Piloting a Weather-Index-Based Crop Insurance System in Bangladesh: Understanding the Challenges of Financial Instruments for Tackling Climate Risks

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Abstract: Bangladesh is one of the most vulnerable countries in the world to extreme climate events. With over 60% of its population living in rural areas, over a third of which lives under the poverty line and depends on agriculture, these climate stresses constitute a major challenge. The traditional financial instruments, e.g., microcredit and relief programs, continue today. However, how climate risk can be tackled through innovative financial instruments focusing on agriculture farms and farmers is crucial. Considering this issue, the Sadharan Bima Corporation and the Bangladesh Meteorological Department joined forces in 2014 to launch a $2.5 million three-year pilot project on weather-index-based crop insurance (WIBCI) executed by the Financial Institutions Division of the Bangladesh government’s Ministry of Finance. This study examined the basic strategy of this pilot project, the major challenges confronted, and possible solutions for creating a successful weather-index-based crop insurance scheme in Bangladesh. We relied on key informant interviews, informal discussions, focus group discussions, and in-depth interviews with the major stakeholders of the WIBCI pilot. These showed the WIBCI pilot to be a promising initiative that still faces problems from limited weather data, a costly business operations system, farmer insurance illiteracy, and fatalism, as well as problems with designing insurance products and recruiting qualified personnel. We compared this WIBCI pilot against the challenges of other projects, recommending best practices for a viable weather-index-based crop insurance system. The insurance mechanism of this study may apply to other vegetation sectors of Bangladesh, e.g., forest plantation or agroforestry for protecting natural resources from natural disasters.

Keywords: climate-induced disaster; weather-index-based crop insurance; agricultural insurance; Bangladesh meteorological department; Sadharan Bima corporation; insurance literacy

1. Introduction

According to the Third Assessment Report of Intergovernmental Panel on Climate Change (IPCC) (2001), Bangladesh is one of the most climate-vulnerable countries in the world [1], facing storm surges, monsoonal flooding, and droughts [2,3], all of which pose major challenges for agriculture [4]. Currently, around 62% of the country’s population resides in rural areas, most of whom are smallholders and over a third of whom live below the poverty line [5]. Smallholder farmers tend to underinvest in new high-yield crops and farm technology [6], withholding money to self-insure against weather and crop
risk by using old seeds and not investing in machinery and the like. Traditional financial risk-reduction strategies, such as borrowing from family, selling land, using microcredit, and saving, are often insufficient to tackle climate-induced risk in Bangladesh. Moreover, structural measures are not always successful for Bangladesh and other countries with extensive exposure to disasters. Financial risk management measures, like microinsurance, including crop insurance microinsurance, customized to the specific needs of the poor, are an effective instrument to address risk [7]. Since 1970–2020, the country has experienced multiple microinsurance initiatives focused on health and agriculture with a diverse range of successes and failures (Figure 1).

![Figure 1. Chronological development of micro-insurance programs in Bangladesh. Source: LightCastle Partners [7].](image)

To improve adaptive capacity with respect to climate extremes and encourage better agricultural investment, both of which will contribute to poverty reduction and enhance human security, the Sadharan Bima Corporation (SBC), the state-owned insurance firm that is responsible for reinsurance in Bangladesh, first introduced a traditional multi-peril crop insurance as a pilot project in 1977. This program failed to develop a sustainable business model because of adverse selection (i.e., recruitment of farmers exposed to greater risks), a poorly administered claims system, poor product design, lack of expertise, and lack of strong policy support from the government and other sectors of the insurance and finance industry [6,7].

The most significant product problem was the use of a single premium regardless of land specifics. In addition, lacking detailed topographical information and weather data, this traditional crop insurance scheme did not tailor contracts to risk or independently check field adjusters, encouraging irregularities, potential corruption, and moral hazards associated with weak details about claims. After 19 years of operation, the program was closed after reaching just slightly over 15,000 farmers and accumulating 500% in financial losses [7,8].

In the decades after this failure, a new strategy for crop insurance has been developed: weather-index-based crop insurance (WIBCI). Instead of compensating farmers for documented peril-specific damages to insured crops, WIBCI makes automatic payments based on weather-triggered data about rainfall, flooding, vegetative indices, etc. along with topographical mapping that identifies the weather risks of crop loss. WIBCI is not without problems, but studies have shown that it has a greater probability of lowering business costs, eliminating moral hazard by replacing traditional claims processes with an impartial weather index payment system, and creating incentives for small farmer investment [9–12]. In 2014, in association with the Bangladesh Meteorological Department (BMD), the SBC
launched a three-year pilot project based on WIBCI, which was funded with USD 2 million from the Asian Development Bank’s Japan Fund for Poverty Reduction, USD 420,000 from the GOB, and USD 60,000 from the Japan Aerospace Exploration Agency [13].

There has been an indisputable increased focus on climate finance in recent years. The global community has agreed that it will be significantly necessary to channel funds to developing countries to help them mitigate and adapt to climate change [14,15]. There are several financial instruments and mechanisms, for example, traditional loans, grants, debt swaps, national climate funds, carbon markets, and insurance instruments. In addition, ministries of Finance can kickstart their national climate change programs and begin to centralize and mainstream the country’s climate financing related to mitigation and adaptation. Therefore, mitigating climate-induced risk requires the architects of WIBCI initiatives to recognize a social if not a moral responsibility beyond standard insurance practices to acknowledge the vulnerable communities and to actively consider the realities of the targeted beneficiaries through a deeper understanding of their socio-economic and geographical contexts and preferences [16].

Connecting remote and diverse communities with technically complex index insurance products is a significant challenge [17]. Both multiperil and weather-index-based crop insurance initiatives have failed to address smallholder poverty because of bias towards larger farmers [18]. With some exceptions, such technocratic initiatives have neglected the most vulnerable, particularly marginalized female farmers [18,19]. It is crucial to explore the challenges facing various stakeholders, such as donor agencies, executing and implementing organizations and partners, and different types of insurance recipients, especially the smallholder farmers. Several studies [20,21] have explored the socio-economic and structural barriers to accessing WIBCI through comparative studies in different countries. However, understanding the challenges of WIBCI within different geographical, environmental, and socio-economic contexts is complex because of the multiplicity of potentially confounding factors. In the ideal world, we would have detailed quantitative measures of WIBCI performance in these contexts and be able to disentangle the insurance strategies that are the most effective in specific contexts. Unfortunately, such comparable information is lacking, in part because of the proprietary nature of many WIBCI projects. Even public agencies are resistant to releasing detailed proprietary data on premiums collected, payments, and detailed business tactics and strategies to protect their business advantage. As a result, we chose to focus on a case study of the insurance strategy of the WIBCI project in Bangladesh to provide a baseline for future comparison. In our analysis, we present what limited information is available on WIBCI programs in Bangladesh. Since there are no published studies to date on any of these WIBCI pilot projects, this should provide a baseline for future investigations.

The aim of this study was to investigate the organization and experience of this WIBCI pilot project, to identify the challenges it confronted in trying to create a sustainable model for crop insurance, and to make recommendations for improvements. In particular, we assessed the interests and challenges faced by different stakeholders relative to the WIBCI, drawing on primary interview data and a desk review of WIBCI summary reports. In addition to identifying challenges to WIBCI, we provide recommendations for how a future weather-index-based crop insurance system in Bangladesh might be organized. In an important sense, this is a study of the creation of an agricultural insurance market where farmers’ are largely ignorant of the concept. With around 12 million smallholders, the 30,000 or so smallholders who have been exposed to information about WIBCI constitutes about 0.0003 percent of all smallholders.

2. Key Concepts
2.1. Crop Insurance

The major aim of crop insurance is to protect farmers against unexpected losses due to natural disasters, such as hail, drought, freezes, and floods. By protecting farmers against extreme weather, crop insurance can encourage farmers to invest in higher-yielding but
more risky crops, farm machinery, and other technology and to protect against losses that contribute to poverty and malnutrition. With respect to weather disasters, crop insurance can also be a critical tool for economic recovery. With increasing weather extremes associated with climate change, crop insurance is also an invaluable climate adaptation option [22,23]. In many circumstances, crop insurance is an essential agricultural risk management strategy that can be combined with institutional credit to reduce the risk of loan defaults, promote economic growth, and improve human welfare [23].

2.2. Transformation of Risk and Increasing Demand for Index-Based Crop Insurance

As discussed earlier, WIBCI has significant advantages over traditional indemnity-based crop insurance. In most of the developed world, such as Canada, the U.S., Australia, Japan, and Western Europe, crop insurance has been based on claims for documented damages caused by weather events, such as hail, flooding, drought, etc. [24]. This requires an expensive adjustment process by which field agents assess farmers’ claims. There may also be significant time lag between damages and payment. This type of system has worked best with larger commercial farmers and has typically required significant governmental subsidies that range from 60–80% of total costs. WIBCI entails a quite different payment system, relying on an objective weather index to trigger payments, which are independent of the losses of specific farmers. This reduces business costs associated with claims, eliminates the moral hazard of incentivizing farmers to plant risky crops and lands, reduces adverse selection by potentially broadening the pool of subscribers, and makes it possible to reduce business costs associated with dealing with widely dispersed small farmers [11,25]. Figure 2 provides an outline of how WIBCI works.

![Figure 2](image-url)

**Figure 2.** The basic mechanism of WIBCI; own design. Adapted from Greatrex et al., 2015 [26].

The most critical issue with WIBCI is establishing the weather index, especially the formal threshold at which payments are triggered. Some systems use automated weather-stations (AWS) to measure rainfall, flooding, drought, and temperature. Others use supplementary rainfall measures, including soil moisture, in situ flood gauges, etc. Still others use vegetative measures, such as vegetative indices and water coverage (i.e., flood) estimates constructed from satellite images. The best systems integrate geographically fine-grained measures from all of the above and include detailed topographical data about locality-specific exposure to flood risk and other kinds of risk. In the Bangladesh context, being inside or outside of polder walls is a critical issue. Small elevation differences also matter, especially for standing water and flood damage [26]. A key question is how well these measures are grounded in accurate geographically fine-grained data with 30 or more years of weather index measures and correlated crop yield data that can be used to reduce basis risk, i.e., “a weak correlation between a selected insurance index and individual loss outcomes” [12]. One of the major problems that WIBCI faces in
gaining greater farmer acceptance and subscribers is such basis risk. Studies have found that small farmers often favor traditional claims systems, partially because of a lack of understanding of an index system and partially because of worries about experiencing a crop loss along with no payment [12,25]. Farmer perceptions are also colored by lack of insurance literacy, fatalistic attitudes, and climate change skepticism [23,27]. An issue to which we return below is how to improve the quality and the geographic fine-grained quality of weather/topographic data and associated crop yield data, which are critical to the viability of WIBCI. Finally, it is also critical to provide clear, concise communications on the weather-index and coverage to make certain that farmers understand what is being offered.

Table 1 provides a summary of recent WIBCI programs operating in developing countries throughout the world. These programs are focused primarily on grain farmers and livestock herders, who are sometimes concentrated in specific subregions and rely on different weather indices. Currently, there are over 50 WIBCI pilot projects or operating programs worldwide with the largest concentrations of subscribers in India (30+ million), East Africa (200,000), Mexico (250,000), and significant numbers in Ethiopia, Senegal, Malawi, and Zambia [28–30].

| Country       | Risk Event                                      | Index Insurance                      | Year Initiated |
|---------------|-------------------------------------------------|--------------------------------------|----------------|
| China         | Weather-related variables                       | Different weather variables          | 2012           |
| Ethiopia      | Drought                                         | Rainfall                             | 2006           |
| Honduras      | Drought                                         | Rainfall                             | 2003           |
| India         | Flood, rainfall, and drought                    | Rainfall                             | 2007           |
| Kazakhstan    | Drought                                         | Rainfall                             | In development |
| Malawi        | Drought                                         | Rainfall                             | 2005           |
| Mexico        | Drought, natural disaster for small farmers     | Rainfall, wind speed & temperature   | 2001           |
| Morocco       | Drought                                         | Rainfall                             | 2018           |
| Nicaragua     | Drought and excessive rain in production season | Rainfall                             | 2006           |
| Peru          | Flood, torrential rainfall from El-Nino         | Rainfall                             | Proposed       |
| Senegal       | Drought                                         | Rainfall & crop yield                | 2012           |
| Sri Lanka     | Torrential rainfall, flood                     | Rainfall                             | 2011–2012      |
| Tanzania      | Drought                                         | Rainfall                             | 2007           |
| Thailand      | Flood                                           | Rainfall                             | 2007           |
| Ukraine       | Drought                                         | Rainfall                             | 2005           |
| Vietnam       | Flood during rice harvest                       | River level                          | In development |
| Bangladesh    | Flood, rainfall, and drought                    | Rainfall & wind flow                 | 2014           |

Sources: Adapted from Skees, 2008 [31], Kawa and Kaitri, 2018 [32], Clarke et al., 2012 [33].

Despite these significant numbers, the literature is filled with concerns about the low uptake among small farmers and debates about the need for and the level of subsidies required to develop farmer trust and acceptance [11,25,34]. In addition to the aforementioned problems of basis risk, lack of financial and insurance literacy, fatalism, etc., many of these pilot projects have been limited by insufficient upscaling (which makes adverse selection more likely), inflexible pricing schemes and coverage, lack of high-quality weather and crop yield data, and a failure to tap the best processes for business operations (especially digital platforms and payment systems). Carter et al. (2017) estimate that the typical WIBCI program involves a 50–70% public subsidy on premiums [11]. Studies have found that small farmer demand for crop insurance is highly price elastic, and upscaling often collapses before reaching a reasonable actuarially based price [35]. In other words, rapid upscaling, which improves the risk pool from the viewpoint of insurance program viability, is imperative, and at least initial subsidies may be required. However, few pilots have significant scale, and they are often designed to focus on high-risk farmers with the investments needed for rapid upscaling are often not made. Small farmers often naively assume that they will get premiums back at the end of the season if there is no adverse event, so there is a major educational task to creating an insurance market. In part, this underscores the problem of insurance literacy, but it also speaks to the risk-adverse culture of small farmers.
Elabed et al. (2013) found that the reservation price for moderately risk-averse small farmers was roughly 50% of an actuarially fair price [36], which means that such farmers will have to be subsidized to subscribe. Compound this with the tendency of private insurance companies to frontload estimated costs by 50% or more into their initial offering premiums to deal with uncertainty [10], and one can see some of the financing obstacles that WIBCI or any type of crop insurance faces. Unfortunately, the detailed comparative information on WIBCI projects and physical/socioeconomic contexts is unavailable, recommending our strategy of providing a detailed case study. We return to these and related issues below.

3. Materials and Methods

To assess the organization, practices, and challenges confronted by the SBC WIBCI pilot project (hereafter “WIBCI pilot”), we relied on qualitative interviews with officials of SBC and the BMD, local NGO activists, and small farmers. Primary data were collected from eight Upazilas under the districts of Rajshahi, Sirajganj, and Noakhali (Table 2) through informal discussions, focus group discussions, in-depth interviews, and key informant interviews with large and small farmers, those who did and did not purchase insurance, those who did and did not receive a pay-out, and women (farmers and non-farmers) as well as men. We also interviewed officials of the local micro-finance organizations involved in implementation: the Centre for Actin Research Barind (CARB), the International Network of Alternative Financial Institutions (INAFI), and the United Development Initiatives for Programmed Action (UDDIPAN). The key informants were essentially experts who have significant participation in and unique knowledge of the WIBCI pilot. We used semi-structured interviews guided by a list of topics and targeted at the particular informant’s probable knowledge domain. Interview topics included: (a) the challenges of the WIBCI scheme; (b) the challenges faced by stakeholders regarding WIBCI; (c) possible strategies to overcoming challenges; and (d) the opportunities of the WIBCI scheme. In addition, we conducted two in-depth interviews and five key informant interviews with the officials of the BMD and SBC and with Upazila-level agricultural extension officers, the two local NGOs, and community leaders in the study sites (Table 2).

We also used nine focus group discussions with local farmers selected based on purposive sampling considering locational risk in the study sites to obtain their views on how the WIBCI was working and how it might serve their needs better. Focus group discussion is frequently used as a qualitative approach to understand social issues [37] and requires a team consisting of a skilled facilitator and an assistant [38,39]. The aim is to obtain a deeper understanding and insights of people and information about the phenomena being studied. It is especially important for collecting data from more marginalized stakeholders. We focused on the following topics: (a) identifying the challenges of the WIBCI; (b) the limitations of the WIBCI; (c) the opportunities of the WIBCI; and (d) recommendations to overcome the challenges. The informal discussions and focus groups contained between 7–12 individuals and lasted for 60 min. We also conducted a literature review comprised of the available literature on index-based insurance, mainly linked to experiences from Asia (i.e., Bangladesh and India), Africa, and Latin America. In addition, we covered a range of climatic risks and livelihood activities. The literature consisted of peer-reviewed articles and other national and international reports, sourced through global bibliographic indexes, Google Scholar, and Google searches. In particular, we also used the reports by the SBC, the Asian Development Bank, and promotional materials developed by the WIBCI pilot.
Table 2. Data collection: locations, methods, and sources.

| Districts      | Risk Events | Upazilas          | Unions                        | Data Collection Methods | Respondents                  | Number of Participants |
|----------------|-------------|-------------------|-------------------------------|-------------------------|------------------------------|------------------------|
| Rajshahi       | Drought     | Godagari          | Gebari                        | FGD                     | Farmers                      | 8                      |
|                |             |                   | Gogram                        | FGD                     | Farmers                      | 10                     |
|                |             |                   | Mohanpur                      | Informal discussion     | Farmers, community leaders   | 12                     |
|                |             |                   | Deopara                       | FGD                     | school teachers              |                        |
|                |             |                   |                                |                         | Farmers                      | 11                     |
|                |             |                   |                                |                         | Officials of INAFI, CARB     | 3                      |
|                |             |                   |                                |                         | & Uddipan, Upazila agriculture extension official |                     |
|                |             |                   |                                |                         | Farmers                      |                        |
|                |             |                   |                                |                         | Farmers                      | 8                      |
|                |             |                   |                                |                         | Farmers                      | 7                      |
| Puthia         | Flood       | Baneshwar         | KII                           |                         | Farmers                      | 9                      |
|                |             |                   |                                |                         | Farmers                      | 10                     |
|                |             |                   |                                |                         | Officials of INAFI & Uddipan | 2                      |
|                |             |                   |                                |                         | Farmers                      | 9                      |
|                |             |                   |                                |                         | Officials of INAFI & Uddipan | 8                      |
|                |             |                   |                                |                         | Farmers                      |                        |
| Shirajgang     | Flood       | Kaliya Horipur    | Informal discussion           |                         | Farmers                      | 8                      |
| Kamarkhanda    |             | Bhdragat          | FGD                           |                         | Farmers                      | 10                     |
|                |             |                   | KII                           |                         | Officials of INAFI & Uddipan | 2                      |
|                |             |                   | FGD                           |                         | Farmers                      | 9                      |
| Tarash         |             | Naogaon           | KII                           |                         | Officials of INAFI & Uddipan | 8                      |
|                |             |                   |                                |                         | Farmers                      |                        |
| Noakhali       | Cyclone     | Baruhas           | KII                           |                         | Farmers                      | 9                      |
|                |             |                   |                                |                         | Farmers                      | 8                      |
|                |             |                   |                                |                         | Farmers, community leaders   | 8                      |
|                |             |                   |                                |                         | school teachers, shop keepers |                        |
|                |             |                   |                                |                         | Farmers                      | 8                      |
|                |             |                   |                                |                         | Farmers, community leaders   | 12                     |
|                |             |                   |                                |                         | school teachers, shop keepers |                        |
|                |             |                   |                                |                         | Sagartika Samaj Unnayan Sangthath | 1                    |
|                |             |                   |                                |                         | Official of Uddipan          | 2                      |
|                |             |                   |                                |                         | Sadhanan Bima Corporation (SBC) | 2                    |
|                |             |                   |                                |                         | Bangladesh Meteorological Department (BMD) | 2                    |
| Companiganj    |             | Sirajpur          | KII                           |                         | Farmers                      |                        |
| Noakhali Sadar |             | Char Matua        | KII                           |                         | Farmers                      |                        |
|                |             |                   |                                |                         | Official of Uddipan          |                        |
|                |             |                   |                                |                         | Sadhanan Bima Corporation (SBC) |                        |
| Dhaka          |             | Dhaka             | In-depth interview            |                         | Bangladesh Meteorological Department (BMD) |                        |

4. Case Study: The WIBCI Pilot in Bangladesh

According to the project brief of the BMD and SBC [40,41], and the concluding summary report of the Asian Development Bank [42], the WIBCI pilot worked in three districts (Rajshahi, Sirajgonj, and Noakhali), protecting against drought risk, unseasonal rainfall risk, cyclone risk, and flood risk. Rajshahi was taken for drought risk in these three districts, Sirajgonj for unseasonal rainfall and flood risk, and Noakhali for cyclone risk [43] (Figure 3). The activities of the WIBCI pilot comprised about 20 union parishads under the three districts (Table 2). Four crops (rice, potato, chilies, and pointed gourd) were selected for coverage.

This provided access to small farmers in different regions of the country with varying weather risks (Table 3). Twenty AWS were installed in the first year and a half of the project to provide critical weather data. The Japan Aerospace Exploration Agency provided satellite mapping of precipitation and technical advice for merging these measures with data from in situ weather stations. After four and a half years of operations, including a year and a half delay of major marketing required to install the AWS plus an additional six-month extension to compile the final report, the project provided seven rounds of small farmer training on weather/climate risks and WIBCI insurance to 16,426 farmers, of whom 9641 enrolled as policyholders for at least one crop cycle [13].

The WIBCI pilot engaged in both direct sales and mediated sales by partnering with four microfinance institutions (MFI) (Figure 4). It also trained 958 staff from the Insurance Development and Regulatory Authority (IDRA), several private insurance companies, the BMD, academics, and other governmental agencies and generated a report with recommendations about a policy regulatory framework to ensure fair and equitable crop insurance and an operational module for designing such an insurance scheme [40]. The overall project used a participatory framework in that farmer focus group discussions were used at multiple stages to solicit feedback on preferences and what is working or not.
Some 31 consultants were used in the technical advisory group to provide evaluation and technical support for the initiative. Figure 4 summarizes the major actors, the basic lines of authority, and the labor division for the various collaborators in the WICBI pilot.

![Figure 3. Multi-hazard map of Bangladesh, and location of the WIBCI pilot project. Source: Huq et al. [44]. Layout and design our own.](image)

**Table 3. Insights of WIBCI pilot project in Bangladesh.**

| No. | Dimensions of WIBCI Pilot Project | Descriptions |
|-----|----------------------------------|--------------|
| 1.  | Geographical context             | - Bangladesh is a hotspot of different types of climate-induced disasters.  
- Cyclone Sidr (2007) and Aila (2009) destroyed about 95% and 46% of standing croplands in the coastal areas.  
- Seasonal floods and flash floods are common phenomena in Bangladesh’s north, north-western, and north-eastern regions.  
- Drought is a severe climatic event in the northern part of Bangladesh. |
| 2.  | Impacts analysis                 | - Climate-induced disasters affect croplands and increase the vulnerability of smallholder farmers.  
- Small and marginal farmers are often excluded from the mechanism of risk-sharing.  
- A traditional financial instrument, e.g., microcredit, and relief programs, are continuing. However, how climate risk can be tackled with the particular focus of farmers is a crucial question. |
| 3.  | Innovation                       | - Adopting weather-index-based crop insurance (WIBCI) is innovative for adapting to climate risk for the large, smallholder, and marginal farmers. |
Table 3. Cont.

| No. | Dimensions of WIBCI Pilot Project | Descriptions |
|-----|-----------------------------------|--------------|
| 4.  | Key objectives                    | • Enhancing resilience of farm-holders to the climate risk.  
    |                                   | • Reduce the climate-induced shocks on the income of farm holders. |
| 5.  | Key performance indicators        | • Installed 20 weather stations.  
    |                                   | • 9641 farm holders enrolled.  
    |                                   | • 16,426 farmers were sensitized on climate risk, WIBCI, and agri-risk management.  
    |                                   | • 400 officials capacitated. |
| 6.  | Location of piloting WIBCI (Districts) | • Rajshahi, Sirajganj, and Noakhali. |
| 7.  | Project duration and key dates    | • 3 years  
    |                                   | • Project approval: 27 March 2013; signing: 25 March 2014; start: 25 March 2014, end: 31 December 2016; revised: 30 June 2018; actual: 11 October 2018 |
| 8.  | Addressed risk events             | • Drought, flood, and cyclone. |
| 9.  | Sources of funding                | • ADB-JFPR, Government of Bangladesh, Japan Aerospace Exploration Agency. |
| 10. | Financial framework               | • 50% premium paid by farmers and 50% subsidized (25% by government and 25% by ADB). |
| 11. | Stages of implementation          | • Step 1: Installation of the weather stations and baseline survey.  
    |                                   | • Step 2: Performance of awareness program through MFIs.  
    |                                   | • Step 3: Enrollment of clients.  
    |                                   | • Step 4: Claims calculations and settlements. |
| 12. | Key aspects of regulatory framework | • The main objective of the regularity framework: to protect policyholders and ensure supervision of the authority.  
    |                                   | • Key components: (a) specifying the rural and social obligation; (b) creating spaces for insurance companies; (c) ensuring consumer protection; (d) allowing non-insurance companies as a distribution channel. |
| 13. | Results                           | • 20 weather stations installed, 7 round piloting, 16,426 farmers sensitized, 9641 farmers enrolled, 936 officials capacitated, underwriting software developed. |

Sources: adapted from [13,45], KII, and FGD, 2019.
5. Results and Discussion

5.1. Limitation of Farmer Knowledge, Trust, and Premium Payment Abilities

In the Bangladeshi context, most small farmers have limited formal education and lack knowledge about how insurance works or relates to their crops. The majority are unfamiliar with the idea of crop insurance and are unbanked, meaning that they have limited contact with the formal financial system. Many worry that insurance is a Ponzi scheme, and the literature and our focus group discussions were full of farmer comments about being robbed by insurance or other financial firms in the past. Many of these farmers were familiar with micro-credit (informal discussion, 2020), but this creates confusion since micro-insurance and micro-credit are very different. Micro-credit involves using the local trust network of small farmers and business people to insure small short-term loans, which must be repaid (typically weekly or bi-weekly), where micro-insurance involves making payments in advance (two to three months) of planting to protect against crop damages. The only micro-credit institution with independent insurance-like experience to date is BRAC, which has experimented with a small-scale system of preapproved emergency loans triggered by declared disasters for roughly 40% of its clientele in designated risk zones, but this is not really crop insurance, and it has strict repayment schedules with about 25% interest.
rates [45,46]. BRAC is reportedly participating in the planning of another WICBI pilot to be launched.

Creating farmer awareness and trust in crop insurance is clearly the biggest challenge in creating a viable scheme. Drawing on our interviews with 152 farmers in study villages under the districts of Rajshahi, Sirajganj, and Noakhali, we found a significant positive relationship ($\chi^2 = 157.00$, sig. value = 0.000) between farmers’ level of insurance familiarity and their willingness to participate in the WIBCI (Table 4). Farmers who were more familiar with how an insurance scheme helps in reducing risk among communities were more interested in participating than those who were less familiar. Familiarity of WIBCI to farmers differs geographically, reflecting the different levels of education [47,48] and knowledge about damages and losses due to various disasters [49].

Table 4. Association between familiarity with WIBCI and willingness to participate in an insurance program (N = 152).

| Familiarity with WIBCI | Rajshahi | Sirajganj | Noakhali |
|------------------------|----------|-----------|----------|
| Not familiar at all     | 56       | 81        | 72       |
| Not familiar            | 52       | 77        | 68       |
| Somewhat familiar       | 45       | 34        | 25       |
| Familiar                | 31       | 23        | 26       |
| Completely familiar     | 27       | 18        | 20       |

$\chi^2 = 157.00$, Sig. value = 0.000, df = 3, $\alpha = 0.05$

Second, at least a third of the rural population is living below the poverty threshold. This means that premium payments, especially coming due at the same time as payments for new seed and fertilizer at planting time is difficult. This is one reason that many crop insurance programs bundle insurance with farm credit or seed/fertilizer purchase (e.g., the system in India), making it impossible to avoid and not requiring payment when cash is scarce. Alternatively, some recommend charging premiums immediately after crops have been sold since money is more available. Certainly, a prepay system without significant subsidy is a major challenge for impoverished smallholders, as all of the aforementioned marketing studies have documented. In the case of the WIBCI pilot, 50% premium subsidies were used in the pilot project [13].

5.2. Limitation of Weather Data Acquisition

The WIBCI pilot depends on the weather data generated by the AWS and the satellite-based rainfall estimates generated by the Japan Aerospace Agency, supplemented by in situ flood gauges where available. These data were combined with yield data for the four covered crops to create a weather-index for triggering payments (KII, 2019).

The AWS proved too limited in coverage in part because of the large geographic areas represented. Seven AWS were installed in Rajshahi, six in Sirajgonj, and seven in Noakhali, but these are large areas with highly variable terrain. There were also delays in AWS installation, which blocked the marketing of the project for almost a year and a half. Because these were new, there was no historical data, which is imperative if one is to test the connection of rainfall measures to historic crop yields. Some of the AWS experienced internet or SIM disturbances, which limited the data quality and forced the project to rely on end-of-the-month measurements for a period. This weakened the initial timeliness of payments, which complicated relations with some farmers. Most weather-index systems go beyond rainfall and temperature data by including satellite measures of flooding, vegetative indices, soil moisture, etc. The WIBCI pilot also had no detailed topographical data (KII, 2019), which made it impossible to adjust for local variances in soil topography and related drought/flood/temperature risk. Finally, as detailed next, there was a need to integrate weather data with crop yields using small ecological units to fine-tune the index and reduce basis risk progressively.
5.3. Challenges of Automation

The major idea behind WIBCI is that a weather-index system can be constructed that is largely automated and capable of monitoring remotely temperature, rain, wind speed, humidity, soil moisture, standing flood water, etc. [50,51] relevant for the growing of crops. The entire aim is to replace field monitoring and personnel with an automated weather-index system. Further, it is important to have multiple types of data to ensure a better fit with actual crop losses on the ground. This requires some level of ongoing in situ assessment, if only to recalibrate and check automated systems, but the ultimate aim is to automate the collection of relevant data. The WIBCI pilot demonstrated that much of this is possible, but considerable progress is needed to create a more automated and accurate/reliable and fine-grained index system with multiple measures and the ability to reduce basis risk.

Crop damage assessment is best performed by remote sensing, combined with local field checks. The latter can be semi-automated by using smart phones to report periodically on planting and crop status (In-depth interview, 2019). This can be built into farmer contracts or administered by field agents [52]. Multiple methods have been devised for assessing vegetative density using satellite images (or more expensive drones), so the major assessment problem is sorting out different crops. Combined with small-scale local field testing, satellite data can provide near real-time measures that can be used to estimate crop yields and combine these with rainfall and other weather measures.

A key feature of such an automated weather index system would be the collection of accurate data on planting dates and crop development. Because of variation in rainfall, temperature, and individual farmer work schedules, planting dates vary from place to place and farmer to farmer. Further, seed varieties vary as to their maturation cycle. Only an automated continuous monitoring system in which farmers share their data about local planting and crop status could fully accommodate this complexity. The WIBCI pilot lacked this complex input and could only crudely estimate this type of information, which is important to reducing basis risk and false payments (positive or negative).

5.4. Administrative Problems and Bridging the Agency-Farmer Link

For operating the WIBCI pilot, a flexible administration with continuous and plentiful opportunities for small farmer input is needed. One cannot fine-tune a product or assess subscriber uptake without continuous and regular feedback. While the WIBCI pilot used focus groups as part of its initial educational and marketing program, these created limited feedback opportunities and were not followed up so as to generate new timely information. Below, we discuss remedies that involve continuously adjusted products that are impossible without regular feedback. It is notable that in the areas where NGOs and MCI s were the major intermediaries, farmer acceptance and uptake were significantly greater, reinforcing the point that a trusted institution and set of contact people are vital to developing trust and a viable system [53]. Only multiple years of continuous experience, including payments that reduce farmer concerns about basis risk, can build the depth of trust and information required. As a key informant commented in his interview, reaching out and educating small farmers is the primary challenge in micro-insurance and requires far more back-and-forth than the WIBCI pilot provided.

A second problem is inter-agency coordination. Poor planning created a year and half delay at the outset to install the AWS. Otherwise, relations between the Meteorological Dept. and the SBC were cooperative. The biggest gap was the absence of ties to the agricultural extension agents and their colleagues in the Ministry of Agriculture, especially regarding farmer choices about crop selection, seeds, and fertilizer, and a history of crop yields that could have refined the weather-index (FGD, 2019). A second missing party was the Dept. of Disaster Management (DDM), Ministry of Disaster Management and Relief, where emergency aid is planned and delivered. Although DDM staff attended training sessions, DDM engagement would be imperative in boosting post-cyclone recovery. The Bangladesh government is a centralized set of bureaucracies where inter-agency coordination is difficult.
It requires cooperation at multiple levels. This problem is unlikely to change. Below, we discuss some opportunities for fostering inter-agency cooperation at both the headquarters, the regional, and the local level that would strengthen a future WIBCI.

5.5. Uncertainty of Insurance Policy to Farmers

Most small farmers are minimally literate and less educated and have never been exposed to insurance. Our focus group interviews confirmed their insurance illiteracy. Many believe that after getting the premium, the insurers will flee with the money, that payments will not be made after a crop loss, or that if no damages are experienced, all premiums will be returned at the end of the coverage period. To be open to learning more about the insurance concept, they first have to trust in the vendor. This is no doubt why farmer uptake was much greater in the areas serviced by the microfinance partners (in-depth interview, 2019). A related problem is providing clear communication in formal statements about coverage. The Pilot had to experiment with providing clear statements about weather-index triggers and coverage terms (in-depth interview, 2019).

5.6. Lack of Actuaries, Crop Scientists, and Meteorologists in Bangladesh

A key problem confronted by the WIBCI is insufficient actuaries and other professionals with experience with weather data, seeds, crop yields, and agricultural prices. Actuaries need to be problem solvers and strategic thinkers with a deep understanding of financial systems and creative methods to estimate risks and costs. In this case, the actuary needs to work closely with a team of crop scientists (agronomists) and meteorologists that have extensive experience and access to 30+ years of data on the links between weather events, topographical detail, and past crop yields. In this WIBCI pilot, the meteorological basis was the stronger of the three, but even it failed to provide geographically fine-grained information as it was limited by relying on AWS that focused on rainfall and temperature, which were often distant from farming areas. Additionally, historical records were lacking. Fine-grained weather data needs to be integrated with historical crop yield data to provide an accurate baseline for a weather index. Although the actuaries and crop scientists were able to come up with basic information, they were challenged by a lack of detailed information on local crop yields and links to weather data. As mentioned, lack of topographical detail was a problem. As a result, a stronger professional and data foundation for WIBCI needs to be developed that can provide a platform for a more accurate weather index system.

5.7. Insurance Product Design and Administrative Costs

The WICBI relied on a single product specified for drought and/or flooding risk. Other research shows that a somewhat more complex product that not only specifies (preferably) multiple risk items but also provides varying loss coverage (i.e., 50%, 60%, 70%) is more popular and likely to secure uptake [11]. Small farmers are often quite satisfied with receiving lower coverage for a lower premium and may prefer products with varying coverage.

A key question is how efficient the WIBCI pilot was relative to other WIBCI projects. Overhead affects the premiums and/or subsidies that must eventually be paid for the initiative. We were able to secure from qualitative interviews estimates of the administrative costs’ share relative to the total costs of the WIBCI pilot and two other recent WIBCI pilot projects in Bangladesh: the Green Delta Insurance project and the SBC-Oxfam flood index for the haor region (interviews 2021). Table 5 shows that the WIBCI pilot was the most efficient, keeping its administrative costs at the lowest level, which should facilitate farmer participation.

There is some evidence that small farmers start off purchasing low coverage and gradually move up as they come to trust the system and are more affluent. They also prefer multiperiod coverage, but this has to be fine-tuned to the area, risks, and specific crops. Ultimately, a multi-product design is required for a viable WICBI program [46,47].
Table 5. Comparison of administration costs and premium and farmer’s payments for different insurance organizations (in USD).

| Responsible organization and project duration | Weather-Index-Based Crop Insurance (WIBCI) | Weather Index-Based Agriculture Insurance | Flood Index-Based Crop Insurance for Haor |
|-----------------------------------------------|--------------------------------------------|-------------------------------------------|----------------------------------------|
| Sadhanan Bima Corporation (SBC)-ADB (2014–2018) | Green Delta Insurance Company, (2015–Present) | Sadhanan Bima Corporation and OXFAM (SBC) (2020–Present) |
| Administrative costs per client per year * | 6–10 | 8–12 | 7–14 |
| Premium and farmers payments (%) | 22–25 | 25–27 | 25–28 |

Source: Crude estimate based on in-depth interview, FGD, and KII, 2020. * These costs do not include the cost of reinsurance.

A related issue is subsidies and the possibility of providing a different mix of coverages. Some WIBCI projects have combined fully state-subsidized catastrophic loss coverage with premium-based variable coverage. This focuses the public subsidy on catastrophic risk while leaving it to the farmer to decide about other crop losses. In any case, alternatives such as this, which would work best by coordination with the DDM, should be considered in future initiatives [47].

In our farmer focus groups, the comment was often made that additional crops and perils should be included. If a farmer loses their crop because of riverbank erosion or pests but has only flood or drought insurance, they end up losing both the crop income and the insurance premium. Such expansion to additional crops and perils is a question that requires further study. As part of a system of continuous adjustment, a WIBCI could weigh the possibilities of adding crops and perils depending on available data and the ability to automate such monitoring. Only experience can tell what coverages will be popular, effective, and operational.

Another common farmer comment was the idea of creating a petition system for crop loss assessment. The difficulty here is that some may be thinking of a claim system, which is incompatible with a weather-index system [48]. Some WIBCI pilots have experimented with a petition system for crop loss assessments, which can provide additional information for improving the weather-index. The practicalities and potential for misunderstandings are significant and need to be weighed against the advantages.

A final point about product design is the need to create a continuous adjustment system that regularly adjusts premiums and coverages based on recent data. With an automated index data system in place, such a flexible system can be implemented. Some contend that public subsidies can be phased out or significantly reduced over time as small farmers become accustomed to crop insurance and its benefits. This also has major advantages relative to climate change. If climate change means gradually increasing risks due to increasing weather extremes, then such a continuous adjustment system will be imperative to dealing with long-term changes. Certainly any viable WIBCI will have to incorporate adjustments to the evolving weather risks that are being covered.

5.8. An Improved Business Platform

Although the WIBCI pilot purchased the software to run an online business platform so that purchases could be entered via a cell phone (including traditional 3G phones, which are common in rural households) and information looked up on pricing, etc., there were problems with reliable service. The internet is technically accessible, but few rural households have immediate access, and so cell phone traffic is the best method.

The payment for crop losses was available through mobile banking, including Bkash and Rocket. However, there were many complaints about mobile banking payments with phone literacy being part of the problem. Over two-thirds of households have access to a cell phone, but this does not ensure that all are familiar with its operations on specific sites or apps. Establishing a viable business platform will require not only more investment in
the technology but also the provision of education in cell phone use and future refinements in business communications.

6. Conclusions and Recommendations

The WIBCI pilot demonstrated that a weather-index system could be developed and combined with an online business platform and a largely automated weather monitoring system to create weather-index insurance for small farmers. The pilot also demonstrated that major improvements in weather and crop data, including historical data that can ground an accurate weather-index system, are imperative. Without such a system, timely and accurate adjustments, which will reduce basis risk, cannot be made to the weather-index. With significant basis risk, small farmer uptake will lag and confidence in the system will not develop. Only multiple rounds of insurance and payments triggered by an accurate weather-index that is strongly correlated with actual farmer losses will build farmer confidence and trust. Building such a system will also require a better supply of qualified actuaries, crop scientists, and meteorologists. In some sense, broader improvements in the insurance industry in Bangladesh, including the creation of actuarial and insurance professional training are needed. There are signs that such developments are taking place in Bangladesh, and the WIBCI pilot has contributed by creating a pilot model, recommendations about a broader policy framework, and an operations module.

Ultimately, the major challenge is educating small farmers about the benefits of prepaid crop insurance system that can be organized around a weather-index basis. In a sense, a market for crop insurance needs to be built. Small farmers have developed their own methods of insuring against risk, holding back often inferior seed from previous crops, diversifying farm and family incomes, using job migration to stabilize household income, starving during the “lean season,” etc. The evidence shows quite clearly that combining insurance with other transactions, such as seed and fertilizer purchase or loans, creates greater uptake. Smallholders are hard-pressed to pay for crop insurance when they are short on cash. Working with NGO and MFI groups is also a major advantage, in part because it encourages trust and familiarity with business platforms. The WIBCI pilot had a roughly 50% yield rate among the small farmers that it contacted, many of whom were recruited from local NGOs and MFI groups. Future efforts should consider partnering with farmers’ clubs and other rural societies that have an agricultural linkage. For example, we may allow the insurance mechanism to translate to other agro sectors of Bangladesh, such as community-based mangrove forest management (e.g., forest plantation insurance and agroforestry insurance). In addition, insurance is relevant to enhance adaptation efforts under some realistic conditions on forest owners’ uncertainty and risk preferences [54,55]. This could be linked to meso-marketing or simply organized through these local groups. Where local clubs can be organized to be collective groups, group insurance could be adopted, which saves costs.

This effort should also consider inter-agency cooperation with the Ministry of Agriculture and its local agricultural extension agents. Evidence [56,57] suggests that these agents have significant farmer trust and are highly knowledgeable about local crop, seed, and fertilizer decisions, which are often bound up with decisions about how best to protect against crop losses. There may also be a possible partnership with the DDM, which is immediately responsible for responses to weather disasters. Ultimately, there may be ways that catastrophic risk to crops can be absorbed by the DDM or structured to provide intermediate-term business loans that can allow small farmers to get back on their feet, thereby limiting the need for a WIBCI to cover all types of weather losses. Such inter-agency collaborations are complex and difficult. They require working simultaneously at national, regional, and local levels. Yet, they may be important to creating a sustainable WIBCI system.

Bangladesh is an increasingly globalized country with major imports and exports. One of the risks of weather insurance is the possibility of region-wide perils, such as major cyclones that bring damage to millions of households and businesses all at the
same time. At present, the SBC operates the reinsurance system for the entire country. As part of the development of a WIBCI, it will be imperative to internationalize aspects of this reinsurance system so that financial stabilization against broad regional losses can be assured. Several large reinsurance companies have been involved in agricultural insurance and could likely become business partners.

The concept of WIBCI is novel to Bangladesh. In fact, the insurance industry in general is underdeveloped. This WIBCI pilot is just a start to find out how to organize such a system. This pilot showed that such a system is feasible but requires better resources and capacity to scale up. It requires a better supply of professional actuaries, crop scientists, meteorologists, and other professionals. Most importantly, it requires a stronger operational plan and an institutional framework within which upscaling is possible and from which a viable system can be launched. It may require public subsidies, perhaps for a significant time, but will have significant benefits in reducing poverty and human insecurity.

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