we will calculate one CE for the entire sample. To reach this final CE measurement, a set of calculations is required. These calculations include that of net income, utility, and expected utility. When conducting these calculations, we use the actual yield loss percentages experienced by each farmer, however we apply them to a prototypical or "standardized" farmer who is assumed to cultivate 1 hectare of rice and whose mean yield is equal to the overall sample mean. Therefore, we have 157 "identical" farmers within the sample; however, yields will differ across farmers within a year according to the actual percentage yield loss that each "real" farmer experienced.

4.5.2 Perfect Insurance Contract – Certainty Equivalent Calculations

Using the above-described AFP_I information for each contract, we can first calculate the net income, π_{ivt}, for each farmer, in each year, with the following equation:

$$\pi_{ivt} = W + (0.25 \times SY_{ivt}) - C - AFP_I + I_{ivt} \tag{10}$$

In the equation above, W is a farmer's wealth, which we set at $200. This value is chosen so that the farmer can afford all of the insurance contracts that will be considered in this analysis. Therefore, this wealth can be thought of as additional income the farmer has on hand. By adding this wealth to each net income equation, we prevent net income from being negative for farmers who experience 100% yield loss, or 0 kg/ha, and who paid for the insurance but received no indemnity. C is the fixed cost of producing rice, which we hold at $0 for the purposes of this study. This cost constant may be adjusted based on a local understanding of rice production costs. According to key stakeholder interviews, this cost might range from $300 - $500 USD per hectare. Finally, AFP and I are the actuarially fair premium paid and indemnity received by the farmer under the relevant insurance contract.

From there, net income, π_{ivt}, is plugged into the following Constant Relative Risk Aversion Utility Function to find utility for each farmer, in each year:

$$U(\pi_{ivt}) = \frac{\pi_{ivt}^{(1-\rho)}}{(1-\rho)}, \text{where } \rho \neq 1 \tag{11}$$

Where ρ is the coefficient of relative risk aversion parameter, which we assume is equal to 2 throughout this study. Given that we have 785 individual yield observations in our sample, we also have 785 utility values. We next calculate the expected utility, EU, for our prototypical farmer by taking the average of the 785 utility values the entire sample.

Finally, we find the certainty equivalent, CE_M^S, for our prototypical farmer under a given scenario (No insurance, Perfect insurance, Index insurance) and under a given method (individual versus village) by finding the net income value the generates the same level of utility as the expected utility. Given the utility function that we have chosen, the CE for a given scenario, *S*, and method, *M*, is found with the following equation:

$$CE_M^S = ((1-\rho) \times EU_M^S)^{\frac{1}{(1-\rho)}} \tag{12}$$

4.5.3 No Insurance Contract – Certainty Equivalent Calculations

We repeat the exact same steps as above for the No Insurance contract case; however, the net income equation is slightly different. If a farmer has no insurance, that means there is no indemnity, and therefore, no AFP. The farmer does not pay for the insurance contract. These adjustments impact our net income equation in the following way:

$$\pi_{ivt} = 200 + (0.25 \times SY_{ivt}) - C \tag{13}$$

We end up with a certainty equivalent, CE_I^N, for each farmer in the No Insurance contract case.

4.5.4 SFSA and Adjusted Rainfall-based Index Insurance Contracts – Certainty Equivalent Calculations

We repeat the exact steps as listed in the Perfect Yield Insurance contract case, but this time for each of the Rainfall-based Index Insurance Contracts, SFSA and Adjusted. The only exception is now net income takes into account any indemnity payouts received based on CHIRPS-measured village rainfall and the AFP_I for each contract as described above. We end up with a certainty equivalent, CE_I^R, for the entire sample in the SFSA Rainfall Contract case, and a certainty equivalent for, CE_I^M, for each farmer in the Adjusted Rainfall Contract case.

4.6 Certainty Equivalent – Village Approach

When taking the Village Approach to measure the CE, we repeat the steps above; however, we base all calculations on the 45 average percentage yield deviations and the AFP_V value. When conducting these calculations, we assume again that there is a "standardized" farmer in each village, and in each year. This farmer's Standardized Yield is calculated by applying the average percentage yield loss in that village, and in that year, to the overall sample mean yield. The Standardized Yields will then be used in the same way, as described above, to calculate certainty equivalents for each of the contracts. These estimates from the village approach can be compared to our estimates from the individual approach to understand the range of certainty equivalents that exist for each rainfall-based index insurance contract compared to the Perfect Insurance contract and the case of No Insurance.

4.7 Certainty Equivalent Results

The Certainty Equivalents (CEs) for each contract under different scenarios of idiosyncratic risk pooling were calculated for the entire sample (Table 4.2).

Table 4.2 Certainty Equivalents (USD/ha insured)

Method	Perfect Insurance	No Insurance	SFSA Rainfall Contract			Adjusted Rainfall Contracted		
			Drought Only	Flood Only	Both	Drought Only	Flood Only	Both
Individual	825.63	654.57	658.31	656.12	648.20	654.54	654.41	654.39
Village	860.08	850.50	854.43	850.35	850.87	850.38	850.40	850.29

The results indicate a clear relationship between the extent of risk pooling and the Certainty Equivalent for each contract. Under the individual scenario, there is more variability in percentage yield loss observations. This high variability in yield translates into high variation in a farmers' consumption, and therefore lowers farmers' perceived value of income. The increased amount of risk and low utility present in the individual scenario results in lower CEs across all contracts. Conversely, under the village scenario, variability in percentage yield loss observations is significantly reduced. This lower variability translates into less variation in farmers' consumption, and therefore increases farmers' utility. More importantly, it results in a higher CE for each contract. The increase in CE reflects the improved financial security perceived by households due to diminished yield risk.

Table 4.2 shows that for every contract, the village CE is higher than the individual CE. This difference underscores the value of pooling idiosyncratic risk, as a reduced variability in consumption enhances the certainty of income, thereby increasing the CE.

4.8 Relative Insurance Benefit – For the Individual and Village Level

Once the certainty equivalents have been calculated for each contract, they can be plugged into the final RIB equation. First, we find the RIB using the individual approach for the SFSA contract:

$$RIB_I^R = \frac{CE_I^R - CE_I^N}{CE_I^P - CE_I^N} \qquad (1\ \ )$$

We do the same for the adjusted rainfall contract:

$$RIB_I^M = \frac{CE_I^M - CE_I^N}{CE_I^P - CE_I^N} \qquad (1\ \ )$$

Lastly, we use the same equations to calculate the final RIB for each contract using the village approach. This time, we use the village certainty equivalents, CE_V^R and CE_V^M**.** We find the RIB using the village approach for the SFSA contract:

$$RIB_V^R = \frac{CE_V^R - CE_V^N}{CE_V^P - CE_V^N}$$

We do the same for the adjusted rainfall contract:

$$RIB_V^M = \frac{CE_V^M - CE_V^N}{CE_V^P - CE_V^N}$$

4.9 Relative Insurance Benefit Results

The Relative Insurance Benefit (RIB) for each contract was calculated to assess the quality of different rainfall-based index insurance products under two approaches: the **individual** approach and the **village** approach (Table 4.3).

Table 4.3 Relative Insurance Benefits of Different Rainfall-Based Index Insurance Contracts

Method	SFSA Rainfall Contract			Adjusted Rainfall Contracted		
	Drought Only	Flood Only	Both	Drought Only	Flood Only	Both
Individual	0.02185	0.00908	-0.03724	-0.00015	-0.00089	-0.00104
Village	0.41008	-0.01521	0.03927	-0.01212	-0.0099	-0.02196

In the **individual approach,** where households do not pool their idiosyncratic risk, the denominator of the RIB formula tends to be much larger than the numerator. This is due to the high yield variability and increased risk experienced at the individual level, making the potential gain from perfect insurance substantial. Consequently, farmers in the individual approach would likely demonstrate a higher willingness to pay for perfect insurance, as it provides a significant benefit over having no insurance at all.

In contrast, in the **village approach,** we see little yield variation, meaning there is little covariate risk present. Instead, there is likely a lot of idiosyncratic risk present that needs to be pooled. Since the index insurance contract can only directly mitigate covariate risks, the benefit of index insurance or even perfect insurance is not very large compared to having no insurance at all. As a result, the numerator and denominator of the RIB formula are closer in value.

Quality Evaluation of Contracts: The SFSA Rainfall Contract covering **drought only** under the village approach yields the highest RIB at 0.41008. Recall that this value represents the percentage of the welfare gain under perfect insurance that is realized with index insurance. In other words, the SFSA drought-only contract achieves 41% of the welfare increase created by perfected insurance. Comparing this number with the other numbers in Table 4.3, we see that this contract provides, by far, the greatest relative benefit to farmers. In contrast, under the individual approach, the **drought only** contract under the SFSA Rainfall Contract results in a much lower RIB of 0.02185. These estimates are vastly different because the SFSA contract detects drought in every village, every year. This translates to a high percentage of covariate risk at the village level, meaning the index contract that is more closely aligned with the actual losses experienced by farmers. As a result, the payouts from the insurance are more likely to accurately reflect the collective need for compensation, leading to a higher RIB at the village level. In contrast, at the individual level, the impact of a drought might differ from farmer to farmer. Even in a drought year, some farmers might experience less severe losses or might have mitigating factors that reduce the impact. Therefore, the correlation between individual losses and insurance payouts might be weaker, leading to a lower RIB at the individual level.

Other contracts, particularly those covering **flooding only** or **both drought and flooding**, exhibit negative RIBs under both approaches, with some exceptions. For instance, the **village approach** in the SFSA Rainfall Contract for **both drought and flooding** yields a small positive RIB of 0.03927, indicating a modest benefit in this pooled risk scenario. However, the Adjusted Rainfall Contract generally shows negative or very low RIBs across both approaches, implying that these contracts would make the farmer worse off than if they had no insurance at all. Chapter 5 is spent exploring possible explanations for these low RIBs.

5. CHAPTER 5: RIB DISCUSSION

5.1 Relationship between self-reported weather shocks and CHIRPS rainfall data

To further explain the low RIB estimates, we need to first understand how much of rice yield variability is actually driven by rainfall. Therefore, in this section, we aim to characterize the frequency of drought and flooding in order to understand their impact on rice production.

When analyzing frequency of drought and flooding, we rely on two sources of data: 1) self-reported drought and flooding occurrences from yield recall survey respondents, and 2) CHIRPS rainfall data. It is important to analyze both because each source measures drought and flooding experiences differently. It is also valuable to understand which data source would minimize basis risk the most in a future index insurance contract.

Self-reported experiences of drought and flooding could be very precise, as it is assumed that a farmer knows best what has happened on his/her farm. They have an on-the-ground view of what weather events happen and how those events impact their crops. However, there could be two problems with their reports in the context of index insurance: 1) When asking farmers to recall their weather experiences over the past five years, recall error may arise. 2) Each farmer's definition for exactly what a "drought" means and exactly what a "flood" means may vary from other farmers' definitions and/or the index insurance provider's definition of drought and flooding in that region.

CHIRPS data provides a numerical precipitation amount for each GPS coordinate. However, this numerical data might not reflect farmers' actual rainfall experiences for a number of reasons: 1) It is a satellite-based data collection system that may produce inaccurate measurements, due to cloud-cover, technical difficulties, etc. 2) It can only measure and report average rainfall across a 5 km x 5 km grid. If there is heterogeneity in rainfall across that grid, CHIRPS may not capture that variability accurately due to its course spatial resolution. Therefore, it might not accurately represent what a farmer experienced.

5.1.1 Contingency Tables

The following contingency tables depict the frequency of drought and flooding events experienced by farmers in the early wet season of each year from 2018-2022. They give us a first glimpse at how closely the CHIRPS rainfall data aligns with self-reported experiences.

Frequency of these weather events is determined based on five data sources:

1. Farmers' self-reported drought and flooding experiences;
2. Drought and flooding experiences based on CHIRPS rainfall data, a **fixed planting date,** and both the SFSA and Adjusted term sheets;
3. Drought and flooding experiences based on CHIRPS rainfall data, a **variable planting date for each farmer**, and both the SFSA and Adjusted term sheets.

Table 5.1 Drought Contingency Table - SFSA

2018-22 – Drought – SFSA Term Sheet							
		Fixed Planting Date				**Variable Planting Date**	
		Drought (99.49%)	No Drought (0.51%)			Drought (60.89%)	No Drought (39.11%)
Self-Reported	Drought (11.45%)	99.13%	0.87%	**Self-Reported**	Drought (11.45%)	61.05%	38.95%
	No Drought (88.55%)	99.54%	0.46%		No Drought (88.55%)	60.93%	39.07%

Table 5.2 Drought Contingency Table - Adjusted

2018-22 – Drought – Adjusted Term Sheet							
		Fixed Planting Date				**Variable Planting Date**	
		Drought (14.87%)	No Drought (85.13%)			Drought (34.92%)	No Drought (65.09%)
Self-Reported	Drought (11.45%)	16.33%	83.67%	**Self-Reported**	Drought (11.45%)	36.56%	63.44%
	No Drought (88.55%)	14.68%	85.32%		No Drought (88.55%)	34.70%	65.30%

Table 5.3 Flooding Contingency Table - SFSA

2018-22 – Flooding – SFSA Term Sheet							
		Fixed Planting Date				**Variable Planting Date**	
		Flood (70.19%)	No Flood (29.81%)			Flood (54.01%)	No Flood (45.99%)
Self-Reported	Flood (24.12%)	79.27%	20.73%	**Self-Reported**	Flood (24.12%)	46.94%	53.06%
	No Flood (75.88%)	67.51%	32.49%		No Flood (75.88%)	56.81%	43.19%

Table 5.4 Flooding Contingency Table - Adjusted

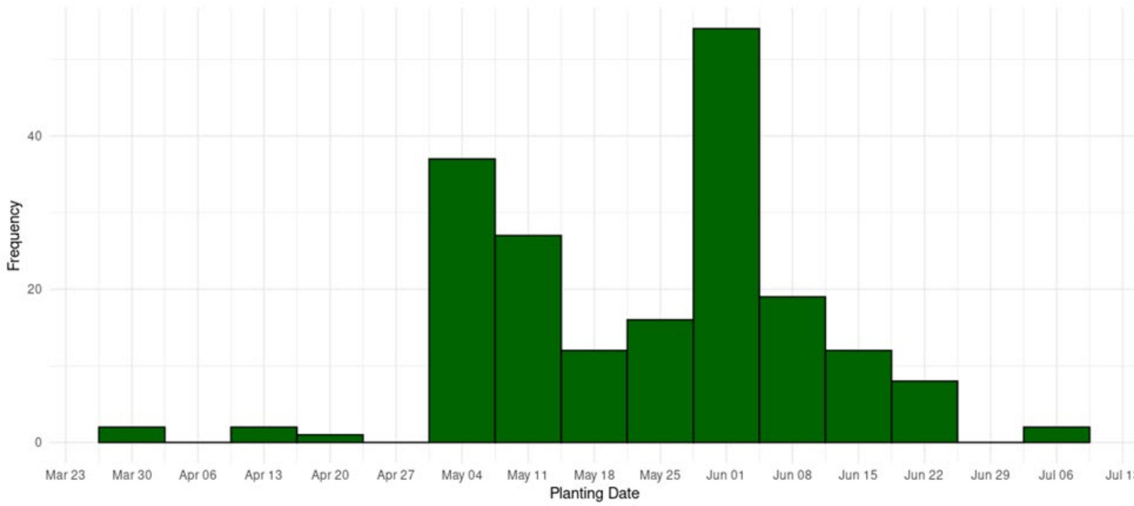
2018-22 – Flooding – Adjusted Term Sheet							
		Fixed Planting Date				**Variable Planting Date**	
		Flood (13.65%)	No Flood (86.35%)			Flood (31.72%)	No Flood (68.28%)
Self-Reported	Flood (24.12%)	10.03%	89.97%	**Self-Reported**	Flood (24.12%)	28.32%	71.68%
	No Flood (75.88%)	14.80%	85.20%		No Flood (75.88%)	32.80%	67.20%

Basis Risk: In the above tables, the highest percentages would ideally appear in the top left and the bottom right boxes, if we were dealing with a high-quality index insurance contract. A high percentage in each of these boxes would mean self-reported weather experiences align closely to SFSA and adjusted term sheet reports of drought and flooding. On the contrary, we see several discrepancies in drought and flooding experiences above. This emphasizes the importance of setting the appropriate rainfall trigger level for the local context. This is also a first hint at the fact that both the SFSA and adjusted contract may have high basis risk. We can see here that farmers are likely not going to receive payouts when they should (false negatives) and are likely going to receive payouts when they should not (false positives).

Fixed vs. Variable Planting Dates: Another comparison we can make from the above tables is the different percentages under fixed versus variable planting date scenarios. For variable planting date, we observe CHIRPS-detected rainfall to line up much better with self-reported experiences under both the SFSA and adjusted contracts. This shows the importance of considering farmers' unique planting dates when designing index insurance contracts. Even if the rainfall trigger is set to an appropriate level, farmers may significantly vary their planting dates. If this is the case, *and* that variation leads to substantial variation in experienced drought or flooding, then unless variable planting dates are accounted for in the index insurance contract, then it is likely to still have high basis risk.

The importance of variable planting dates is further depicted in *Figure 5.1*. With planting dates in our study ranging from March 30 to July 6, we can better understand why assuming a set planting date can construe the true drought and flooding experiences of farmers.

Figure 5.1 Histogram of Planting Dates



5.2 Regression Analysis: Rainfall Impact on Yield

Now that we understand the frequency of rainfall risk, we want to go one step further in quantifying how well the SFSA and Adjusted contract indices predict individual yields and yield losses. Through regression analysis, we aim to establish causality between rice production and variations in precipitation in the study area. This needs to be done for both the self-reported weather shocks and the weather shocks measured by CHIRPS. For the analysis of this CHIRPS data, we separately apply the terms laid out in both the SFSA contract and the Adjusted Rainfall-based contract. The same multiple linear regression equation can be used for all instances:

$$Y_{t,i} = \beta_0 + \beta_1 D_{t,i} + \beta_2 F_{t,i} + \beta_3 D_{t,i} F_{t,i} + \beta_4 X_i + \alpha_i + e_{t,i}$$

In the equation above:

- $Y_{t,i}$ = rice yield, or percentage yield deviation, in time period *t* and for farmer *i*.
- $D_{t,i}$ = 1 if the farmer, *i*, experienced deficit rainfall (drought) in time period *t* and zero otherwise.

- $F_{t,i}$ = 1 if the farmer, i, experienced excess rainfall (flooding) in time period t and zero otherwise.
- $D_{t,i}F_{t,i}$ = 1 if the farmer, i, experienced both drought and flooding in time period t and zero otherwise.
- X_i stands for a number of independent variables to control for, which includes age, gender, years growing rice, and total land size.
- α_i = fixed effect capturing time-invariant commune- and year-specific characteristics.
- $e_{t,i}$ = the error term.

5.2.1 Regression Results: Rainfall Impact on Yield

Table 5.5 reports regression coefficients when yield (in kilograms) is the dependent variable, revealing how drought and flooding events, individually and in combination, influence crop yield. Table 5.6 reports regression coefficients when percentage yield loss is the dependent variable, offering insight into how these weather events affect yield variability in relative terms.

Table 5.5 Regression Results – Rainfall Impact on Dependent Variable: Yield (kg)

Column #	(1)	(2)	(3)	(4)	(5)
Variable	Self- reported	SFSA - CHIRPS Fixed Planting Date	SFSA - CHIRPS Variable Planting Date	Adjusted - CHIRPS Fixed Planting Date	Adjusted - CHIRPS Variable Planting Date
Drought ($D_{t,i}$)	-1,233.57***	239.224	-122.42	-64.28	-88.89
Flooding ($F_{t,i}$)	-2,129.49***	-485.281	-127.21	-131.35	-191.53
Both Drought & Flooding ($D_{t,i}F_{t,i}$)	-1,245.06***	---	-1.69	-967.43	-107.69
Sample Mean	2,671.85	2,671.85	2,671.85	2,671.85	2,671.85
R^2	0.3286	0.0303	0.02718	0.02845	0.02823

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Table 5.6 Regression Results – Rainfall Impact on Dependent Variable: Percentage Yield Loss (%)

Column #	(1)	(2)	(3)	(4)	(5)
	Self-reported	SFSA - CHIRPS Fixed Planting Date	SFSA - CHIRPS Variable Planting Date	Adjusted - CHIRPS Fixed Planting Date	Adjusted - CHIRPS Variable Planting Date
Drought ($D_{t,i}$)	-0.3644***	0.2289***	0.0658	0.0424	0.0328
Flooding ($F_{t,i}$)	-0.7067***	-0.4158	0.1192	-0.0309	0.0074
Both Drought & Flooding ($D_{t,i}F_{t,i}$)	-0.3305**	---	0.1273	-0.0153	-0.0326
Sample Mean	-0.00014	-0.00014	-0.00014	-0.00014	-0.00014
R^2	0.2910	0.0347	0.00386	0.000896	0.00115

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

As seen in the above tables, both the SFSA and adjusted contract indices do a generally poor job at predicting the impact of rainfall on yield and yield deviations, as compared to self-reported weather shocks. We see this first by observing the coefficient estimates for the SFSA and adjusted contract. The estimates indicate a much smaller impact of rainfall on yield and yield deviations. At times, the estimates even indicate improved yields when a weather shock is experienced, as seen in columns 2-5 of Table 5.6.

R^2: Another way of understanding the strength of each model in explaining the variability in the dependent variables is to observe the R^2 values. Here, higher R^2 values indicate models that better explain the variance in yield/yield deviations, and lower R^2 values suggest that the models have limited explanatory power, and additional factors may need to be considered when thinking about yield variation. In both Table 5.5 and Table 5.6, we see that column 1 has the highest R^2. Taking column 1 from Table 5.5 for example – this model explains approximately 32.86% of the variance in yield due to self-reported experiences with weather shocks. This is relatively high, suggesting that the self-reported data has a considerable explanatory power over yield. However, if we look at columns 2-5 in each table, we see that these models explain a very small proportion of variance in yield and yield deviation. These low R^2 indicate that models using SFSA and adjusted contract term sheets alongside CHIRPS data to measure rainfall experiences have limited explanatory power for yield and yield deviations.

Multicollinearity: When running the regression for SFSA – CHIRPS Fixed Planting Date, the interaction coefficient ($D_{t,i}F_{t,i}$) results in no output due to multicollinearity with the Drought coefficient ($D_{t,i}$) and the Flooding coefficient ($F_{t,i}$). This multicollinearity is occurring due to the severely high rainfall trigger for drought. This results in most farmers, in most years, experiencing drought according to the SFSA term sheet. Since this is the case, flooding generally only occurs when a drought is also detected. Therefore, the interaction coefficient is not distinguishable from the individual coefficients. There are only four instances out of all 785 observations where a drought does not occur, and a flood does occur. These few observations do not play a large enough role to avoid multicollinearity. Essentially, in this SFSA – CHIRPS Fixed Planting Date model, there is no variation in the binary drought outcome.

Fixed vs. variable planting date: The fixed and variable planting date indices in both the SFSA and adjusted contracts show similarly low levels of predictive power, with little difference between them in terms of R^2 values and statistical significance. This result is surprising, as one would assume that when farmers' unique planting dates are considered, the weather shocks they experience may better align with rice production outcomes. This further depicts that the rainfall indices are not set at the right level to begin with, so adjusting planting dates has little impact on these models' ability to predict yield and yield deviations.

The limited predictive accuracy of the indices used in these index insurance contracts underscores the relatively low RIBs observed. This finding highlights a critical limitation in the effectiveness of these indices in forecasting yield losses, thereby contributing to the extremely small RIBs associated with these insurance products.

5.3 Basis Risk: False Positives and False Negatives

RIB values can be further explained by graphing out instances of false positives and false negatives. As discussed previously, false positives occur when a farmer does not deserve a payout – they did not experience large yield losses – but receive one. On the other hand, false negatives occur when a farmer does not receive a payout, even though they experienced high yield losses. These instances are important, as they are directly related to basis risk, which is generally the risk that an insurance payout does not perfectly correlate with the actual loss experienced by the insured. If an insurance contract poses high basis risk, that contract's RIB should be low.

To plot these payout experiences, we first must define when each of them occur.

- **Severe False Negative:** Contract underpays by 10 – 30%
- **Small False Negative:** Contract underpays less than 10%
- **True Negative:** No payment deserved, and none received
- **Severe False Positive:** Contract overpays by over 30%
- **Small False Positive:** Contract overpays by less than 30%
- **True Positive:** Payment deserved, and payment received

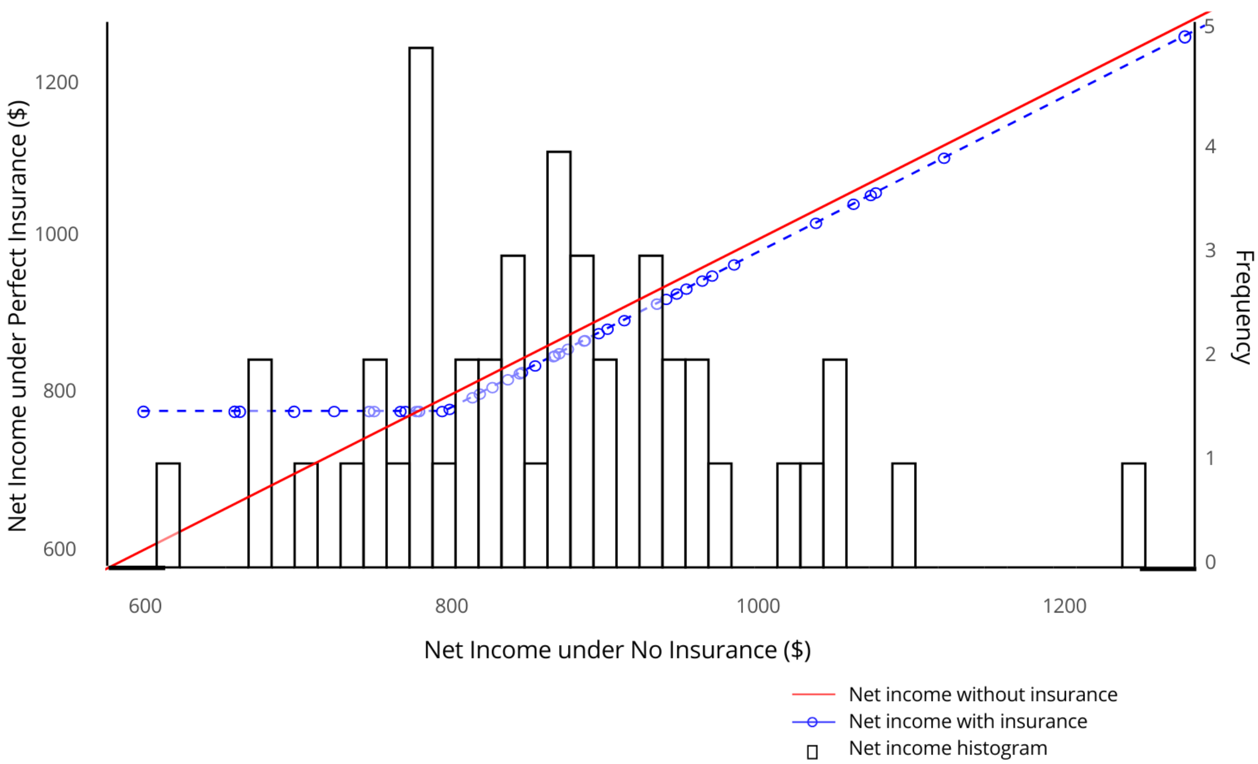
Each instance is plotted against a graph where net income with no insurance is displayed along the x-axis and net income with perfect insurance is displayed along the primary y-axis.

5.3.1 Basis Risk Results

Figure 5.2 displays the frequency at which a standardized farmer under the Village Approach would experience the varying levels of net income under No Insurance on the horizontal axis.

The dashed blue line depicts net income under Perfect Insurance and puts a floor under net income at 10% of yield loss, such that it will never fall below $790. It is important to note that these net income amounts do not reflect true net income, as rice production expenses were assumed to be $0. Realistic net income for study farmers is likely to be $300-$500 lower than what is depicted in *Figure 5.2.*

Figure 5.2 Histogram of Net Income experiences under No Insurance for a Standardized Farmer in the Village Approach

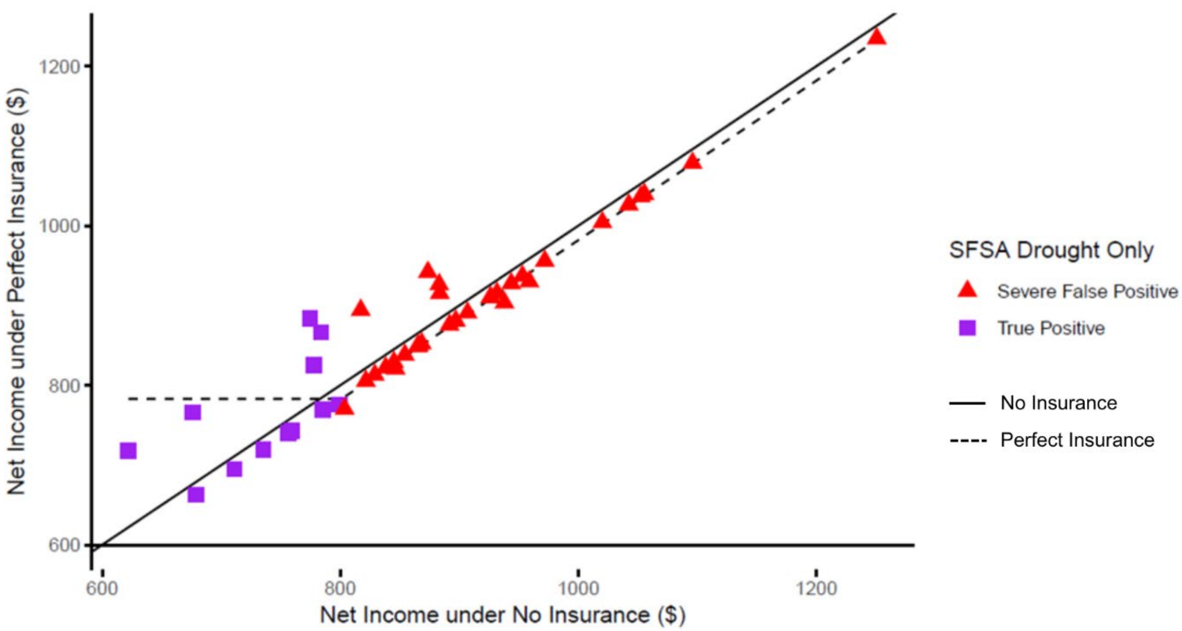


With these net income experiences under No Insurance and Perfect Insurance in mind, *Figures 5.3 and 5.4* map out net income for Drought Only scenario of the SFSA and adjusted index insurance contracts, respectively. For the SFSA contract, we face a unique situation. As noted in previous sections, due to the indices set by SFSA, drought is detected on essentially all plots in all years. Therefore, it is not possible for a farmer to experience a "negative" payout under this contract – they will always receive some level of payout.

However, from *Figure 5.3* we see both "True" and "False" positives occur. The "True Positives" that lie below the 45-degree line are not intuitive – you would expect these to be "False Negatives", as it appears that they are not getting a payout even though they have large yield losses. However, these farmers are actually receiving payouts, they are just extremely small payouts compared to the large AFP they paid under this Drought Only contract.

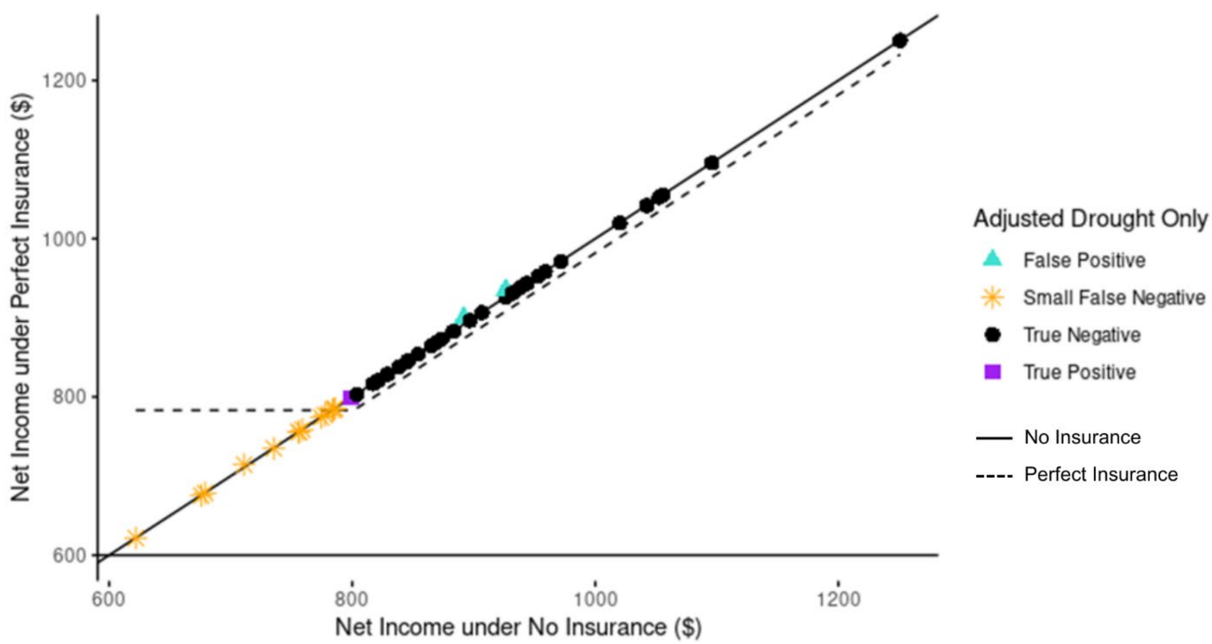
Similarly, the "Severe False Positives" that lie just below the 45-degree line look very much like "True Negatives", where the farmer theoretically did not suffer a large enough loss to constitute a payout, and they did not receive one. However, in reality, they are receiving a small payout that does improve their overall net income situation because of the extremely high AFP they paid for this coverage.

Figure 5.3 Quality of the SFSA Drought Only index insurance contract, compared to Perfect Insurance and No Insurance.



Turning to *Figure 5.4*, we see net income mapped out for the adjusted contract Drought Only scenario. Here, both "Positive" and "Negative" outcomes occur, as drought was not experienced so frequently. In fact, drought was rarely experienced under the adjusted contract, which partly explains why most of these points fall along the 45-degree line. The other reason they fall along this line is because the AFP for the Drought Only scenario in the adjusted contract was extremely small – just 0.51 USD. Here, the most common occurrence is for a farmer to not suffer a yield loss (according to the adjusted index insurance contract indices), and therefore not receive a payout – a "True Negative". Only one time does our standardized farmer experience a yield loss and receive a payout for that loss, a "True Positive". If the index insurance contract were functioning properly, there would be several more "True Positive" instances, and these payouts would be much larger, increasing net income more than we see here.

Figure 5.4 Quality of the SFSA Drought Only index insurance contract, compared to Perfect Insurance and No Insurance.



These results reiterate the high basis risk involved in both contracts, although due to different reasons. Contracts with this level of basis risk and these low RIB measures should not be offered to farmers, as they will often be worse off after adopting the insurance. While this has many implications on the design and supply side of these contracts, Chapter 6 explores other feasibility factors that should be considered in this space, more along the demand side.

6. CHAPTER 6: ADDITIONAL FEASIBILITY CONSIDERATIONS FOR RICE INDEX INSURANCE IN BATTAMBANG

Chapter 6 consists of additional feasibility considerations to be made when designing and implementing index insurance contracts for rice, specifically in Battambang. It draws on qualitative data collected through Focus Groups Discussions (FGDs) and Key Stakeholder Interviews (KSIs). Among the considerations to be made, farmers' access to information and trust between players in the insurance system contribute significantly to the feasibility of index insurance products.

6.1 Context, Data Collection and Methodology

6.1.1 Focus Group Discussions

The purpose of the FGDs was to understand farmers' access to information and perceptions of index insurance, share with farmers how index insurance could help them become more resilient, and to understand gendered differences in household decision-making. Four total Focus Group Discussions were held, with two in the Sangkae District and two in Moung Ruessei District. In each district, a randomized sample of 11 women (FGD #1 and #4) and 11 men (FGD #2 and #3) from yield recall survey respondents were selected to participate in the discussions. The sampling process may be skewed, as only those respondents who answered their phone and were available to attend the FGD the next day were able to participate. Table 6.1 depicts participant characteristics of each FGD.

Table 6.1 Focus Group Discussion Participant Characteristics

FGD #	District	Women or Men	# of FGD Participants	Average Age	Avg Yrs Growing Rice	Avg Total Land Size (ha)	# of HH with prior II experience
1	Sangkae	Women	6	34	13.67	5	0
2	Sangkae	Men	5	42.6	21	6.6	0
3	Moung Ruessei	Men	6	36	16.33	6.25	1
4	Moung Ruessei	Women	5	52.4	34.4	7.6	2
Totals			22	41.25	21.35	6.36	3

Accessibility and gender constraints were considered when deciding on FGD meeting location, timing, and participant composition. The Sangkae FGDs were hosted at CE SAIN's ATP in Battambang, as this was a central location between communes and connected participants with CE SAIN's extension network if they were not already aware of it. The Moung Ruessei FGDs were hosted in a community structure in Srae Ou. The village chief had informed the research team that this was a common meeting location for farmers in the commune, and it was also centralized. Women's FGDs were purposely scheduled for the early morning and late afternoon to avoid lunch time. Women are often the busiest around the lunch hour, so scheduling this way allowed for as many women to attend as possible. Lastly, we separated men and women with the goal of hearing participants' true opinions and experiences, without the pressure of answering in a certain way due to the other gender being present.

The FGD Outline is attached as Appendix D. A few of the same questions asked in the yield recall survey were verbally validated in the FGD (i.e., rice yield before/after weather shock, most impactful weather shocks they experience, etc.). An informational video developed by SFSA on weather-based index insurance for rice producers was played, which ignited discussion and questions on how exactly the product works. Lastly, an interactive game was played with the raising of colored cards to understand gendered decision-making in the households.

Each FGD was facilitated by Punlork Men of CE SAIN, with support and notetaking (in English) done by Sareth Oun of CE SAIN. The entirety of each FGD was recorded using a voice recorder. These recordings were later transcribed and translated by an online tool, Simon Says AI. The translated documents were then coded and analyzed for common themes using the NVivo Software for qualitative data.

6.1.2 Key Stakeholder Interviews

The purpose of the KSIs was to identify the landscape of trust amongst stakeholders currently investing in index insurance for rice in Cambodia and understand what approaches they are taking to design/implement insurance products. In total, 10 KSIs were held in person over the seven weeks of in-country data collection (*see list of interviewees and affiliations in Table 6.2).*

Table 6.2 Key Stakeholder Interview Information

Name	Affiliation	Title	Topic of Interest
Dr. Seng Veng	Department of Agricultural Land Resource Management	Director	Governmental viewpoints and support of index insurance
Chanthol Uch	International Rice Research Institute (IRRI)	Senior Manager	IRRI's innovations and previous projects focused on index insurance for rice
Dr. Mark Doyle	United States Agency for International Development (USAID)	Deputy Director, Sustainable Economic Growth Office	USAID's involvement and awareness of index insurance in Cambodia
Dr. Sareth Chea and Thida Lim	Cambodian Agricultural Research and Development Institute (CARDI)	Head of Socioeconomics Office, Researcher	Possibility of bundling improved rice seeds with index insurance
Arindom Baidya, Sophary Long	Syngenta Foundation for Sustainable Agriculture (SFSA)	Consultant, Project Manager	SFSA's research, projects, and areas of collaboration on index insurance
Chhem Vutha, Ny Lyhoung, Saovanna Or	Forte Insurance	Director of Agriculture Insurance, COO, Assistant General Manager	Forte's index insurance pilot projects
Phalleng Ban	Prevoir (PKMI)	CEO	Prevoir's approach and new pilot project

Thol Than, Sokhom Khlaing	Commercialization of Aquaculture for Sustainable Trade (CAST) Cambodia	Technical Leads for Access to Finance and Private Sector Support Services	CAST's index insurance scheme for aquaculture
Jhelum Chowdhury	Emerging Markets Consulting	Consultant for Cambodia Rice SDP	Cambodia SDP project challenges & successes
Ponleu Cheu	Cambodia Australia Partnership for Resilient Economic Development (CAP RED)	Lead of Trade, Investment, and Agri-food Innovation	CAP RED programming and landscape knowledge

An overview of KSI questions by topic can be found in Appendix E. Interviews were not recorded; however, detailed notes were taken.

6.2 Results and Discussion

6.2.1 Focus Group Discussions

6.2.2 Self-Reported Yields Before/After Weather Shocks

In each FGD, participants were asked to share average rice yield on their best plot both before and after a weather risk (i.e., drought, flooding) occurs. This question was meant to ground participants in the goals of the discussion, but also allowed us as researchers to validate the yield recall survey data with a smaller sample size. *Figures 6.1* and *6.2* display these yield results, showing 3,032.5 kg/ha as the average yield before weather risks and 652.5 kg/ha as the average yield after weather risks. This compares closely to the yield recall survey data, where 3,353.79 kg/ha was the average yield when no weather risks were faced, and 1,269.07 kg/ha was the average yield if either drought or flooding was experienced on each farmer's best plot.

Figure 6.1 Yield Before Weather Risk

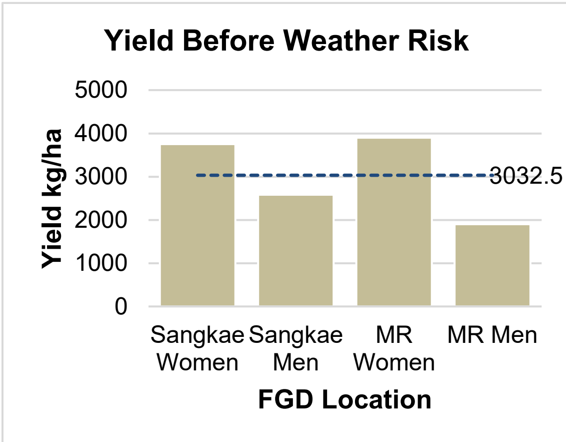
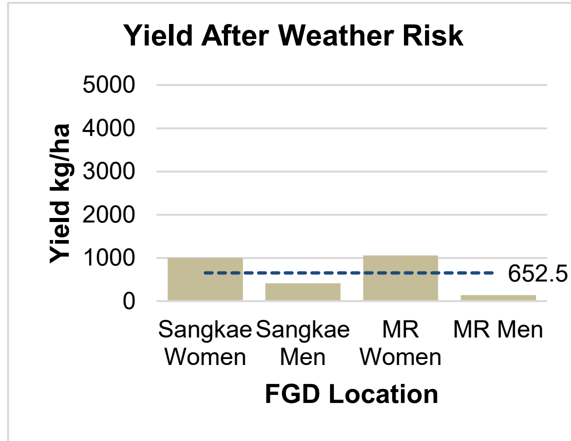
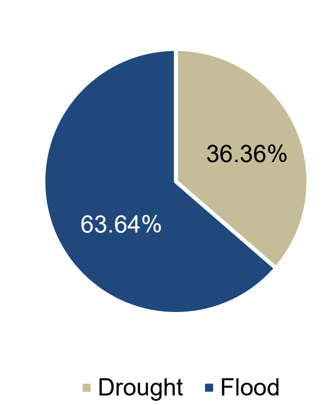


Figure 6.2 Yield After Weather Risk



It is also interesting to note here that women consistently reported higher yields, whether they faced weather risks or not. This contradicts findings from the yield recall survey, where being a woman farmer meant that self-reported rice yield averaged 468.08 kg/ha less than men's average yields. There may be several reasons for this. While men and women's yields may differ due to unequal access to resources and inputs, both genders may inflate their self-reported yields in social settings as a way to align with their peers and avoid embarrassment, a form of conformity bias (Asch, 1951). On the other hand, focus group participants may report lower than experienced yields if they think researchers may be more likely to give them resources or help them if their yields are lower. Giving researchers "what they want to hear" is often referred to as confirmation bias (McSweeney, 2021).

Figure 6.3 Most Concerning Weather Risks



Further, FGD participants were asked which weather risk they found more concerning and detrimental to their rice crop. As seen in *Figure 6.3*, 36.36% of participants indicated drought was more devastating, while 63.64% indicated flood was more devastating to their rice yield. When comparing this to the self-reported yield recall survey data, we see these results echoed –

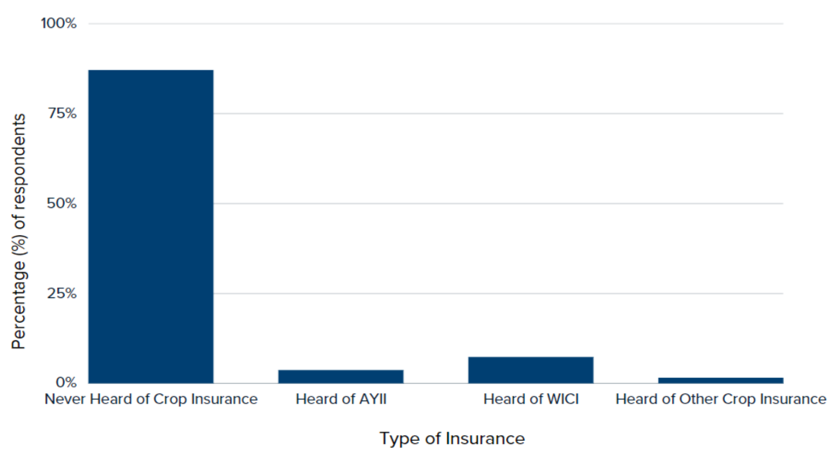
drought caused yields to decrease by only 1,234 kg/ha, while flooding caused yields to decrease by 2,129 kg/ha.

The next portion of the FGDs asked participants what they could do differently on their farms to improve their average yields. This question was asked to gather information on welfare-enhancing activities farmers might be more likely to invest in if they had insurance. Several activities mentioned included using improved seeds, applying more fertilizer, and preparing rice fields with machinery.

6.2.3 Crop Insurance Awareness

As anticipated, based on a thorough literature review, very few rice producers in Battambang were familiar with crop insurance. Insurance generally is a new concept for Cambodians, as life

Figure 6.4 Familiarity with Crop Insurance



insurance, health insurance, and vehicle insurance are not commonly offered, especially in rural areas. As seen in *Figure 6.4*, the majority of FGD participants had never heard of crop insurance. Interestingly, 14 respondents had heard of weather index crop insurance (WICI), as this was a product offered by Forte in 2022, in two of our study's target villages – Toul Prum Muoy and Srae Ou.

This finding is integral in understanding how to increase demand for future index insurance contracts. The more exposed farmers are to both the general concept of insurance and the specific characteristics of index insurance, the more likely they are to adopt it (Vasilaky, et al., 2020). The top three reasons for not having crop insurance can be summarized as:

1. **Unfamiliarity –** farmers are generally unaware of the concept of crop insurance.
2. **No contact information for the insurance provider –** Even if farmers do understand what crop insurance is, they do not know whether it is available to them or who to contact in order to sign up.
3. **Lack of trust in the product and insurance provider –** The majority of farmers in Toul Prum Muoy and Srae Ou who had previously experienced Forte's WICI product had bad experiences. Several farmers expressed concerns about paying for the insurance contract, but never again heard from the provider, Forte, even after experiencing yield losses due to flooding. One explained that this is likely because a damn broke upstream of their village, which flooded their fields. The flooding was not due to excess rainfall in their village. This highlights one difficulty of a rainfall-based index insurance product, it is not able to detect yield damages outside of precipitation.

6.2.4 Interest in Index Insurance

When presented with SFSA's 4-minute overview of weather-based index insurance for rice producers in Cambodia, FGD participants were given open space to ask clarifying questions. Table 6.3 presents the most common questions asked across FGDs.

These questions provide valuable insights into the kinds of capacity building needed for farmers before introducing crop insurance products to them. While answers to some of these questions may vary across products, other answers would be evident to farmers if they were trained in the basic concepts of crop insurance. As found in other studies focused on the demand for crop insurance (Maganga, et al., 2021), farmers are keenly interested in the monetary aspects of these products – premium and indemnity amounts.

Table 6.3 Common questions asked about crop insurance

"What seasons does it cover?"
"How much does it cost?"
"How much of a payout can I receive?"
"How is the rainfall measured?"
"What if other weather [not drought or flooding] or pests impact my rice yield?"

The question on how rainfall is measured is especially relevant to the Cambodian context, as there are few rainfall stations located throughout the Battambang province. This is one integral challenge insurance providers face in Cambodia when designing high quality weather/rainfall-based insurance products.

6.2.5 Farmer-Perceived Pros and Cons of Index Insurance

After asking questions about index insurance for rice, FGD participants were asked to share more about their perceived "pros" and "cons" that might come along with these types of products. Table 6.4 summarizes these perceptions. Generally, farmers like the possibility of

Table 6.4 Pros and Cons of Index Insurance from Farmers' Perspective

Pros	Cons
If drought or flooding occurs, and yield losses are experienced, we will receive compensation.	We will have to borrow money to pay the premium, and there is no guarantee of getting money back.
This money can be used to buy new seeds or assist with land preparation.	Weather shocks are irregular, so it is hard to know when to buy insurance.
Less money needs to be borrowed from the bank to continue farming after a weather shock is experienced.	We have no confidence in the product or insurance provider because neighbors have had negative experiences.

receiving a payout after a disaster and using that money to invest in future land preparation or new seeds. However, they lack trust in the insurance provider and fear paying for something that will not give them a good return.

6.2.6 Household Decision-Making

Lastly, the FGDs provided valuable insights into who makes financial decisions within these rice-producing households. This data allows us to think about how insurance companies should market and design future index insurance products, to ensure they are attractive to the main household decision-makers and are as inclusive as possible.

Figure 6.5 Household Decision Making

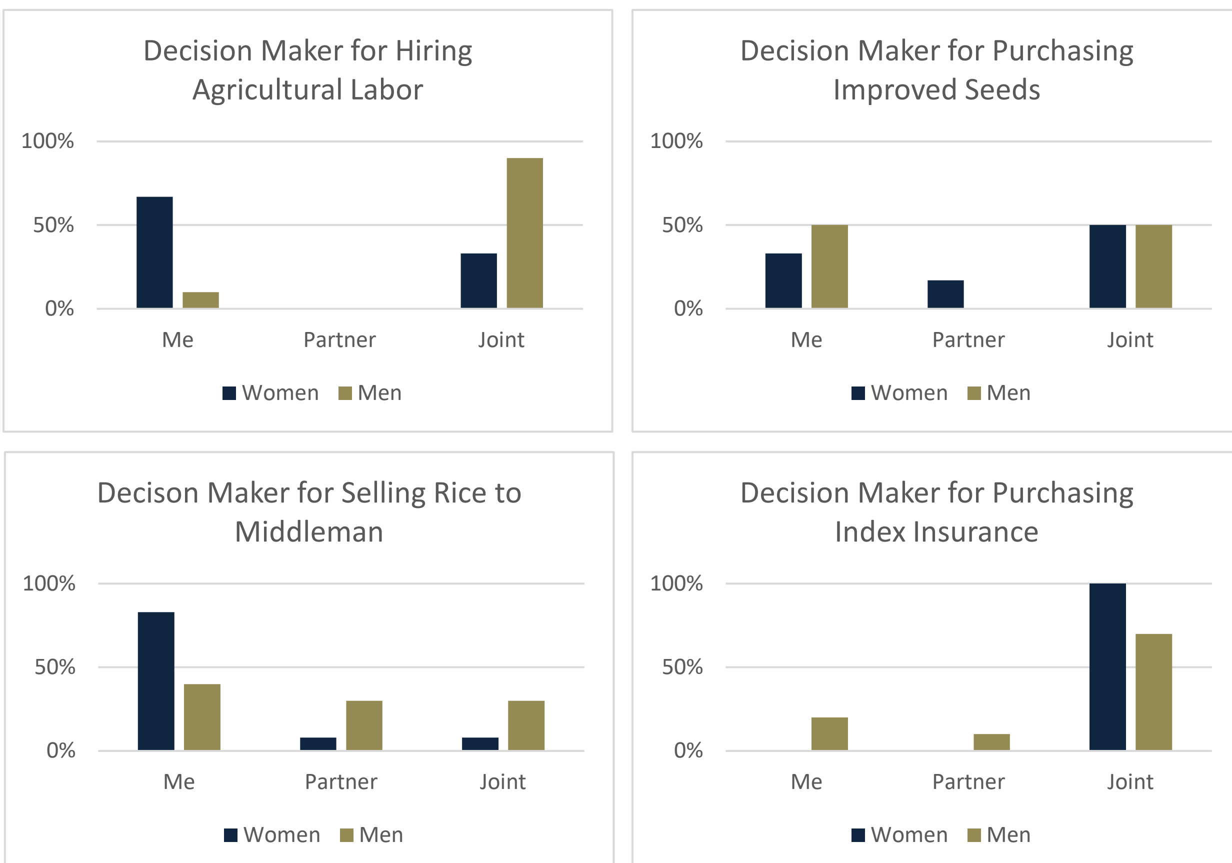


Figure 6.5 shows women's and men's responses to four different types of decisions that need to be made at the household level. It appears that women and men might make a joint decision when it comes to hiring agricultural labor and purchasing improved seeds. However, women indicate they often make the decision to sell rice to middlemen, while men's responses are split. Overall, men and women both agree that purchasing index insurance would be a joint household decision. Moving forward, this necessitates that index insurance products for rice producers in this area appeal to the needs of both women and men. Both genders should also be well informed on how index insurance works, as this result shows that they will work together to make an educated decision on whether or not to invest in the product.

6.2.7 Key Stakeholder Interviews

The KSIs provided information on current index insurance pilot projects in Cambodia, who is funding and/or leading these efforts, which commodities they are targeting, and what kind of products they are testing. Forte is the prime insurance company rolling out these products, while SFSA plays a large role in building farmer demand. Index insurance has primarily targeted rice in Cambodia; however, other commodities such as maize, cassava, and horticultural crops such as watermelon, sweet melon, and cherry tomatoes are being explored.

The most successful index insurance pilot project in Cambodia has been the Weather Indexed Crop Insurance (WICI) scheme. It is pioneered in partnership by the Ministry of Economy and Finance, the Rice Sector Development Program (SDP), and Forte. Since the first pilot in 2015, the project has enrolled 54,800 rice producers. It provides a fully subsidized insurance product to farmers, with 50% of the $10 premium being paid by Forte and the other 50% by the Ministry of Economy and Finance. The project has trained only 7,756 female farmers on financial literacy, showing an obvious gap in the delivery of training services to women. Table 6.5 provides an overview of these pilot projects and products.

Table 6.5 Current Pilot Projects and Products in Cambodia

Project	Stakeholders	Product
Cambodia Rice SDP	ADB, Forte	WICI for rice
Extension Of RIICE Project	Syngenta Foundation	AYII for rice, WICI for maize
CAST	Syngenta Foundation, Forte	Aquaculture index insurance
USAID HARVEST III	PKMI (Prevoir)	Developing WICI product for rice and cassava

6.2.8 Lessons Learned: Challenges

Several challenges were identified through Key Stakeholder Interviews and concepts were re-emphasized through interviews held in the Philippines.

1) **Lack of Government Investment:** Contrary to the Philippines and other countries' long-standing, government-run crop insurance programs, crop insurance in Cambodia is typically funded and offered through the private sector or development programming. The Government of Cambodia does not lead any crop insurance efforts, although they have partnered with some private insurance providers and development partners to pilot various products. This leads to several challenges.

The first challenge with a private sector led insurance program is that the private sector needs to make a higher margin than the government. Crop insurance schemes that are state-run are typically seen as welfare enhancing programs and do not require the government entity to earn a profit. However, with privately provided products, companies must charge higher premiums. To achieve this, private insurance providers have partnered with development projects who will subsidize the product while it is being piloted. However, development project budgets run out and private insurers typically are unable to achieve the margin they need. Without the government's intervention, farmers are left paying a high price for crop insurance coverage.

Additionally, several stakeholders echoed findings in Akter et al., 2016, saying that Cambodians, especially women, trust government institutions more than they do private insurance providers. Therefore, government involvement and investment in index insurance products is vital.

2) **Lack of Data Availability:** Several types of data are needed to design and implement a high-quality index insurance contract. These data include crop yield data, rainfall data from weather stations, and remotely-sensed rainfall data – in this case, from CHIRPS. Access to crop yield data, specifically for rice, is limited. The Ministry of Agriculture, Forestry and Fisheries (MAFF) is the best-known dataset for yield data but is only available at the district level and for the years of 2007-2010, 2013, and 2019 (SFSA, 2020). Commune-level yield data can sometimes be available through the provincial departments (PDAFF) but is often untrustworthy and highly variable. Village-level yield data for rice is not available. Rice yield data was collected in some provinces through the previous RIICE initiative. Unfortunately, the RIICE technology requires frequent maintenance, upkeep, and data collection to remain relevant, and this is one of the technologies the government has chosen to stop investing in.

Cambodia also lacks weather stations to collect on-the-ground weather and rainfall data. Various sources indicate that the Ministry of Water Resources and Meteorology manages about 20 working automatic weather stations and about 50 rain gauges. In this project's sampling area, there is only one working automatic weather station, and it is managed by CE SAIN at their ATP.

3) **Lack of Farmer Demand:** A common challenge discussed throughout KSIs was the lack of farmer demand for index insurance. As highlighted in the FGD results, a large reason for this

is that farmers have never been exposed to the concept, let alone insurance for other hazards (i.e., life insurance, health insurance, etc.). Government investment in index insurance could increase farmers' trust in these products, and in turn, increase demand. One point to make is that most index insurance products offered to farmers have thus far been fully subsidized and free for the farmer. Therefore, understanding farmers' willingness-to-pay for these products may reveal that farmer demand actually decreases as the premium increases. Lay et al., 2023, have started exploring this issue.

4) **Lack of multi-stakeholder convening and cross-collaboration:** A final challenge reiterated by several local stakeholders is the lack of information sharing and cross-collaboration in the index insurance space in Cambodia. Several actors we spoke with were unaware of other initiatives that were taking place or did not have information or results from previously completed pilots.

6.2.9 Lessons Learned: Opportunities

1) **Increasing Government Investment:** Generally, across all identified challenges, the top solution is to increase government involvement and investment in data-gathering technologies, weather stations, and product support (subsidies). Not only does their involvement increase farmer trust and demand, but it also ensures a more sustainable future for index insurance. The most prominent way the government could invest in these initiatives is by prioritizing the updating and use of the RIICE technology. This includes hiring and training personnel who are familiar with remote-sensing and modeling products.

2) **Improving Data Availability:** With a new MAFF administration, now is an exciting time to start collecting and maintaining agricultural yield datasets. Through new investments in the country-wide agricultural extension programming, a strong focus should be placed on

utilizing extension agents to collect this data. When it comes to the availability of weather data, CE SAIN has recognized the difficulties posed by a lack of weather stations and has installed five of their own across Phnom Penh, Kampong Cham, Kampong Thom, Siem Reap, and Battambang provinces. Leveraging funding from other development organizations or projects to install even more weather stations is necessary to get the level of weather data needed to develop high-quality index insurance products.

3) **Building Farmer Demand:** If index insurance is going to be scaled in Cambodia, farmer awareness-building needs to happen first. SFSA has committed significant resources towards this through videos, manuals, and farmer education sessions, but more needs to be done. One idea is to leverage the existing cooperative structure present in many rural Cambodian communities to reach farmers more efficiently. Additionally, the agricultural extension network, including CE SAIN, could develop and facilitate training sessions focused on the idea of agricultural index insurance.

4) **Encouraging Multi-Stakeholder Convening and Cross-Collaboration:** Multi-stakeholder sessions where everyone shares their "side of the story" are necessary for moving index insurance initiatives forward in Cambodia. While Forte works with most development groups to pilot these products, the different development groups should convene to understand what has or has not already been done. Additionally, this highlights an opportunity for more scientific research to be done, referenced, and shared at these multi-stakeholder convening. Throughout this study we have learned that Cambodia's agricultural insurance context is much different from surrounding countries, and locally driven research needs to be done to understand the best mechanisms for creating and implementing high-quality products.

7. Conclusion

Rice production in Cambodia, specifically the Battambang province, is an extremely important livelihood activity. Increasing weather risks, most notably high variation in rainfall that results in droughts and flooding, impact rice yield and in turn, the welfare of rice producers. This thesis explored agricultural index insurance as a potential risk management tool for rice producers who are exposed to these climatic risks. While index insurance is a promising risk management tool globally, we find that there are several constraints facing the development of a high-quality, rainfall-based index insurance product for rice in Cambodia.

While there is high yield variation in Battambang province, a large part of that variation is due to idiosyncratic risk. Since, at best, index insurance can insure only against covariate risk, this leaves much risk in the system unaccounted for. With this in mind, we conducted an ex-ante quality analysis of two rainfall-based index insurance contracts, with three sub-contracts each, to determine their impact on farmer welfare relative to a hypothetical contract that perfectly measures losses. The resulting low, and sometimes negative RIB measures indicate that farmers are generally not better off with these contracts than having no insurance at all, and sometimes worse off. These low RIB measures are further explained by 1) large differences in self-reported versus index insurance-detected drought and flooding experiences; 2) index insurance rainfall indices that do not properly predict impact on rice yield; and 3) high basis risk in the index insurance contracts that results in severe false positives and false negatives. As a result, we believe the index insurance contracts analyzed here should not be offered to rice producers until the indices are better aligned with their realistic drought and flooding experiences.

Through this study, we identified additional feasibility considerations to be made when designing an index insurance product. In Cambodia specifically, improving access to information for farmers and enhancing trust amongst insurance-sector stakeholders is necessary for any index insurance product to be successful in this space. Moving forward, increased investment by the government would improve both the supply of and demand for high-quality index insurance. Specifically, their investment in data collection tools – weather stations, remote sensing and yield estimation tools, and farmer surveys – would improve insurance providers' access to the weather, yield, and agronomic data necessary to develop higher quality products. Additionally, increased government investment would build farmers' trust in agricultural insurance products, potentially resulting in higher demand.

8. Future Research

As emphasized throughout this thesis, there are several areas where future research could greatly contribute to the development of high-quality index insurance products in Cambodia. Importantly, practical research should be done by gathering local weather and agronomic data to inform realistic rainfall indices that align as closely as possible to the real rainfall experiences of rice producers. This may be challenging with the current lack of available data. Therefore, future research should also turn towards area-yield index insurance as an alternative. Understanding the relative welfare benefits of area-yield index insurance contracts will be important as policymakers and private insurance providers choose which type of product to scale up in Cambodia. On the other hand, research on risk management tools *other than* index insurance should be done to better understand the idiosyncratic risks faced by rice producers and how they can be better managed.

From the demand perspective, much more needs to be understood about what mechanisms are the most successful at improving farmer uptake of index insurance. Once these mechanisms are identified, implementing them will be crucial for the success of any index insurance initiative. It will be important to scientifically document more of the benefits farmers receive from adopting any type of agricultural insurance. While this can be difficult with the lack of index insurance pilots taking place, any new pilot project should be paired with a study that documents direct benefits to farmers. This will produce vital, currently missing information that the government needs in order to invest more in these products.

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Thesis Appendices – Katheryn Gregerson
Feasibility Study on Agricultural Index Insurance for Rice Producers in Battambang, Cambodia

1.1 Appendix A: Yield Recall Survey Questionnaire

Yield Recall Survey

UC Davis and UC Davis Health
Consent to Participate in Research

Title of study: Feasibility Study on Agricultural Index Insurance for Rice Producers in Battambang, Cambodia
Investigator: Katheryn Gregerson

Introduction and Purpose
You are being invited to join a research study.
The purpose of this study is to determine if the risks facing rice production in the Battambang province are insurable through an area-yield index insurance contract.

If you agree to be in this research, you will be asked to complete a survey. You will be asked questions about your historical rice yield data from 2018-2022. Additional questions are asked to better understand the types and levels of risk facing rice production. It will take about 35 minutes to complete the survey.

There is no direct benefit to you from taking part in this study. We hope that the research will further our understanding of the insurability of risks facing rice yield in the Battambang province. If feasible, index insurance has the potential to promote resilience and improve your livelihood as a rice producer.

The risks of this research are minimal. Some of the questions might make you feel uncomfortable or upset. You do not have to answer any of the questions you do not want to answer.

Confidentiality

As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk. Your responses to the survey questions will include information that identifies you. This identifiable information will be handled as confidentially as possible. However, individuals from UC Davis who oversee research may access your data during audits or other monitoring activities.

To minimize the risks of breach of confidentiality, we will link your survey responses to an ID code once all surveys have been completed. When linked to an ID code, your survey will be stripped of identifying information (i.e., respondent's name, cell phone number). All data will be stored on a password protected, secured cloud service appropriate for the sensitivity of data collected. For data that is coded with the linking key, the linking key will be destroyed after 90 days.

We will use your information to conduct this study. Leftover data collected for this research may also be used for future research studies. We will not share any personally identifiable information. Our goal is to make more research possible. These studies may be done by researchers at this institution or other institutions, including commercial entities. Data may be placed in one or more external scientific databases for access and use. We will not ask you for additional permission to share de-identified information.

Compensation
You will not be paid for taking part in this study.

Rights
Taking part in research is completely voluntary. You are free to decline to take part in the project. You can decline to answer any questions and you can stop taking part in the project at any time. Whether or not you choose to take part, or answer any question, or stop taking part in the project, there will be no penalty to you or loss of benefits to which you are otherwise entitled.

Questions
If you have any questions about this research, please feel free to contact the investigator at +1402-871-1983 or kgregerson@ucdavis.edu.

If you have any questions about your rights or treatment as a research participant in this study, please contact the UC Davis, Institutional Review Board by phone: 916 703 9158 or by email: HS-IRBEducation@ucdavis.edu.

If you agree to take part in the research, please give verbal consent.

Enumerator, please indicate if respondent gave verbal consent: Yes (1) No (2)

No.	Enumerator, please fill in section A in advance:		
A1	Enumerator Code		
A2	Date of Interview (DD/MM/YYYY)		
A3	Province	Battambang	
A4	District	Moung Ruessei	Sangkae
A5	Commune (write name + code)		
A6	Village (write name + code)		
A7	GPS Coordinates	Longitude:	Latitude:

No.	**Enumerator, please read:** *Thank you for your time and for sharing your experience.*	
B1	Respondent Code	
B2	SURNAME of respondent	
B3	Given (First) Name of respondent	

B4	Age of respondent		
B5	Gender of respondent	**Male (0); Female (1); Other (2); Prefer not to say (3)**	
B6	Do you have a cell phone?	**No (0) Yes (1)**	
B7	What is the best number to contact you at if we have follow up questions?	**+855**	
B8	For how many years have you been growing rice? *(if < 5 years, do not proceed with survey)*		
B9	What is the total land size of your farm?	**Area (#):**	**Unit: ha (1); m2 (2); Other (specify):**

No.	**Enumerator, please read:** *Now I will ask some questions about your rice production.* If the farmer does not plant rice in that season, put **code (0)** for the entire season column.									
		Early Wet Season **Month/ Week**		Late Wet Season **Month/ Week**		Dry Season **Month/ Week**		**Month Codes**		**Week Codes** (you may select more than one)
C1	In what month and week do you normally plant rice?							**January (1) February (2) March (3) April (4) May (5) June (6)**	**July (7) August (8) September (9) October (10) November (11) December (12)**	**1st week of the month (1) 2nd week of the month (2) 3rd week of the month (3) 4th week of the month (4)**
C2	In what month and week do you normally transplant rice? (if N/A, put N/A)									
C3	In what month and week do you normally harvest rice?									

Enumerator: Begin with 2022. If they cannot remember a specific detail: **code (-9).** If they did not plant in a certain season, you may leave that row blank.

		D1a	D1b	D1c	D2a	D2b	D3a	D3b	D4a	D4b	D5
YEAR & SEASON Early wet se s n 1 Late wet se s n 2 Dry season 3		In YEAR & SEASON did you plant rice on your best plot? **Circle:** Yes (Y) No (N)	Which type did you plant on your best plot? Short-term (<115 days) (1) Medium-term (116-135 days) (2) Long-term (>136 days) (3)	What variety did you plant on your best plot? Sro Nge Sral (1) Sro Nge Tngorn (2) Kun Chin (3) Sen Kro Oub (4) Other (5) (specify)	**Area** planted in rice on your best plot **Area (#)**	**Unit** Ha (1) m2 (2) Kong (3) Other (4) (specify)	**On this plot and during this season:** Was there drought? Yes (1) No (2)	Was there flooding? Yes (1) No (2)	**Rice Production** **Amount (#)**	**Unit** # of bags (1) (check size) # of kilos (2) # of baskets (3) 1 basket = 12 kg Other (4) (specify)	Compared to normal yield on this plot, this year's and season's yield was… Normal (1) Better (2) Worse (3)
2022	1	Y N									
	2	Y N									
	3	Y N									
2021	1	Y N									
	2	Y N									
	3	Y N									

Enumerator: Begin with 2022. If they cannot remember a specific detail: **code (-9).** If they did not plant in a certain season, you may leave that row blank.

		D1a	D1b	D1c	D2a	D2b	D3a	D3b	D4a	D4b	D5
YEAR & SEASON Early wet se s n 1 Late wet se s n 2 Dry season 3		In YEAR & SEASON did you plant rice on your best plot? **Circle:** Yes (Y) No (N)	Which type did you plant on your best plot? Short-term (<115 days) (1) Medium-term (116-135 days) (2) Long-term (>136 days) (3)	What variety did you plant on your best plot? Sro Nge Sral (1) Sro Nge Tngorn (2) Kun Chin (3) Sen Kro Oub (4) Other (specify)	**Area** planted in rice on your best plot		**On this plot and during this season:**		**Rice Production**		Compared to normal yield on this plot, this year's and season's yield was… Normal (1) Better (2) Worse (3)
					Area (#)	**Unit** Ha (1) m2 (2) Kong (3) Other (specify)	Was there drought? Yes (1) No (2)	Was there flooding? Yes (1) No (2)	**Amount (#)**	**Unit** # of bags (1) # of kilos (2) # of baskets (3) Other (specify)	
2020	1	Y N									
	2	Y N									
	3	Y N									
2019	1	Y N									
	2	Y N									
	3	Y N									

Enumerator: Begin with 2022. If they cannot remember a specific detail: **code (-9).** If they did not plant in a certain season, you may leave that row blank.											
		D1a	D1b	D1c	D2a	D2b	D3a	D3b	D4a	D4b	D5
YEAR & SEASON Early wet se s n 1 Late wet se s n 2 Dry season 3		In YEAR & SEASON did you plant rice on your best plot? **Circle:** Yes (Y) No (N)	Which type did you plant on your best plot? Short-term (<115 days) (1) Medium-term (116-135 days) (2) Long-term (>136 days) (3)	What variety did you plant on your best plot? Sro Nge Sral (1) Sro Nge Tngorn (2) Kun Chin (3) Sen Kro Oub (4) Other (specify)	**Area** planted in rice on your best plot **Area (#)**	**Unit** Ha (1) m2 (2) Kong (3) Other (specify)	**On this plot and during this season:** Was there drought? Yes (1) No (2)	Was there flooding? Yes (1) No (2)	**Rice Production** **Amount (#)**	**Unit** # of bags (1) # of kilos (2) # of baskets (3) Other (specify)	Compared to normal yield on this plot, this year's and season's yield was… Normal (1) Better (2) Worse (3)
2018	1	Y N									
	2	Y N									
	3	Y N									

No.	**Enumerator, please read:** *Lastly, we would like to ask a few questions about your familiarity with index insurance.*	
E1	Have you heard of: Weather-Indexed Crop Insurance (WICI) from Forte Insurance **(1)** Area Yield Index Insurance (AYII) from Forte Insurance **(2)** Or any other type of crop insurance **(3)**, please specify: ________________________________ I have not heard of crop insurance. **(4)**	
E2	Have you ever bought a crop insurance contract for your rice? Yes, I currently have a crop insurance contract for my rice. **(1)** Yes, I used to have a crop insurance contract for my rice, but not anymore. **(2)** No **(3)**	

Notes:
**Enumerator, please note additional comments here (why did they not plant in a given year?, could they not come up with an answer to any of the questions?, did they seem to like the idea of insurance?, etc.).*

Enumerator: The survey is now complete. Thank you for your time. We will connect with you via cell phone if we have any follow up questions.

2.1 Appendix B: Village Chief Interview Questionnaire

Key Informant Interviews with Village Chiefs
List of Interview Questions

To be asked in a Key Informant Interview at the beginning of each Yield Recall Survey data collection time in each village (8:30-9:00 AM and 12:30-1:00 PM).
Interview should last no longer than 30 minutes.

Purpose *(students, please share this with the Chief)*

The purpose of this study is to determine if the risks facing rice production in the Battambang province are insurable through an index insurance contract. Index insurance is a type of crop insurance that provides payouts to farmers when they face yield losses due to extreme weather events such as drought or flooding.

Students, please explain the concept of index insurance, in the same way you explain it to farmers during the surveys.

The research study is being conducted by Katheryn Gregerson for her master's degree from the University of California, Davis, in the United States.

We would like to interview you to gain a better understanding of:

1) The setup/mapping of your village for sampling purposes
2) Characteristics of rice producers in your village
3) Common practices of rice producers in your village and how these have changed over time
4) Extreme weather/climate change events that have impacted your village in the past 5 years

Record GPS Coordinates here:	
Latitude:	Longitude:

Village Name:	
Village Chief First & Last Name:	
Village Chief Contact Phone Number:	

Interview Questions *(Students, please take notes throughout the interview under each question. You will upload these notes to KoboToolBox at the end of the day.)*

	May we please see a map of your village? This will assist us in locating farmers to survey.
	Please take a picture of the village map or draw one on your own. Check this box if a picture of the map was taken.

	How many total households are there in your village?

	What is the average land size for farms in your village? *(ha, m2, kong, or other)*

	Can you give us an estimate of the number of ***rice producers*** in your village? *(this should include any farmer who produces rice, even if they grow other crops in addition to rice)*

	Can you point out one or two areas on your village map where there are many rice producers located close together?

	(this is likely where we will conduct our surveys)
	Either take a picture of this area of the map and/or write down the name of the road or other identifiers. We need to be able to navigate to this location once the interview with the Village Chief is complete.

	One more question about the map. Can you point out where some of the higher yielding rice farms are located and where some of the lower yielding rice farms are located? *(We would like to survey both types of farmers.)*

	Do rice producers in your village typically plant rice in the:
	Early wet season Late wet season Dry season Additional notes:

	Do most rice producers in your village:
	Hand sow their rice seeds directly into their plot Grow rice seedlings first, then transplant them into their plot Additional notes:

	Follow-up to question 8: Has this planting method changed in recent years? *(If they indicate farmers transitioned from transplanting to direct hand sowing, ask in what year and why?)*

Improving Yield Recall Over the Past 5 Years Our research focuses a lot on climate change and severe weather events. We will be asking rice farmers in your village whether flooding, drought, or other weather events have occurred on their farms over the past 5 years. To get a better understanding of this before we talk to farmers, we would like to walk through the past 5 years with you and try to recall what weather events occurred in your village each year.					
10.	**2022**	**2021**	**2020**	**2019**	**2018**
	Flooding Drought Other, please specify:	Flooding Drought Other, please specify:	Flooding Drought Other, please specify:	Flooding Drought Other, please specify:	Flooding Drought Other, please specify:

11.	As you can see, it can be difficult to remember these events from many years ago. We would like to help farmers remember what happened in each year better. To do this, we would like to brainstorm with you about major (non-weather-related) events that happened in your village, province, or country for each year. *(examples: elections, new construction, festivals or celebrations, sporting events, etc.)*	
	2022	
	2021	
	2020	
	2019	
	2018	

Conclusion
Thank you. Do you have any questions about index insurance or the purpose of our study?

3.1 Appendix C: Spatial Random Sampling Design

Enumerator Instructions and Random Sampling Plan

This document is meant to help student enumerators understand how we will select farmers for surveying each day. We will follow this plan for each of the 8 villages, and we will complete data collection from 2 villages per day.

When we arrive in each village, we will request a map from each Village Chief (or draw one). We will also ask them to identify a "target area" where many rice producing households are located. Additionally, they will advise on where we can find farmers' households with both high productivity and low productivity (yields). After we have finished our Key Informant Interview with the Village Chief, we will ride all together in the van to this target area(s).

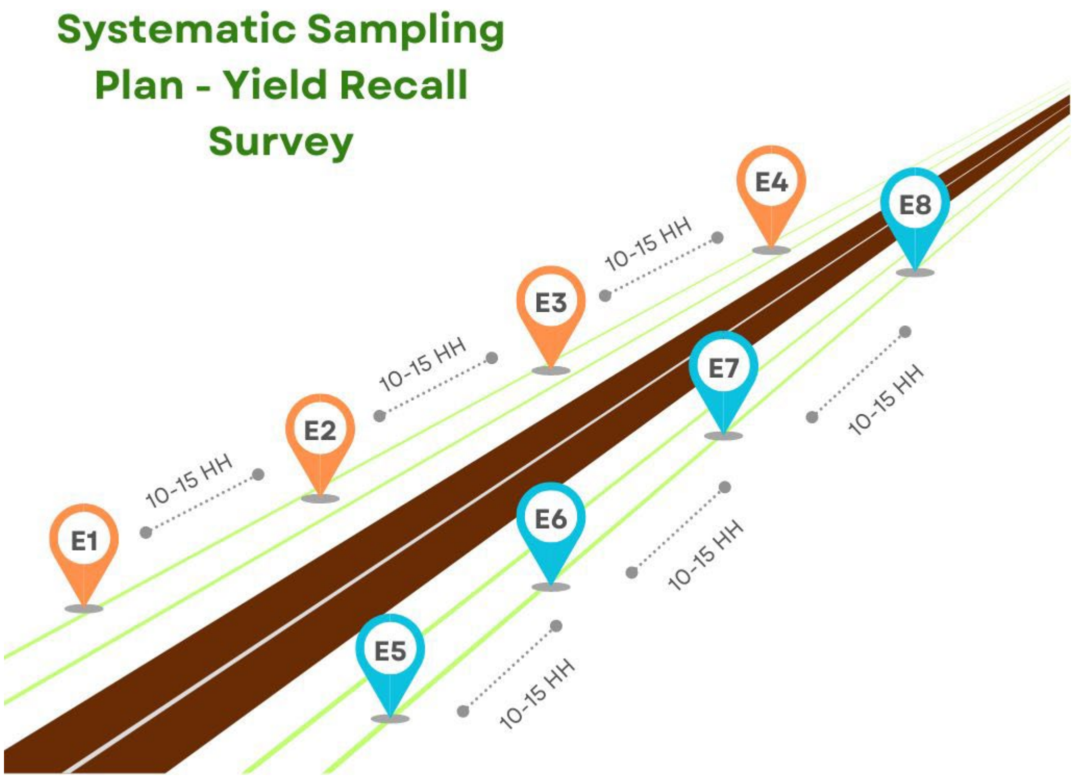
In the picture below, you will see that E1, E2, E3, and E4 will survey farmers on the left side of the road. E5, E6, E7, and E8 will survey farmers on the right side of the road. Depending on the set up of the village, enumerators will start their surveys about 10-15 households apart.

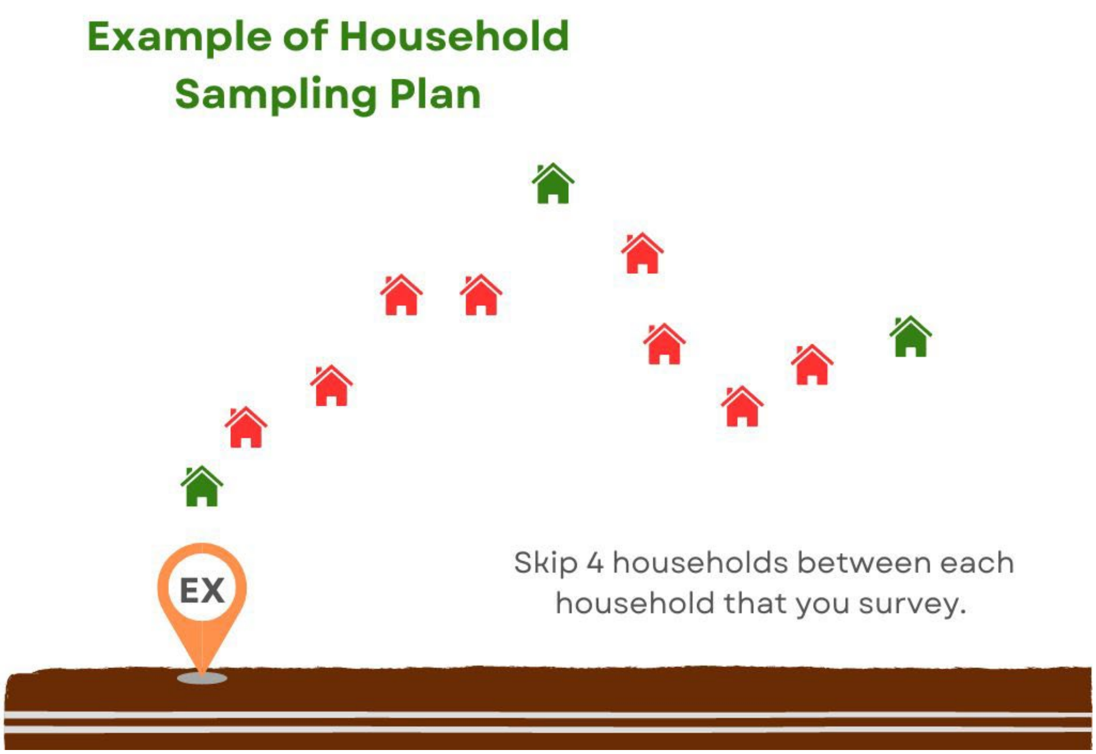
At this location, each enumerator will be expected to survey at least 3 farmers. If you have remaining time, you can survey 4 farmers total. We will use systematic sampling to do this. It is important that in between each household, you skip 4 households, and then survey the next one you come across. Please see the diagram below. You do not have to follow the road we drop you off on, maybe you will go deeper into the village, away from the road. We want the households to be as "different" as possible.

Each survey is estimated to take ~35 minutes. You will have plenty of time to conduct the surveys in each village, so please take your time while also respecting time constraints of the farmers.

After each survey has concluded, please take 5-10 minutes to check the responses you recorded on your paper. If you are missing anything, please follow up on that question with the farmer. If you have any questions, please contact Kat through Telegram.

Once you have completed 3 surveys, please text an update to the Telegram group. We will either come pick you up in the van or let you know that you have time for 1 more survey. Once all enumerators are finished with their surveys, we will depart in the van.


Systematic Sampling Plan - Yield Recall Survey
E1
E2
E3
E4
E5
E6
E7
E8
10-15 HH


Example of Household Sampling Plan
EX
Skip 4 households between each household that you survey.

4.1 Appendix D: Focus Group Discussion Outline

Focus Group Discussions - Logistics and Questions

Sample Size	4 total focus group sessions (n=20) **FGD 1:** 5 women from Sangkae **FGD 2:** 5 men from Sangkae **FGD 3:** 5 women from Moung Ruessei - Kakaoh Commune **FGD 4:** 5 men from Moung Ruessei - Kakoah Commune
Sampling Plan	**Reasoning:** Separating women and men: We want the participants to feel comfortable sharing their true opinions with each other. We also ask specific questions about risk aversion, insurance demand and adoption, and financial decision-making that likely differ by gender. We will compare the differences between the FGDs. Why different FGDs in Moung Ruessei vs. Sangkae?: The Cambodia Rice SDP (led by ADB and Forte) is currently piloting index insurance in the Kakaoh Commune of Moung Ruessei. We would like to understand differences in farmers' exposure, knowledge, and perceptions of index insurance. Therefore, we will compare responses from these farmers with responses from farmers in the Sangkae District, who have likely not been exposed to index insurance. **Invitation Method:** Once surveys are completed in Sangake District, Kat will select 5 women and 5 men to participate in FGDs. She will contact them by cell phone on Friday, July 28th to invite them to their FGDs that will take place on Sunday, July 30th. Participants may be selected from either commune and should be as diverse as possible. Once surveys are completed in the Kakaoh Commune of Moung Ruessei District, Kat will select 5 women and 5 men to participate in FGDs. She will contact them by cell phone on Saturday, July 29th to invite them to their FGDs that will take place on Monday, July 31st. Participants will only be selected from the Kakaoh Commune and will be chosen based on their experience/exposure to ADB's index insurance product.

Timing	**Sunday, July 30th:** Women's FGD#1 - Sangkae - ATP - 7:30-9:00 AM Men's FGD#2 - Sangkae - ATP - 10:30 - 12:00 PM Women's FGD #3 - Moung Ruessei - central location - 2:30 - 4:00 PM 1.5 hours long each, with light refreshments provided. **Monday, July 31st:** Men's FGD#4 - Moung Ruessei - central location - 7:30 - 9:00 AM 1.5 hours long, with light refreshments provided.
Location	**Sangkae:** CE SAIN's Agricultural Technology Park (ATP) in Battambang. **Moung Ruessei:** TBD central location in Moung Ruessei District, Kakaoh Commune ***(perhaps where we met the Village Chief?).***
Supplies Needed	Recorder Consent forms for all participants Tablets for 2 enumerators to take notes on Large tear sheets of paper Markers Pens Notepads for participants to take notes on Clipboards (re-use ones from student enumerators) Colored index cards for decision-making question Projector capabilities to play CAST informational video → will need to have it downloaded.
Purpose	To better understand: Rice producers' experiences with and perceptions of crop insurance (& how this varies across ADB-exposed communes vs. non-exposed ones). Gendered differences in insurance demand and financial decision-making. Development impacts of index insurance on rice producers (what new investments would farmers make if they were covered by index insurance)?

Focus Group Questions:

Introduction: *(5 min.)*
Facilitator: Share the purpose of the FGDs and the rules we will follow throughout the time. Then, ask each participant to introduce themself.

**Make sure all participants have signed their consent forms. Consent forms will ask each participant to confirm whether or not they are okay with being recorded and having their photo taken.*

- Welcome
- Purpose of the FGDs
    - The purpose of these FGDs is to learn more about your experiences with and perceptions of crop insurance. We are also interested in how the adoption of index insurance might impact you and your farming operation.
    - Katheryn Gregerson is a researcher at the University of California, Davis, and she is conducting this research to fulfill requirements of her master's degree.
- Ground Rules:
    - This should be a participatory, interactive discussion. We are here to learn from you, so we expect to be listening to your thoughts and opinions most of the time, instead of leading the discussion ourselves.
    - Rights:
        - Taking part in research is completely voluntary. You are free to decline to take part in the project or you can stop taking part in the project at any time.
    - Recording and Confidentiality:
        - When you take part in this discussion, you will be audio recorded. The recording will be transcribed, but your name will not be included on the transcription.
        - All data will be stored on a password protected, secured cloud service appropriate for the sensitivity of data collected. We will not share any personally identifiable information.
- Introductions
    - Ask participants to say their name and what village they reside in.
    - *As farmers share their names, the notetaker will write each name down on the tear sheet table (prepared beforehand).*

<u>*Notes - Notetaker, please be sure to note each participants' name and the village they reside in here:*</u>

Section 1: Risk Identification and Impact (15 min.)
Facilitator: Thank you all for participating in our Yield Recall Survey this past week. We appreciate your responses and see this FGD as an opportunity to "dive deeper" or learn more about your individual risks, behaviors, and thoughts concerning agricultural index insurance. Before we talk about those topics, we would like to get a better feel for how weather risks impact your rice farming operation.

Weather Risks and Impacts:

Before we get started, we would like to get a baseline sense of what your average rice yield is on your farm. This will help us all when answering the following questions.

Facilitator: Go around the room and ask each participant to share their average (or normal) rice yield. Notetaker will write their response in the table column next to their name.

Notes (write down everyone's average rice yield here):

From the survey, we learned that drought and flooding are two weather risks that impact your rice yield. Between drought and flooding, which one are you more concerned about?

Facilitator: Go around the room, asking each participant to choose which one they are most concerned about (and why). Notetaker will write their response in the next table column.

Notes (record "drought" or "flood" here for each participant, along with their reasoning why):

Okay, now imagine that a drought or a flood happens on your farm. What happens to your rice yields as a result of this drought/flood?

Facilitator: Let participants think for a few moments, then ask each of them to share a new number for rice yield after a drought/flood occurs (this number will likely be lower than their average yield). Notetaker will write this new yield number in the next table column.

Notes (write down everyone's new rice yield here):

Section 2: Costly Coping Strategies (10 min.)
Facilitator: Now that we have a stronger understanding of how your yields vary due to weather events, we want to know more about what you do as a household or on your farm when your rice yields decrease.

As a family, what do you do in your household or on your farm when your rice yields decrease?

Facilitator: Here is a made-up example from Kat's family farm in the United States that might help get you thinking. Last month, there was a terrible flood that wiped out all of her family's maize crop. Because of the timing in the growing season, they could not replant the maize. They needed to figure out what else they could do instead. For her family, they decided to plant other vegetable crops that had a shorter growing season and could withstand the drought better. Her family also had to sell one of their tractors because of their decrease in profit for the year. Her mom also decided to buy less meat for the family, as they had less money to spend on food.

Facilitator: Ask participants to take a few minutes to think about this. Then, have them each share their responses out loud.

<u>*Notes:*</u>

Section 3: Development Impact of Index Insurance (15 min.)
Facilitator: Now we want to look on the positive side of things and think about the average or "normal" yield we get for our rice each year.

With your average rice yield in mind, what could you do differently on your farm to improve that yield? *(here the facilitator may give an example yield number for a really high yielding field in the area)*

Facilitator: Let participants share their responses as they think of them. This part should induce an interactive discussion. Responses might include: invest in improved seeds, buy more fertilizer, transplant the rice, etc.

Notes:

Why are you currently not doing this?

Facilitator: Responses here might include: lack of money, no access to these inputs, lack of knowledge, etc. Ask participants to explain why they are not allocating their money to this input/tool/resource, why they do not have access to it, why their neighbors have higher yields, etc.

Notes:

Section 4: Familiarity with Agricultural Index Insurance (20 min.)
Facilitator: Thank you for sharing your thoughts about your yields and the risks that you face on your farms. Now, we would like to think more about this idea of crop insurance and how it might help you manage those risks.

Exposure to Index Insurance:

Prior to today, had you heard of weather-indexed crop insurance (WICI) from Forte Insurance, Area Yield Index Insurance (AYII) from Forte Insurance, or any other type of crop insurance?

If yes, when and where did you hear about it?

Notes (record a number of "yes's" and "no's" in regards to hearing about crop insurance):

If anyone has heard of crop insurance, record their name and type of insurance here:

Do you currently have a crop insurance contract for your rice (maybe it is called WICI or AYII)?

What insurance company is your contract with?

Facilitator: For these questions, just ask the group. Likely, few of them will have a contract. If they do, ask them to share details (not just what company they have the contract with, but also if they've received payouts, how much they had to pay for the insurance, etc.). Don't take too much time on this, but it is good to get an understanding of this basic information.

Notes (record a number of "yes's" and "no's" in regards to having a crop insurance contract):

Please list any insurance companies named here:

If you do not have crop insurance, why not?

Notes (record responses here):

Educational Video:

Before moving on, we would like to get on the same page about crop insurance. We have talked about many terms and want to make sure we understand their different definitions. This is a video that shares more about crop insurance and why it might be important to you:

Play video: https://www.youtube.com/watch?v=drXbsleAPZc

Discuss video:

What questions do you have after watching the video?

Notes (list out any questions asked here):

Section 5: Perceptions of Index Insurance (10 min.)
Facilitator: Now that we have a better understanding of what index insurance is, we would like to hear your thoughts on it. To do so, we can list out some pros and cons on these tear sheets. (have one tear sheet for pros, one for cons)

From what you currently know:

What do you see as a positive or "a pro" with this type of insurance?

What do you see as a negative or "a con" with this type of insurance?

Facilitator: Let each participant brainstorm for 2 minutes, share with another person in the room for 2 minutes, and then share with the bigger group for 6 minutes. Through this format, hopefully anyone who has not spoken up yet will share their thoughts.

A notetaker will have one tear sheet for "pros" and one for "cons". They will write the participants' responses on the applicable sheet as they share with the group.

Pros:

Cons:

Section 6: Gendered Differences in Financial Decision-Making (10 min.)
Facilitator: It is helpful to know your thoughts on index insurance so that future products may suit your needs as best as possible. The whole point of index insurance is to help farmers become more resilient to the shocks they face. Lastly, we want to learn more about how your household makes financial decisions.

Facilitator: Each participant should have 1 pink card (for "me"), 1 yellow card (for "my partner"), and 1 green card (for "joint decision"). For each question, ask the participants to raise the card that aligns with whoever makes that decision in their household. The notetaker will record how many pink, yellow, and green cards get raised for each question.

After this activity for each question, ask participants for their thoughts on the decision-making process and anything they would like to add.

In your household, who would make the decision to hire agricultural labor to help on your farm?

Pink count:
Yellow count:
Green count:
Notes:

In your household, who would make the decision to purchase improved rice seeds?

Pink count:
Yellow count:
Green count:
Notes:

In your household, who deals with “middlemen” or buyers when selling your rice (if you sell your rice)?

Pink count:
Yellow count:
Green count:
<u>Notes:</u>

If your household was offered an index insurance contract, who would make the decision to purchase the insurance?

Pink count:
Yellow count:
Green count:
<u>Notes:</u>

Conclusion: *(5 min.)*
Is there anything else you would like to share about your thoughts on agricultural index insurance? *<u>Notes (record any questions or thoughts shared here):</u>*   *Facilitator:* Thank you so much for your participation in our focus group discussion today. We greatly appreciate and value the thoughts and ideas you shared. We may follow up with you if any additional questions come up. Here is a handout with the contact information for the WICI contract offered by Forte Insurance. Please let us know if you have questions about this. *This will likely only be applicable to farmers in the Moung Ruessei District.* Feel free to stick around, finish the food, and let us know if you have any questions about this process or index insurance in general.

**Example of the table used to guide discussion in the FGDs & for notetaker to take notes on:*

FGD #1 - Women in Sangkae

Respondent Code	Name	Average Rice Yield (in a normal year)	Drought vs. Flooding	Average Rice Yield After a Drought or Flood

5.1 Appendix E: Key Stakeholder Interview Questions

Interview Guide for KSI with [enter stakeholder name] - [enter date]

1. **Connect**
   - Explain our backgrounds and mutual connections
2. **Discuss research project and objectives**
   - Partnership with CE SAIN
   - Focusing on rice in Battambang
   - Methods:
     - Knowledge Transfer Sessions
     - Key Stakeholder Interviews
     - Yield Recall Survey (n=192)
     - Focus Group Discussions (n=22)
3. **Overview of their organization**
4. **Their experience and work in Cambodia**
   - Specific project work
   - Target crop, region, type of insurance contract (AYII, WICI, etc.), premium cost, indemnity cost, farmer outreach, etc.
5. **General Rice System Learnings**
   - See "Question List".
6. **Overall thoughts (benefits and constraints) when promoting index insurance in Cambodia:**
   - **Benefits to ask about:** previous products that have been successful, partnerships with MFIs, etc.
   - **Constraints to ask about:** weather data availability, yield data availability, farmer demand, trust, etc.
   - What else do they have to add?
7. **Partners in Cambodia:**
   - What partners have you worked with in Cambodia on index insurance?
   - Who are the well known groups that work in this space?
   - Who else would you recommend speaking with?
8. **What additional research needs to be done:**
   - Are there additional commodities/value chains that have opportunities for increased production and profitability? If so, which ones?
   - Have you seen that farmers are willing to pay for this product? Do they trust the institutions that are offering it to them?
   - What gaps do you see in current academic and donor-funded research on this topic?
9. **Wrap Up/Next Steps**
   - Is there anything else you would like to share with me today?
   - How would you like to stay connected and updated on research progress?

Question List

This comprehensive list includes questions grouped by topic. Prior to each interview, I identified which topics the stakeholder has expertise in and only asked from those sections.

Rice Value Chain

1. What are the most common varieties of rice planted in Battambang province?
2. Is it common for rice producers in Battambang to plant twice per year, once in the wet season and once in the dry season? Please describe their typical planting schedule.
3. How do rice producers dry their grains? Is this most commonly done on their plots, or do they sell it to someone else for drying?
4. When are the peak times for rice producers in Battambang to sell their harvested rice? Who do they sell it to?
5. Are there active rice cooperatives in Battambang? How common is it for rice producers to be members of cooperatives?
6. What benefits do rice cooperatives offer to producers?
7. Does rice contract farming exist in Battambang province? What companies do rice producers usually contract with?
8. Are there additional commodities/value chains that have opportunities for increased production and profitability? If so, which ones?

Weather Risk for Rice in Battambang

1. What are the most significant weather risks facing rice producers in Battambang province?
2. How often do these weather risks impact rice yield in Battambang (i.e., yearly, every few years, etc.)?
3. How much of the weather risk experienced by rice producers in Battambang is shared (covariate) and how much of it is individual (idiosyncratic)?
4. What is the topography like in Battambang? Do rice producers experience different types of weather patterns across the province?

Current Agricultural Insurance Landscape

1. Have you heard of agricultural index insurance before? If so, please explain your current understanding of it.
2. Do you know of any insurance companies that currently offer agricultural/crop insurance? If so, please name them.
3. Do you think any of these insurers would be interested in the provision of index insurance?

Growth and Investment Opportunities for Rice Producers

1. Are rice producers in Battambang falling short of their potential in terms of productivity and income?
2. Are rice producers in Battambang taking advantage of opportunities to increase investment and income?
3. What existing growth opportunities are rice producers not taking, if any?

4. Are those opportunities physically accessible in Battambang province?
5. Do rice producers have access to finance to help them take advantage of investment opportunities?

Public and Private Sector Interest and Support

1. Is the Royal Government of Cambodia and the Ministry of Economy and Finance (MEF) aware of and/or open to index insurance?
2. Do you know of any public or private sector partners who are established in Battambang province and might be interested in supporting an index insurance product?
3. Are there NGOs already doing financial literacy or other related work in the area?

Innovations in Rice Research (Improved Seeds)

1. Do farmers currently purchase improved seeds, or do they mainly save their own seeds from season to season?
2. How much more expensive are improved rice seeds than conventional rice seeds? Do you think cost is a factor holding rice producers back from investing in these seeds?
3. What risks do these improved seeds protect against (i.e., drought, etc.)?
4. Aside from improved seeds, what are some other innovations in the rice sector that are currently being introduced to or adopted by rice producers?

Previous Pilots Lessons Learned (Specifically Rice SDP)

1. In your pilot, what commodity were you targeting?
2. Which region(s) were you working in, and why did you select those regions?
3. What indices did you select for the pilot product? What process did you go through to determine these would be the highest quality indicators of crop loss?
4. How did your pilot product work? Was the insurance linked to production costs, input costs, in-kind inputs, loans, etc?
5. Who did you partner with to develop and deliver your index insurance product?
6. Were farmers interested in the pilot product? What information did you gather on their interest, demand, and perceptions of index insurance?
7. Were there any payouts to farmers in your pilot?
8. What were the main lessons learned from your pilot? Why did you not move forward with introducing a product after concluding the pilot project?