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International Water Management Institute

199

Working Paper

Economics of Index-based Flood Insurance (IBFI): Scenario Analysis and Stakeholder Perspectives from South Asia

R. P. S. Malik and Giriraj Amarnath

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IWMI Working Paper 199

Economics of Index-based Flood Insurance (IBFI): Scenario Analysis and Stakeholder Perspectives from South Asia

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Acronyms and Abbreviations

AIC	Agriculture Insurance Company of India Limited
APR	Actuarial Premium Rate
CCIS	Comprehensive Crop Insurance Scheme
DCF	Discounted Cash Flow
DLTC	District Level Technical Committee
FGD	Focus Group Discussion
GoI	Government of India
IA	Implementing Agency
IBFI	Index-based Flood Insurance
IoT	Internet of Things
IRDA	Insurance Regulatory and Development Authority
IWMI	International Water Management Institute
KII	Key Informant Interview
MNAIS	Modified National Agricultural Insurance Scheme
NAIS	National Agricultural Insurance Scheme
NCIP	National Crop Insurance Programme
NDVI	Normalized Difference Vegetation Index
NGO	Nongovernmental Organization
PMFBY	Pradhan Mantri Fasal Bima Yojana (Prime Minister's Crop Insurance Scheme)
SAO	Seasonal Agricultural Operation
SAR	Synthetic Aperture Radar
SLCCCI	State Level Coordination Committee on Crop Insurance
SLTC	State Level Technical Committee
WBCIS	Weather Based Crop Insurance Scheme

Summary

Insurance is increasingly being recognized as a key player in any comprehensive strategy on disaster risk management and financing, and in helping those who are adversely affected to recover quickly. Despite recognition of the advantages offered by insurance cover, insurance markets all over the world have struggled to provide affordable flood insurance in high-risk areas.

Of the various impacts of flooding, the damage to standing crops is perhaps the most significant. This is particularly the case in a developing country setting where millions of small farmers cultivating small pieces of land face starvation, hunger, malnutrition and loss of their only source of income due to crop loss as a result of floods. Given that the damage to crops due to floods generally occurs over vast areas on which the crops are cultivated, effective implementation of flood insurance poses many challenges. Besides being very time consuming and expensive, the loss estimation process hampers speedy payouts of compensation to farmers, thereby undermining the utility of insurance. This defeats the very purpose for which insurance is provided and dissuades farmers from enrolling in or continuing with the insurance scheme.

The International Water Management Institute (IWMI) has been grappling with issues related to the development of an appropriate insurance product suitable for large-scale application in vulnerable economies to provide risk cover to poor farmers against crop losses due to floods. IWMI has recently developed an Index-based Flood Insurance (IBFI) product. IBFI is a specialized case of index insurance designed specifically to provide cover against flood-induced crop losses through the innovative use of remote sensing-based datasets and numerical hydrologic/hydrodynamic models for determining the flood thresholds.

Besides the technical soundness of any product, the economics of such an intervention is important to ensure its long-term recognition and sustenance by different stakeholders. An economic evaluation of the intervention should normally be undertaken ex post after the scheme has been operational in the field for some time. However, this paper attempts at conducting an ex ante assessment of the economics of IBFI from the perspectives of different stakeholders, and discusses the methodological challenges and data issues encountered. The issues and processes involved are empirically illustrated using a hypothetical case study based on a synthesis of data drawn from a host of sources/studies on related issues and certain assumptions.

The results of this hypothetical case study are presented from the perspectives of the three main stakeholder groups in a crop insurance scheme, i.e., farmers, the insurance company and the government, under two flooding and three crop damage scenarios. The findings suggest that from the perspective of an individual farmer, the amount received as compensation for crop losses from the insurance company far exceeds the costs incurred to pay the premium. From the perspective of the insurance company, the district-level estimates of revenue earned exceeds the costs incurred, although the margin between the two changes depending on the flooding-damage scenario that occurred. From the perspective of the government, the cost of providing a subsidy on the insurance premium far exceeds the costs it would incur to provide ex post compensation to those farmers who incur crop losses, though the level of compensation to those affected would differ in the two cases.

As already emphasized, the above costs and benefits are for demonstration purposes only and are explicitly valid only for the values of various parameters assumed in deriving these values for the flooding and crop damage scenarios. Any change in the value of any underlying parameter will change the outcome of benefits and costs and, therefore, the validity of inference drawn about the economics of insurance. These estimates need to be reworked when better data are available and a final decision about the economics of IBFI could be taken.

Economics of Index-based Flood Insurance (IBFI): Scenario Analysis and Stakeholder Perspectives from South Asia

R. P. S. Malik and Giriraj Amarnath

Introduction

Floods are a natural phenomenon with both negative and positive impacts. Floods, however, should not always be considered as a hindrance to economic development. They play a major role in replenishing wetlands, recharging groundwater, and supporting agriculture and fisheries systems, making floodplains preferred areas for human settlements and economic activities (WMO and GWP 2007). All floods, however, are not advantageous: while normal seasonal flooding is often beneficial, extreme and unpredictable floods cause a variety of impacts, e.g., death and injury of individuals, damage to buildings, crops and vehicles, disruption of traffic and production, contamination or erosion (Merz et al. 2010). Floods are an important source of risk for the agriculture sector; floods expose agricultural producers, rural financial institutions and governments to financial risks (World Bank 2009). Therefore, the destructive impacts of floods have been a far greater cause for concern than their constructive effects.

To minimize the adverse impacts of floods, countries around the world have been experimenting with diverse flood management solutions. Countries have been investing in both structural and nonstructural measures to reduce the incidence of flooding, minimize the damage caused by flooding, and address the risks associated with losses due to floods. The structural measures include engineering interventions, such as the construction of dams or dikes, river levees and embankments; river diversions; widening and deepening of riverbeds; and the setting up of flood detention basins. The nonstructural measures include flood insurance, flood forecasting and installation of early warning systems, and other non-engineering actions. While both structural and nonstructural measures are important to deal with the adverse impacts of floods and to provide risk coverage, it is difficult to hazard a guess as to which type of intervention is better or more effective than the other under the prevailing conditions. In fact, both measures complement each other; if structural measures are the bones of a flood management program, nonstructural mitigation is considered as its flesh (Lin et al. 2007).

Consideration of flood damage in the context of the decision-making process of the flood risk management policy is still a relatively new concept. However, insurance is getting increased recognition as a key player in any comprehensive strategy for adapting to natural hazards. Insurance increases resilience against residual risks that cannot be prevented or mitigated; can incentivize engagement and investment in risk mitigation measures; and reduces pressure on the fiscal budget of the governments in dealing with natural disasters. Flood insurance has often been perceived to be relatively more cost-effective than the other options aimed at reducing flood risk (Figure 1).

Despite the advantages that flood insurance offers, insurance markets all over the world have struggled to provide affordable flood insurance in high-risk areas. Even in many developed markets, a flood is an 'uninsurable risk' in coastal areas or on floodplains. According to Swiss Re (2012), "no other peril defies the basic principles of insurability to the same degree as floods." High expected losses have impaired the commercial viability of insurance and many households at risk do not have access to affordable insurance. It has, therefore, become common for the state to support flood risk insurance; where insurance penetration is low, governments partly bear the cost of flood risk coverage.

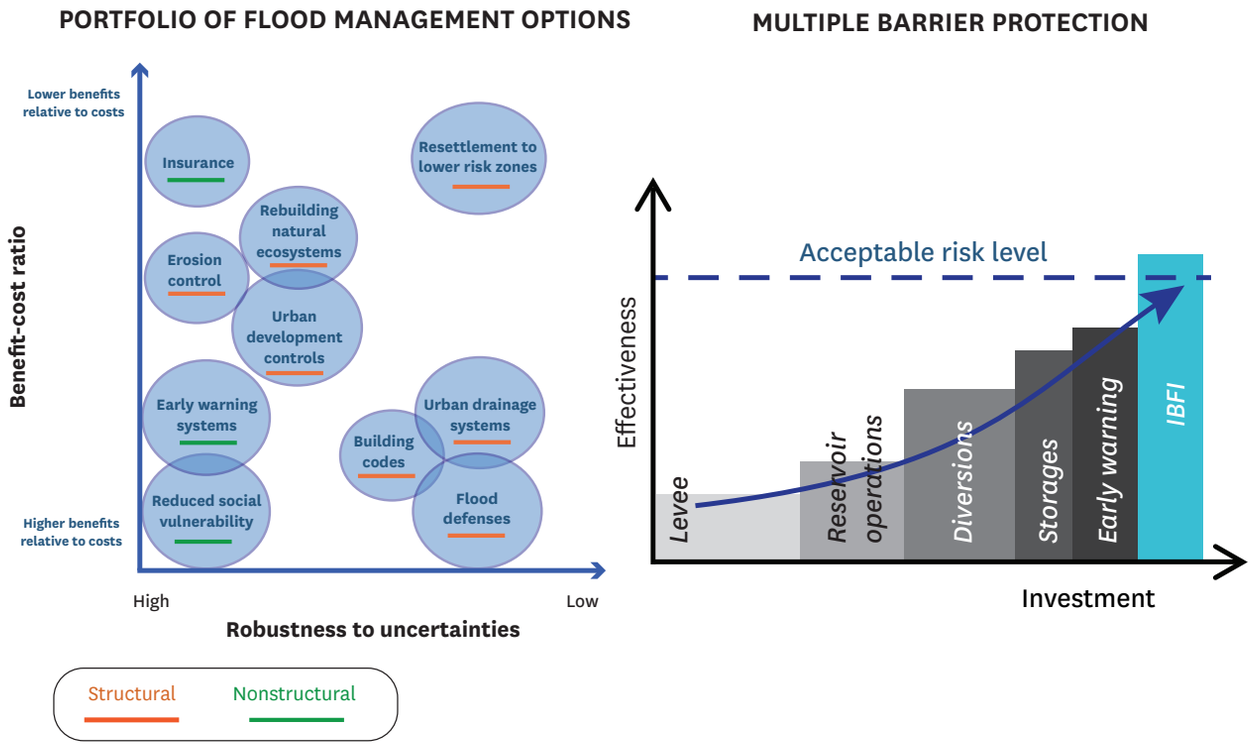

Figure 1. Concept diagram on integrated disaster risk management with index insurance for risk reduction measures or reducing the economic loss.

Sources: Jha et al. 2011; Ranger and Garbett-Shiels 2011.

Note: IBFI - Index-based Flood Insurance.

Insuring Crop Losses Due to Floods: The Evolution of Index-based Flood Insurance (IBFI)

Of the destructive impacts of floods, the damage caused to standing crops is perhaps the most significant. This is particularly the case in developing countries where millions of smallholder farmers cultivating small pieces of land face starvation, hunger, malnutrition and loss of their only source of income due to the destruction of crops as a result of floods. To protect these farmers from crop losses, the governments in these countries have been experimenting with various types of crop insurance schemes against multiple perils (floods, hailstorms, frost, windstorms, disease and drought). However, crop insurance has often proved to be difficult to implement in practice. Appendix 1 briefly illustrates how crop insurance has evolved over time in India.

Typically, crop insurance covering different types of catastrophes have either been indemnity-based (payout is based on crop damage) or index-based (payout is based on a certain weather index, e.g., rainfall, which is correlated with crop yield) schemes. Crop damage due to floods generally occurs over vast areas of cultivation. Therefore, effective implementation of flood insurance poses many challenges. The human and capital costs involved in assessing crop losses are high and extend over a long period of time. Besides the high costs, this lengthy loss estimation process hampers speedy payouts of compensation to farmers, thereby undermining the utility of insurance. Also, this defeats the very purpose for which insurance is provided and dissuades farmers from enrolling in or continuing with the insurance scheme. An alternative approach, referred to as index-based insurance, does away with the need for manually measuring crop losses in the field. Insurance payouts are triggered when an index crosses previously determined thresholds of a specific or composite variable such as temperature, rainfall, Normalized Difference Vegetation Index (NDVI), etc. This simplified product has major advantages such as accuracy, transparency, elimination of loss adjustment, farmer satisfaction and rapid settlement of claims. In theory, flood index insurance could potentially offer the same benefits that weather index insurance offers for other perils such as drought, erratic temperature, etc.

Many multi-peril insurance products, which also cover damages due to floods, are available and have been

widely used. However, there is probably no insurance product available as yet that specifically covers crop losses due to floods. The International Water Management Institute (IWMI) has been grappling with issues related to the development of an appropriate insurance product that is suitable for large-scale application in vulnerable economies to provide risk cover to poor farmers against flood-induced crop losses. IWMI has recently developed an Index-based Flood Insurance (IBFI) product[1] (Figure 2). IBFI is a specialized case of index insurance designed specifically to provide cover against flood-induced crop losses[2] through the innovative use of remote sensing-based datasets and numerical hydrologic/hydrodynamic models for determining the flood thresholds. Freely available optical and synthetic aperture radar (SAR)-based remote sensing datasets from Landsat, Sentinel-1 and Sentinel-2 can be used for mapping historical and current flood events to determine the spatial extents of floods. Hydrodynamic models can then be developed to help determine the spatiotemporal variability of flood parameters. The flood parameters (flood depth and duration) at daily time intervals for a specific period of time can be used to create an IBFI scheme, thereby setting up flood depth and duration as a proxy for the insured crop (for details, see Amarnath et al. 2017; Amarnath and Sikka 2018; Matheswaran et al. 2019). Using an area-based approach, IBFI is easy to operationalize and implement by insurance companies, enables prompt quantification of crop losses in a transparent and easily understandable way by different stakeholders, and is amenable to supervision by the regulator/government.

IWMI has also developed multiple business models to explore possible ways to tackle some of the challenges associated with marketing such an innovative insurance product and ensure effective scaling up. These business models describe how different stakeholders, such as the government, private industry, microfinance companies and nongovernmental organizations (NGOs), can contribute to taking this product to end users and ensure scaling up (Amarnath et al. 2021).

IBFI, as developed, is a methodologically complex but comprehensive and robust formulation for estimating flood losses. It utilizes data, collected scientifically using high-tech modern-day equipment, to derive numerical values of various parameters required for the efficient roll out of flood insurance. The accompanying business models should help to ensure speedy and widespread adoption of the product by farmers. However, it is not clear at this stage how the economics of IBFI will work out for different stakeholders. The economics of

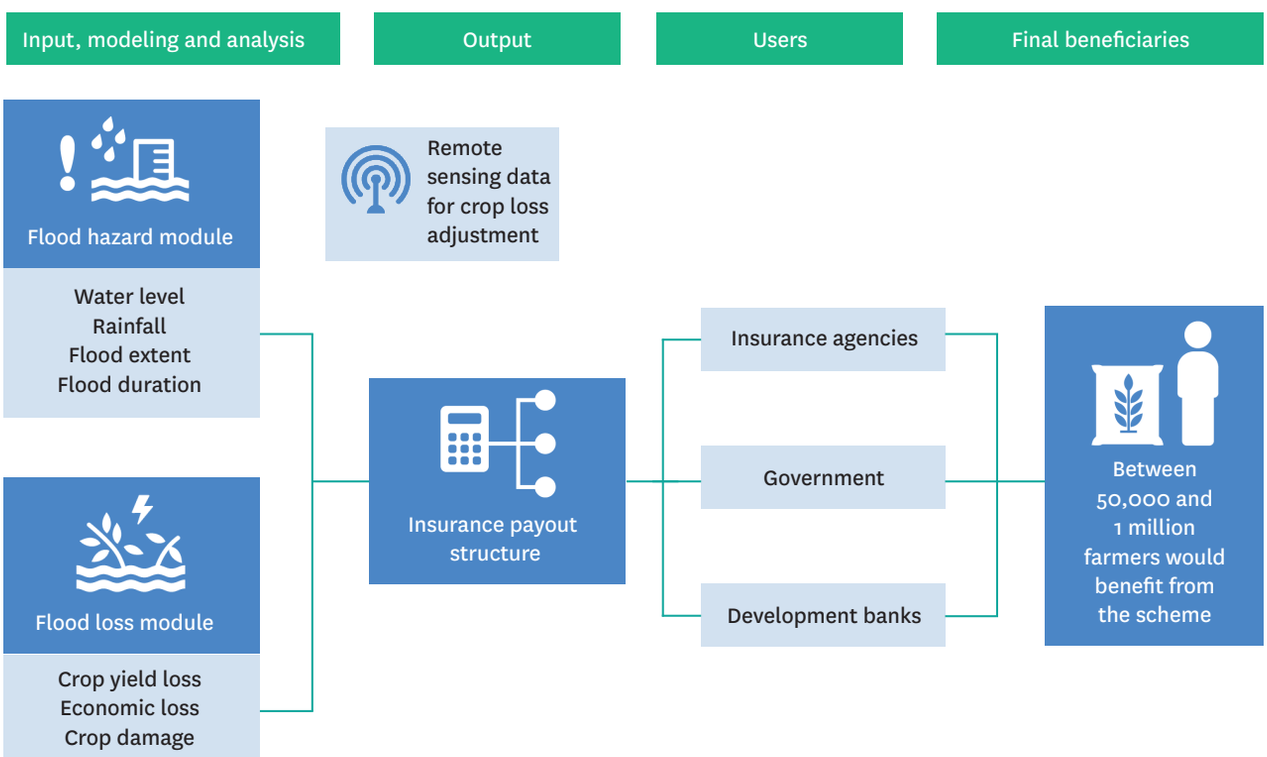

Figure 2. Concept of Index-based Flood Insurance (IBFI).
Source: IWMI.

[1] https://ibfi.iwmi.org

[2] IBFI is not a comprehensive insurance product designed to insure against different types of losses that occur due to floods, e.g., loss of agricultural production, housing, other infrastructure, life, etc. IBFI only insures a prospective policy holder against crop losses up to a predefined level depending on the predefined trigger level and timing of incidence of floods.

any intervention is important to ensure its long-term recognition and sustenance by different stakeholders. An economic evaluation of the intervention should normally be undertaken ex post after the scheme has been operational in the field for some time. However, this paper attempts at conducting an ex ante assessment of the economics of IBFI from the perspectives of different stakeholders, and discusses the methodological challenges and data issues encountered. These issues are empirically illustrated using a hypothetical case study based on a synthesis of data drawn from a host of sources/studies on related issues.

Economic Analysis of Flood Management: A Brief Review

Economic analysis has often been used to guide policy and investment decisions on alternative strategies for achieving the stated end objectives. In the literature on economic analysis, the economics of flood management has, however, been a relatively less researched subject. A review of some of the available literature on the economics of flood management indicates that undertaking an economic analysis of flood management is both complex and problematic, and beset with a number of conceptual, methodological and data availability issues. There are no agreements on what constitutes costs and benefits. Often, the costs and benefits of interventions are not even readily apparent, and even if apparent, they are difficult to identify and attribute. Generally, the practice, to date, has been to include only the direct costs as well as direct benefits, even though indirect and intangible costs and benefits are also slowly being recognized as being important. The costs of indirect impacts are more difficult to estimate and quantify than the costs of direct impacts. There are methodological issues associated with the measurement and quantification of various costs and benefits, and methodologies are still being developed for the monetary evaluation of indirect and intangible costs and benefits. The literature on estimating the costs and benefits of flood management also highlights problems relating to the availability and quality of data for a long enough time period.[3]

A review of the literature on undertaking an economic analysis of flood management further indicates that most of the available evidence on the costs and benefits of flood risk reduction is narrowly focused and, therefore, of limited use. Most economic research has focused on more easily quantifiable return on investment in 'hard' structures (dams, levees, etc.). Very few studies are available on the costs and benefits of and return on investment in 'softer' measures (such as hazard mapping, early warning, flood insurance, and promoting evacuation to protect people's lives) for mitigating flood impacts.

In any comprehensive strategy of adaptation to natural hazards, softer measures could in fact be the key player. While softer measures such as flood insurance cannot per se provide protection against the damage caused by floods, flood insurance can provide financial protection that complements the traditional flood risk management measures and ex post interventions. In practice, quite often, various structural and nonstructural flood management interventions are undertaken in tandem. Therefore, attributing and isolating the confounding outcomes of these measures to different specific measures of flood management become challenging. The problem of attribution adds to the complexity when the interest is on evaluating the economics of a specific flood protection measure (such as flood insurance) aimed primarily at securing a specific damage caused by floods (such as loss in crop production).

Another important issue in undertaking an economic analysis relates to the lumpiness of the capital invested and time period over which benefits of this investment are realized and costs recovered. Structural interventions, once undertaken, help moderate and reduce the incidence of floods and possible losses arising therefrom over a period of time. However, flood risk mitigation interventions, such as buying an insurance policy, needs to be undertaken every crop season/year. Structural interventions require most of the capital cost to be incurred before the project starts providing benefits, which then lasts several years, and the costs are accordingly recovered over a long period of time (e.g., 50 or 100 years). The 'softer' flood risk mitigation interventions (such as flood insurance) do not require a lumpy capital investment to be made at one point of time. Also, these measures do not help to reduce the incidence of floods or the losses therefrom over a long period of time. Therefore, there is no necessity to recover capital costs over a specific time period. An insurance policy can be bought every crop season/year with the payment of a small insurance

[3] A recent study conducted by Resources for the Future (Kousky 2012) also underlines the problems associated with estimating the costs of even the clearly identifiable direct impacts. The study states: "The thorny theoretical problems involved in estimating the economic consequences of disasters are coupled with extreme data limitations that make actual estimates far from what would be the hypothetical 'true' disaster costs." Further, regarding 'extreme data limitations', the study identifies the lack of good data as a global challenge: "Even in highly developed countries with generally good record-keeping, comprehensive disaster loss data are difficult to come by. Thus, all disaster numbers should be interpreted with some degree of caution."

premium by a person seeking protection from the possible losses incurred due to floods. Investing in an insurance product against floods is only a coping strategy undertaken every year as opposed to investing in hard infrastructure, which is a one-time investment to provide protection from floods over a long period of time.

Undertaking an economic analysis of flood insurance aimed at reducing the risk of crop losses due to floods is thus quite challenging. The challenge is further complicated when attempting to undertake such an analysis for a proposed new flood insurance product (such as IBFI) with no historical data on any of the required parameters.

Economic Analysis of Flood Insurance for Crops: The Approach

Mitigating the risks associated with a natural disaster through enrolment in an agricultural insurance scheme involves several costs. For long-term financial sustainability and economic viability of the insurance scheme, it is necessary that the benefits derived from participation in the scheme are at least equal to or higher than the costs incurred. Further, it is important that the benefits exceed costs not only in the aggregate for the scheme as an entity but also individually for each of the different groups of stakeholders associated with the provisioning of insurance.

In the crop insurance industry, there are essentially three broad groups of stakeholders, i.e., those seeking to (i) mitigate the risk involved (e.g., farmer), (ii) provide risk cover (e.g., insurer), and (iii) provide societal welfare and ex post disaster relief assistance to those affected by such natural disasters (e.g., government) (Figure 3). Each of the three groups of stakeholders carefully assesses the extent to which its intended objectives can be achieved from participation in the insurance program and implicitly assesses the costs of and benefits from its participation.

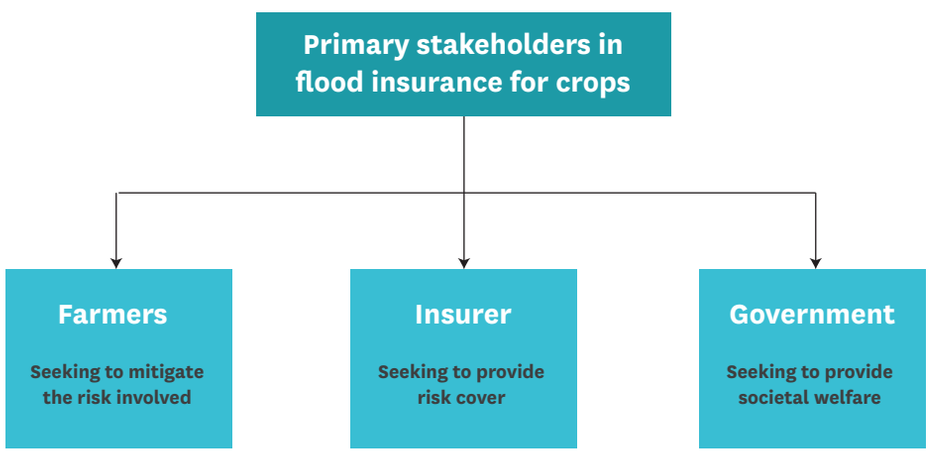

Figure 3. Primary stakeholders in the flood insurance scheme providing coverage against crop losses.

The primary stakeholder in the insurance scheme providing coverage against crop losses attributable to floods is the set of farmers who face the brunt of such natural disasters. The main objective of these farmers is to protect themselves from the financial losses that may occur due to crop damage as a result of flooding. By buying an insurance policy, the farmer transfers this risk of crop loss to the insurer. However, farmers who anticipate that there is a low risk of flooding and subsequent crop losses are less likely to buy insurance. When buying an insurance policy, the farmer has to bear the cost of the insurance premium. They also incur some costs in the form of foregone income that could have accrued if they did not have to pay the premium. Before deciding to buy an insurance policy, the farmer implicitly assesses the utility of the insurance product; calculates the likelihood of a disaster event happening and the magnitude of financial losses they might have to incur as a result of crop damage; and evaluates these losses against the cost of the premium. Given that such adverse events do not occur every year or occur with a predetermined regularity, before buying insurance, a rational farmer would need to take a medium- to long-term view of the costs and likely benefits that may accrue over an extended period of time and in continuing to stay insured over this time period. While no insurance claim is the best bet against the premium cost incurred, some farmers construe this as a financial loss and a waste of money spent on buying insurance. As a result, several farmers tend to discontinue their insurance policy if no crop damages occur and, therefore, no insurance payouts are received over a short period of time (e.g., 2-5 years).

The second stakeholder in the flood insurance scheme is the insurer, who plays the pivotal role of providing

insurance cover and undertakes the risk of crop damage caused by flooding. In providing this insurance cover, the insurer needs to incur several costs such as (i) preparing the risk profile through acquisition of historical and current data on a variety of variables (such as size of landholding, distance from farm to river, weather parameters, etc.) from diverse sources; (ii) creating awareness about the insurance product among prospective clients; (iii) setting up infrastructure and partnering with grassroot organizations to sell the insurance product; (iv) determining the cost of the premium; (v) collecting the premiums; (vi) estimating the losses that could occur due to flooding; (vii) settlement of claims; and (viii) liaising with a host of institutions including the government insurance regulator. The insurer has to assess the likelihood and cost of damage against the set premium and ensure this rate is favorable in the marketplace. The insurer also has to take into consideration a government's response to the disaster event. When the actions taken by a government or the international community cover the costs of a catastrophe, this reduces the attractiveness of an insurance product (Hallegatte et al. 2016).

To minimize its business risk, an insurer often buys a reinsurance policy from a reinsurer. Accurate data on several parameters for a long enough time period are required to build a robust risk profile. If such data are unavailable, insurance companies may sometimes find it difficult to more precisely and accurately plan their operations and, therefore, face the risk of incurring losses. The potential clients of the insurance product are usually poor farmers with the inability and willingness to pay the cost of the premium. Therefore, insurance companies cannot fully transfer the costs of these uncertainties to the farmers by including these costs in the premium. For an insurance company to be able to provide insurance services to its clients, the revenue collected (benefits) from premiums should be equal to or higher than the cost of organizing the insurance scheme and the compensation paid to farmers for the losses they incur due to floods, as per the insurance policy agreement.

The intensity of a disaster event and the extent of damage it can cause vary over different years. In chronically flood-affected areas such as parts of India and Bangladesh, floods of varying intensity occur almost every year. However, unlike in years when major floods occur and almost everyone in the catchment area is affected and suffers major crop losses, in years with moderate intensity flooding, the damages may be restricted to parts of the area and/or partial damage to crops in the entire area. Major floods can often come in succession. If that happens, insurance companies would be required to make huge payouts in successive years. However, if floods do not occur or affect only a portion of the catchment area, insurance companies will have to make payouts only to a section of the insured population and limited to the extent of crop damage. As in the case of farmers, to sustain their business, an insurance company must also take a long-term view of the costs and benefits of continuing to provide insurance services over an extended period, because natural disasters with a similar intensity may not occur every year.

The third stakeholder in the flood insurance scheme is usually the government, whose main concern is societal welfare. After a natural disaster strikes, the government is morally and legally bound to organize post-disaster relief and rescue operations, and provide immediate assistance to those affected. In such situations, the government uses its own resources supplemented by resources made available by international and bilateral donors and governments. Sometimes, individuals, religious organizations, local NGOs and philanthropies, either directly or in collaboration with the government, come forward to provide support to those affected. Often, due to having limited resources, government assistance is limited to providing immediate post-disaster relief (e.g., shelter, food, medicines, etc.) and an ad hoc amount to compensate for the infrastructural and economic losses suffered by individuals and communities. This compensation is usually far lower than the actual economic losses incurred by those affected, and this is paid several months after the disaster occurred and caused damages. In undertaking these operations, the government faces several challenges such as estimation of the actual losses, and in organizing and managing the distribution of relief aid. The system of aid distribution is often grossly inefficient and marred by corruption and undue delays. Further, given the uncertainty about the amount of money required for providing disaster relief in a year, in years of extensive damage, government spending is far greater than the funds allocated for this purpose in the budget. This disrupts budgetary provisions and impacts financial allocations to other sectors of the economy, with their attendant implications.

There has been substantial debate among stakeholders about the need for moving away from inefficient, uncertain, ad hoc, and ex post disaster relief practices to more efficient, determinate, and accurately estimated ex ante interventions in providing relief to those prone to and impacted by disasters and misery.[4] Government interest in promoting crop insurance lies in making, at least partly, such shifts possible by moving away from providing ex post disaster relief compensation to a relatively more efficient predetermined third-party

[4] While governments and policy makers have pondered over these questions, there are no easy answers. Very little empirical evidence is available to compare and assess the relative merits and demerits of ad hoc payments versus insurance subsidization. It has been argued that if in the judgement of the government it is socially desirable to have a large proportion of the population covered against a certain risk, introduction of subsidies can stimulate the demand for insurance. Additionally, it has been argued that subsidies are a possible way to counter the effects of adverse selection (Glauber 2004). It has also been argued that subsidization of insurance is a superior alternative to ubiquitous ad hoc disaster assistance in terms of costs to the taxpayer, and from a moral hazard perspective (Glauber 2004).

managed compensation distribution mechanism. For this purpose, the government often looks for opportunities to collaborate with those likely to be affected by natural disasters (such as farmers) and those who can provide risk cover against possible losses from such disasters (such as insurance service providers). By encouraging farmers to buy ex ante flood insurance and thereby transferring their risk of crop losses to the insurance companies, the government expects to move away from ex post distribution of compensation to ex ante insurance handled by a third party with the government overseeing implementation of the process.

To facilitate such a transition, the government provides incentives to both groups of stakeholders, i.e., those willing to buy insurance cover (farmers) and those willing to provide insurance cover (insurer). Given the high cost of the insurance premium and the inability and unwillingness of the poor farmers to pay the premium, the government generally provides some sort of financial support to farmers to moderate the cost of the premium and encourage more farmers to opt for insurance.[5] In addition, the government provides financial and administrative support to insurance companies to meet part of the cost of compensation payouts in years of heavy losses (as per the agreement with farmers), and/or partly contributes towards the administration costs of insurance companies. Thus, for the government to justify its continued involvement in promoting the move to crop insurance, the costs of encouraging such a move must be lower than the cost incurred otherwise in providing ex post compensation to those affected. As in the case of farmers and insurance companies, the government, while assessing its economics, must also take a long-term view of the costs and benefits and remain engaged over this period when those affected are compensated.

Thus, for a crop insurance scheme to sustain, the benefits (realized, expected, perceived or foreseen; quantifiable in monetary terms or otherwise) to each of the stakeholders must be higher than the costs incurred individually by each of them. Thus, a stakeholder would continue to participate in a crop insurance scheme if the conditions in Equation (1) are met.

$$(PVB)_{s,t} \geq (PVC)_{s,t} \quad \text{.....(1)}$$

Where:

$(PVB)_{s,t}$ = Present value of benefits for stakeholder s over the time period t (s = 1 for farmers, s = 2 for insurers, s = 3 for the government)

$(PVC)_{s,t}$ = Present value of costs for stakeholders over the time period t

Economic Analysis of Flood Insurance for Crops: The Formulation

In the domain of crop insurance, the extent of insurance cover (the sum insured) is generally determined either on the basis of the estimated value of crop output per hectare or on the cost of crop production per hectare. Given that these values could differ from one farm to another, the general practice has been to prescribe uniform values for the sum insured for all farmers within a given administrative region where subregions have the same agroclimatic conditions. In India, for example, these values are generally notified by a government agency and estimated on the basis of detailed data on the cost of cultivation and crop yields. The crops notified for coverage under the insurance scheme and values of these parameters vary from district to district (or any other geographical area defined as an insurance unit), and are determined by a local-level expert agency (such as the District Level Technical Committee [DLTC] and State Level Technical Committee [SLTC]).

Some of the variables used in equations throughout this paper are defined below:

I = Sum insured per hectare of the notified crop
D = Total number of farmers in the district (insurance region)
d = Fraction of farmers in the district who cultivate the notified crop for which insurance is provided
N = D*d = Number of farmers in the district who cultivate the notified crop
C = Total land area under the insured crop in the district (hectares)
C/N = Average area under the notified crop cultivated per farmer (ignoring the differences in size distribution of farmers)
A = The estimated actuarial premium rate (%) for providing insurance cover for the sum insured (I)
$\alpha * I$ = The total insurance premium payable per hectare

[5] A rationale consistently given is that the provision of subsidies for agricultural insurance helps to increase participation in crop insurance and thereby reduces the need to provide ad hoc disaster assistance for crop damage. Has the increase in subsidies on insurance led to a reduction in ex post disaster assistance? Limited empirical evidence available suggests that in the United States of America (USA), over the past decade, there has been a dramatic increase in the purchasing of crop insurance along with reduced federal use of ex post disaster assistance. Again, while this correlation is interesting, it is insufficient to unambiguously prove that higher insurance purchasing has caused reduced federal reliance on ex post disaster assistance (Coble and Barnett 2013).

Economics of Insurance: Insurance Company Perspective

The gross revenue of an insurance company (GRI) for one crop season is equal to the premiums it collects from the insured farmers for providing coverage against crop damage, as shown in Equation (2).

$$GRI = N * C/N * \alpha * I \quad (2)$$

The cost to the insurance service provider consists of (i) the cost of organizing insurance operations, including administering and managing the various activities associated with implementation of the insurance scheme; and (ii) compensating farmers for crop losses in accordance with the terms and conditions in the insurance policy agreement.

The variable T is defined below:

T = Average overhead costs per season (including commissions paid) for organizing insurance operations for a particular district. This cost would vary depending on the number of farmers buying insurance

The second component of costs to the insurer is the compensation payouts to insured farmers for crop losses incurred due to floods. The extent of crop losses is determined by the proportion of the crop area of insured farmers that is impacted by floods, stage of crop growth, depth of inundation, and duration of flooding. Since IBFI is an index-based insurance, it does not take the individual farmer as a unit for measuring crop losses due to floods and paying compensation. In the case of IBFI, if the crop losses in a given unit area exceed a certain predefined threshold level, all farmers get compensation at the predefined level.

Even though floods may occur frequently in a given region, these may not occur every year and/or may not affect the same areas or same set of farmers each year. The economics of providing insurance against floods in a given year will vary depending on whether floods occur during the year or not, the proportion of farmers that get impacted and the extent of loss incurred by farmers. In a year when floods do not occur or if the flooding does not cause damage to the extent that insurance companies have to compensate farmers for the losses, the insurance companies may walk away with substantial profits. On the contrary, if in a given year, floods cause widespread damage and extensive crop damage, insurance companies may have to pay a considerable amount as compensation and they may experience substantial losses. Given the uncertainty in the occurrence of floods in a given year, it is important when assessing the economics of flood insurance to also consider a long enough time period to account for fluctuations in variables that impact the year to year economics.

The variables used in Table 1 are defined below:

F_1 and F_2 = Two different flooding scenarios representing the periodicity of floods over a period of t years. Scenario F_1 represents a flooding scenario where floods occur with a periodicity of twice in five years. Scenario F_2 represents a flooding scenario where floods occur every alternate year

DS_1, DS_2 and DS_3 = Three alternative but identical crop damage scenarios associated with each of the two flooding scenarios

Θ_i ($i = 1, 2, 3$) = Percentage of insured farmers impacted by floods corresponding to crop damage scenarios DS_1, DS_2 and DS_3

Θ_{ij} ($i = 1, 2, 3$; $j = 1, 2, 3$) = Percentage of insured farmers impacted by floods incurring different intensities of crop damage

μ_k ($k = 1, 2, 3$) = Percentage of the sum insured (I) payable per hectare as compensation by the insurance company to the insured farmers (subject to the limit imposed by indemnity level) corresponding to the three levels of crop damage (Θ_{ij})

The impacts of flooding are explained clearly in Table 1. Table 1 provides details of alternative flooding scenarios, crop losses associated with each scenario, alternative combinations in which flooding-crop damage scenarios may occur, proportion of farmers impacted and the percentage of sum insured payable as compensation to these farmers.

Table 1. Alternative scenarios related to flooding periodicity, crop damage, farmers impacted, and the percentage of sum insured payable as compensation corresponding to different levels of crop damage.

Flooding Scenario (F)	Crop Damage Scenario (DS)	Flooding Scenario-Crop Damage Scenario (F-DS)	Percentage of insured farmers impacted by floods	Percentage of insured farmers impacted by floods incurring crop damage			Percentage of sum insured payable as compensation to farmers incurring crop damage		
				Severe	Substantial	Moderate	Severe	Substantial	Moderate
F_1	DS_1	F_1-DS_1	θ_1	θ_{11}	θ_{12}	θ_{13}	μ_1	μ_2	μ_3
F_1	DS_2	F_1-DS_2	θ_2	θ_{21}	θ_{22}	θ_{23}	μ_1	μ_2	μ_3
F_1	DS_3	F_1-DS_3	θ_3	θ_{31}	θ_{32}	θ_{33}	μ_1	μ_2	μ_3
F_2	DS_1	F_2-DS_1	θ_1	θ_{11}	θ_{12}	θ_{13}	μ_1	μ_2	μ_3
F_2	DS_2	F_2-DS_2	θ_2	θ_{21}	θ_{22}	θ_{23}	μ_1	μ_2	μ_3
F_2	DS_3	F_2-DS_3	θ_3	θ_{31}	θ_{32}	θ_{33}	μ_1	μ_2	μ_3

With sparse geographically disaggregated, historical, micro-level data available on various flood parameters and associated crop losses, coupled with uncertain climate change conditions, determining the probability of flood occurrence, its timing and intensity with a fair degree of accuracy is difficult. As a result, the costs that the insurer may have to incur in making payouts to farmers as compensation for crop losses cannot be estimated fairly accurately in advance. During a particular crop season, floods may not occur at all, may occur and inundate and damage the entire crop area, or may occur and partly inundate the crop area for varying lengths of time. In each case, the extent of crop damage and, therefore, the payouts from the insurer will differ. Depending on the values of the parameters Θ and μ under different flooding scenarios, the payouts by the insurance company will vary. The cost of payouts by the insurance company per crop season for a given flooding and crop damage scenario is shown in Equations (3) and (4).

$$COI = C/N * N * \Theta i * (\Sigma\Sigma\Theta_{ij} * \mu_k)$$
$$i = 1, 2, 3; j = 1, 2, 3; k = 1, 2, 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Assuming that the insurance company has no other insurance activities in the region of operation and it does not cross-subsidize its losses from this activity from other operations elsewhere, it will be economical for the insurance company to continue to provide insurance cover over a defined period t if:

PV (Gross premium collected) – PV (Operational costs + Cost of payouts to farmers) ≥ 0

$$PV(GRI)_t - PV(COI + T)_t \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Economics of Insurance: Farmer's Perspective

Cost to the Farmer

The cost involved in a farmer buying an insurance policy consists of the cost of the premium as determined by the insurer minus the government subsidy, if this is applicable to the premium, and the cost of foregone revenue the farmer could have earned by investing the money spent on buying insurance in other yield-enhancing activities. The availability of a premium subsidy makes buying insurance more affordable for the farmer and could incentivize more farmers to opt for insurance. Assuming the costs of foregone revenue the farmer could have earned by utilizing the money spent on paying the premium in an alternate way as being negligible, the per season cost to the farmer of buying an insurance policy in the absence of any government subsidy on the premium is shown in Equation (5).

$$COF = \alpha 1 * I * C/N \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Benefits to the Farmer

The farmer benefits from crop insurance when money is received from the insurance company as compensation for crop losses that occur due to floods as per the terms and conditions of the insurance agreement. The amount of compensation will vary depending on the flood characteristics, crop area impacted by floods, resultant crop losses incurred, and the trigger value for determining the level of compensation payment. The benefit per farmer per crop season is shown in Equations (6) and (7).

$$GRF = Y_i * \mu_k * I * C/N \quad \textit{where}: k = 1, 2, 3 \ldots\ldots\ldots (6)$$

It is economical for a farmer to buy insurance and continue to remain insured over a period of time t, if:

$$PV(GRF)_t - PV(COF)_t \geq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Economics of Insurance: Government's Perspective

Cost to the Government

The cost to the government in providing insurance cover for crop losses due to floods comprises of three components: (i) administrative costs in providing support to the other stakeholders and organizing the insurance business process (including framing of procedures, rules, regulations, etc.), supporting collection and making available relevant data for use by insurance companies and other stakeholders, overseeing the implementation, and ensuring compliance and safeguarding the interests of different stakeholders; (ii) providing a premium subsidy to those farmers who want to buy insurance but cannot afford to pay the full cost of the premium; and (iii) helping insurance companies with procuring reinsurance or in reimbursing the cost of payouts (beyond the indemnity level of compensation) in years of heavy losses, etc.

Some of the variables used in equations throughout this paper are defined below:

G = Per season average administrative cost per insurance district incurred by the government in organizing an insurance activity, overseeing its implementation and in covering other miscellaneous costs such as providing data, etc.

β = Fraction of farmers cultivating the insured crop who require a government subsidy

α1 = Percentage of the sum insured payable as premium by the farmer

α1 * I = Premium payable per hectare by the farmer for insuring the crop

$(\alpha - \alpha_1) * I$ = Government subsidy payable per hectare towards the insurance premium

Per season cost to the government in providing a subsidy towards the insurance premium for insured farmers requiring a subsidy is shown in Equation (8).

$$COG = \beta * N * C/N * (\alpha - \alpha_1) * I \quad \text{..... (8)}$$

Total per season cost to the government (COG) in providing insurance is shown in Equation (9).

$$COG = G + \beta * N * C/N * (\alpha - \alpha_1) * I \quad \text{..... (9)}$$

Benefits to the Government

One of the overarching goals of the crop insurance program has been the reduction in or elimination of providing ad hoc post-disaster assistance. By investing in crop insurance, the government, therefore, expects to move away from the practice of providing ad hoc ex post compensation to partially or fully cover the crop losses incurred by farmers. The benefit to the government, therefore, is a reduction in or elimination of expenses on (i) administering an ex post relief distribution program; and (ii) providing ex post, ad hoc financial compensation to farmers to partly mitigate the losses incurred as a result of crop damage. Through the provision of crop insurance, the government, however, does not expect to save much in providing ex post relief distribution and immediate assistance to all those affected.

Some of the variables used in equations throughout this paper are defined below:

E = Administrative costs incurred by the government in administering an ex post compensation distribution program to farmers for crop losses per season per district

$\underset{\cdot}{p}$ = Percentage of farmers incurring major crop losses due to floods and, therefore, eligible for compensation from the government

m = Compensation provided by the government per crop per hectare to farmers incurring major crop losses due to floods

Total benefits to the government (BOG) per season per district = Savings in cost to the government in administering an ex post compensation distribution program for farmers incurring crop losses due to floods is shown in Equations (10) and (11).

$$BOG = E + \underset{\cdot}{p} * N * C/N * m \quad \text{..... (10)}$$

For the government to continue to be involved in the insurance business, the benefits in terms of a reduction in the administrative costs for post-disaster compensation distribution to farmers for crop losses must be higher than the costs incurred by the government (in providing a subsidy to farmers and support to the insurer). Thus, encouraging the move to providing ex ante crop insurance is beneficial from the government's perspective if over a period of time t:

$$PV(BOG)_t - PV(COG)_t \geq 0 \quad \text{..... (11)}$$

Factors that Can Impact the Sustainability and Viability of Flood Insurance

While the success of a flood insurance scheme depends on several factors, two important parameters that can significantly impact the outcome of the scheme and its sustainability are the values of t (time frame over which the costs and benefits are assessed and measured) and N (number of farmers who enrol in the insurance scheme).

In general, the damage caused by floods would be minimal in some years, but the damage could be extremely high in other years. The probability of occurrence of floods of different intensities and consequently the magnitude of damage they may cause are not known with any degree of certainty. With such a risk profile, it is difficult to identify an optimal time period over which the costs and benefits should be evaluated? The years when large claims are made for flood damage will have a dominating influence on the analysis. For a flood event that has an annual probability of 1 in 30 or 1 in 50, consideration of data from even two decades is insufficient to accurately assess whether the prices are matching the risk. Thus, depending on the value assigned to t, the outcome can differ significantly.

An associated problem with the value given to t is how it is perceived differently by various stakeholders. If various stakeholders value t differently, it may be difficult to sustain flood insurance over a longer period. In general, if there is no flood-related damage and no insurance claims are received by farmers in a few consecutive years in the short term, farmers usually lose interest in buying insurance and there is a strong tendency to discontinue buying insurance, unless they are compelled to do so by law or it is mandated as a precondition for availing some other benefits from the government. In contrast, the other stakeholder, the insurance provider, would generally like to engage over a longer time period unless government regulations forbid them from doing so beyond a specific time period. The third stakeholder, the government, is often not very clear about the usefulness of engaging over different extended time periods, but would nevertheless be willing to engage over a long enough period of time for, besides other reasons, political compulsions.

The second important parameter that impacts both the viability of the insurance scheme as well as the economics of crop insurance is the number of farmers in a region willing to buy flood insurance. Information available suggests that crop insurance has generally been associated with low penetration rates, implying that only a few of the potential number of farmers in a region enrol for crop insurance. There could be many reasons for low enrolment in crop insurance: high cost of the insurance premium and the inability or unwillingness of poor farmers to pay this cost, unfair business practices by the insurer, delays in the payment of compensation, etc. However, it is important to underline that for an insurance provider to continue to provide insurance in a given region, it must have a critical minimum number of clients to insure. This lower bound on the number of clients will vary from region to region depending on the circumstances prevailing, and it is difficult to specify a constant number of clients for all locations and across different insurance products. While in some countries crop insurance is compulsory for all farmers, it is voluntary in others. Some countries follow a mix of the two approaches: crop insurance is compulsory for a section of the farmers while optional for others.

Economics of Index-based Flood Insurance (IBFI)

The methodological framework described above for assessing the economics of flood insurance has now been used to demonstrate the economics of IBFI. As mentioned earlier, IBFI is yet to be operationalized in the field, although pilot testing of the scheme has recently been undertaken (2017 *kharif* season) in selected areas of Bihar state in India. Aheeyar et al. (2019, 2020) presented some of the preliminary findings from IBFI implementation in 2018 and 2019. Some of the findings from these studies have been summarized in Appendix 2.

In India, for example, it is envisaged that IBFI will be introduced as a specialized insurance product in flood-prone areas of the country within the flagship crop insurance scheme *Pradhan Mantri Fasal Bima Yojana* (PMFBY), which was started recently by the Government of India (GoI) to provide comprehensive insurance cover to farmers for crop losses incurred due to several reasons (see Box 1 for the salient features of PMFBY). IBFI is, therefore, envisioned to broadly follow the same administrative and procedural practices as those prescribed for PMFBY. It is important to keep this in mind while trying to evaluate the economics of IBFI and in addressing the diverse methodological complexities in assessing the values of various parameters required for estimating the costs and benefits. We briefly elaborate on some of the relevant issues of PMFBY that could have a bearing on assessing the economics of IBFI.

Compulsory Versus Optional Flood Insurance

As discussed previously, the entire crop insurance industry depends crucially on the number of farmers opting to buy insurance. Given the generally high premium rates for crop insurance and the usually low ability/willingness of poor farmers to pay the cost of the premium, despite the availability of the government subsidy on the premium, farmers are often not keen to buy insurance. To ensure that a sufficient number of farmers register for crop insurance, the government has made agricultural insurance compulsory for those farmers who take crop loans from institutional sources (such farmers are referred to as loanee farmers) and voluntary for those outside of the formal credit system (such farmers are referred to as non-loanee farmers). Making insurance compulsory helps to reduce adverse selection compared to optional selection. However, a vast majority of small, marginal and tenant farmers, and sharecroppers either do not or cannot have access to institutional credit facilities for a variety of reasons. Thus, making agricultural insurance, including flood insurance, optional carries the risk of leaving out a large section of vulnerable people. While the government subsidy is available for all farmers willing to buy insurance (loanee and non-loanee), buying insurance is voluntary for non-loanee farmers. Some of the available evidence suggests that only 5% of non-loanee farmers (excluding the states of Maharashtra and West Bengal) enrolled in the PMFBY scheme in the *kharif* season of 2016 (Bhushan and Kumar 2017).

Thus, for an insurance company willing to provide insurance services in a given region (district), the assured customer base is, at most, equivalent to the number of farmers taking loans from institutional sources. The insurer does not have to put in much effort to get this minimum number of farmers on board. However, the extent to which the insurer can increase its customer base depends on how much effort it is willing to put in to enrol non-loanee farmers. Achieving this will involve developing innovative marketing strategies, building partnerships, winning farmer confidence and incentivizing non-loanee farmers to enrol for insurance. The implication of not being able to enrol a sizeable number of non-loanee farmers will impact the insurer's customer base, and can influence the fixation of premium rates and therefore its business operations and profitability.

Box 1. Salient Features of the *Pradhan Mantri Fasal Bima Yojana* (PMFBY) scheme.

Coverage of farmers: All farmers, including sharecroppers and tenant farmers, growing notified crops in the areas eligible for coverage. Compulsory for all farmers taking out Seasonal Agricultural Operation (SAO) loans from financial institutions (i.e., loanee farmers) for notified crops and optional for non-loanee farmers.

Coverage of crops: Food crops (cereals, millets and pulses), oilseeds, annual commercial/horticultural crops.

Coverage of risks: For risks to sowing and planting and standing crops (sowing to harvesting), comprehensive risk insurance is provided to cover yield losses due to unpreventable risks, such as drought, dry spells, floods, inundation, pests and diseases, landslides, natural fire and lightning, storms, hailstorms, cyclones, typhoons, tempests, hurricanes and tornados, postharvest losses, and localized calamities.

Levels of indemnity: Three levels of indemnity, i.e., 70%, 80% and 90% corresponding to high, moderate and low risk levels are available for all crops.

Level of sum insured: Sum insured per hectare for both loanee and non-loanee farmers is the same and equal to the scale of finance as decided by the DLTC. The sum insured for irrigated and non-irrigated areas may be separate.

Premium rates: The Actuarial Premium Rate (APR) to be charged by the implementing agency (IA). The rate of insurance charges payable by the farmer are capped by the government.

Use of Area approach: The scheme operates on the basis of the 'area approach', i.e., defined areas for each notified crop for widespread calamities. The insurance unit is the village/village *panchayat* (council) or any other equivalent unit for major crops. For other crops, it may be a unit above the village level.

Intermediary commission: The bank and other financial institutions to be paid service charges at 4% of the premium collected from farmers. Rural agents engaged in providing insurance-related services to farmers to be paid appropriate commission as decided by the insurance company, subject to a cap prescribed under the Insurance Regulatory and Development Authority (IRDA) of India regulations.

Release of subsidy: The government to release 50% of the total estimated premium subsidy to impanelled insurance companies at the beginning of the crop season on the basis of business projections submitted by each insurance company.

Reinsurance: The insurance company to take all necessary steps to obtain appropriate reinsurance cover for their portfolio. In cases where the premium-to-claims ratio exceeds 1:3.5 or the percentage of claims to the sum insured exceeds 35% (whichever is higher) at the national level in a crop season, then the government will provide protection to IAs. The losses exceeding the above-mentioned level in the crop season would be met by equal contributions from the central government and relevant state governments. The liability of payment of all claims shall be of the concerned IAs only. In the case of non-fulfilment of the above-mentioned condition, insurers shall be responsible for settling admissible claims in states where losses exceed the above ceiling.

Technology: Use of innovative technologies such as satellite imagery to rationalize crop cutting experiments.

Source: PMFBY 2016.

Level of Sum Insured and Provision of Government Subsidy on Insurance Premium

Given the low ability/willingness of a majority of the farmers to pay the insurance premium, the government fixes the amount of the premium payable by farmers. Under the PMFBY scheme, the government has fixed a premium of 2% of the value of the sum insured to be paid by farmers for all *kharif* crops, 1.5% for all *rabi* crops, and 5% for annual commercial and horticultural crops or the actuarial premium rate, whichever is less. The remaining amount of the premium is paid by the government as a subsidy. The subsidy amount is shared equally by the central and the concerned state government. All farmers (both loanee and non-loanee) who opt to buy insurance are eligible for the premium subsidy; there is no upper limit on the government subsidy for the actuarial premium rate.

The sum insured[6] per hectare for both loanee and non-loanee farmers is the same and equal to the scale of finance (equal to the cost of cultivation plus some profit). This amount is decided by the DLTC and is predeclared by the State Level Coordination Committee on Crop Insurance (SLCCCI) and notified accordingly. The sum insured for an individual farmer is, therefore, equal to the scale of finance per hectare multiplied by the area of the notified crop proposed by the farmer for insurance cover.

Demarcation of the Insurance Region and Time Period for Providing Insurance Services

As per the PMFBY guidelines, it has been suggested that for effective implementation of the scheme, a cluster approach may be adopted under which a group of districts with variable risk profiles can be allotted to an insurance company through competitive bidding for a period of up to 3 years. However, different states have slightly altered these guidelines to suit local conditions prevailing on the ground. In the flood-prone state of Bihar, for example, district-level contracts for only one crop season are being given to various insurance companies following the process of competitive bidding. We envisage that IBFI, when implemented in Bihar, will also be contracted for one crop season.

With insurance contracts being given out for only one crop season leaves the insurer in a very ambiguous situation to take on the role of a risk guarantor. Usually, in the insurance industry, the commercial risks for an insurer evens out when it continues to engage in the provision of services over a reasonably long period of time (seasons/years). In the case of IBFI, where insurance contracts are likely to be given on a per season basis, such a leeway does not exist. In a given season, if severe floods occur in the area where an insurance company operates, it may need to make heavy payouts to those insured and may experience losses, which it may or may not be able to recover depending on whether it gets selected to provide insurance cover in the next season. On the contrary, if floods do not occur during a particular season and the insurer does not have to make significant payouts, it could walk away with substantial profits. Due to the unavailability of fairly reliable data for estimating the probability of occurrence and intensity of floods with a fair degree of accuracy, this small tenure for providing insurance services could be a risk for the insurer. As a result, the insurance company may be fixing premium rates at a level higher than what it would have otherwise charged for an assured contract for providing insurance services for a longer period of time.

The time period an insurance company provides insurance services is one crop season. However, this is not the case for the other two stakeholders – the farmers and the government. The farmer will continue to receive insurance cover from one crop season to another, irrespective of which insurance company is selected by the government to provide these services. Similarly, from the government's perspective, the insurance services and premium subsidy will continue to be made available to the farmer from one crop season to another irrespective of which insurance company is selected to provide insurance services. Thus, while the farmer and the government can take a medium- to long-term view of the costs and benefits of buying and provisioning insurance cover from one crop season to another, the insurance company can only take a short-term view of one crop season due to the uncertainty of it being selected to provide insurance in the same district in the following crop season.

[6] It is important to highlight the difference between the sum insured and the level of indemnity in insurance parlance. The sum insured is based on the cost of cultivation and is at least equal to the loans disbursed. Often, the state government decides the sum insured for various crops for a district within the state. The sum insured can extend up to the value of the threshold yield. The sum insured is stated in the policy schedule and implies the amount which shall represent the company's maximum liability for any and all claims incurred under the policy. Three levels of indemnity, i.e., 90%, 80% and 60% corresponding to low-, medium- and high-risk areas, respectively, are generally available to farmers for all crops. This implies that the farmers themselves have to bear the loss of the first 10%, 20% and 40% in low-, medium- and high-risk areas, respectively. This situation is generally referred to as 'deductible'.

Economics of Index-based Flood Insurance: A Hypothetical Case Illustration from Bihar (India)

As mentioned earlier, IBFI is yet to be operationalized in the field. Therefore, due to the unavailability of data at this stage, it is difficult to demonstrate how the economics of IBFI would impact the three groups of stakeholders: farmers, insurers and the government. This will depend on several factors: (i) number of farmers that opt for IBFI, (ii) value of t (time period) over which the economic analysis is being undertaken, (iii) premium rates, (iv) discount rate chosen, (v) frequency of floods of different intensities occurring over the time period being considered, (vi) proportion of insured farmers that are impacted, (vii) proportion of crop area impacted and the extent of crop losses incurred, and (viii) amount of compensation associated with different levels of crop damage, etc. However, to empirically demonstrate how the economics could be assessed, we developed a hypothetical case synthesizing data from similar and related sources (different government websites, other published/unpublished sources, insurance companies, IRDA, and other informed estimates), and used some guesstimates on the values of those parameters for which no distant or related data source was available. The results derived may thus be seen as being more indicative in nature for demonstration of the methodology, which can of course be improved as better and more detailed data become available.

We base our hypothetical case study in Katihar, a flood-prone district in the state of Bihar, India. Data on some of the relevant parameters in this district, readily available from some of the official publications and relevant studies, and some derived on the basis of informed estimates are given in Table 2.

Table 2. Hypothetical basic data for Katihar district, Bihar, India.

Items	Unit	Value	Remarks/source
Total number of farmers	No.	420,293	Government of Bihar
Number of farmers cultivating rice	No.	336,234	Assumed to be 80%
Total area sown under the rice crop 2015-2016	Ha	104,234	Government of Bihar
Average area under the rice crop per farmer	Ha	0.31	Calculated
Number of rice farmers insured under the PMFBY scheme (9.02%)	No.	30,328	PMFBY 2016
Number of loanee farmers insured under the PMFBY scheme	No.	29,850	PMFBY 2016
Number of non-loanee farmers insured under the PMFBY scheme	No.	478	PMFBY 2016
Sum insured per hectare	INR	44,000	Cholamandalam MS General Insurance Company Limited
Actuarial premium rate	%	18.90	Actual for *kharif*; PMFBY 2016
Total sum insured	INR	413,683,899	Calculated
Share of premium payable by farmer per hectare (2% of sum insured)	INR	880	Calculated
Premium paid by the government per hectare (subsidy)	INR	7,436	Calculated
Indemnity level (70%)	INR	30,800	Calculated
Total premium collected by the insurer	INR	78,186,257	Calculated
of which			
Payments made by farmers	INR	8,273,678	Calculated
Government subsidy	INR	69,912,579	Calculated

As discussed earlier, we consider two different flooding scenarios and three flood damage scenarios. Given the uncertainty about the periodicity with which flooding occurs, we consider two flooding scenarios (F1 and F2) with different patterns of flooding over the study period. In scenario F1, we assume that flooding occurs twice in a five-year period. In scenario F2, we assume that flooding occurs every alternate year. For each of the two flooding scenarios, we consider three crop damage scenarios: DS1, DS2 and DS3. In scenario DS1, we assume that in each flood year, 50% of the insured farmers are impacted by floods. Of the impacted farmers, 60% incur crop losses to the extent that entitles them to compensation of 100% of the sum insured; 20% of the farmers impacted by floods incur crop losses to the extent where insurance claims are equivalent to 70% of the sum insured, and the remaining 20% of farmers incur crop losses which are below the threshold level of compensation and are not entitled to any compensation. To illustrate this further, of the 100 farmers who received insurance cover, 50 incurred crop losses. Of these 50 farmers affected, 30 received full compensation for the sum insured, 10 received compensation equivalent to 70% of the sum insured, and the remaining 10 did not receive any compensation because their losses were below the threshold level fixed for determining payment of compensation. The corresponding values for scenarios DS2 and DS3 were similarly defined and are given in Table 3. Since IBFI is based on an 'area approach', even if the floods in the area do not adversely impact all the farmers the same way, all the farmers still receive compensation from the insurance company.

Table 3. Crop damage and loss compensation scenarios.

Damage Scenario	Fraction of insured farmers impacted	Of the impacted farmers, fraction eligible for full compensation	Of the impacted farmers, fraction eligible for 70% compensation	Of the impacted farmers, fraction not eligible for any compensation
DS1	0.5	0.6	0.2	0.2
DS2	0.6	0.4	0.2	0.4
DS3	0.4	0.7	0	0.3

For examining the economics from the government perspective, somewhat different assumptions have been made. In practice, when compensating farmers ex post for the losses they incur, the government does not follow the area approach used in IBFI. It only compensates those farmers who have actually been impacted. Further, the government's ex post compensation does not vary according to the proportion of crop loss incurred, but is fixed on a per hectare basis irrespective of the area of actual crop loss. Thus, if the area of crop loss is greater than a certain value, all the affected farmers are paid an equal compensation per hectare. We assume that the government does not provide any ex post compensation if the area of loss is below those associated with damage scenario DS3, and provides equal compensation per hectare for losses equal to or greater than those associated with damage scenario DS2.

The Government of Bihar has been issuing contracts to insurance companies for one season under the PMFBY scheme. It is likely that contracts for the same duration will be issued for IBFI. When assessing the long-term economics of IBFI, it is important to take a medium- to long-term view. We assume that the value of t (time period) is 20 years, although any other value for t can be considered. As discussed earlier, we consider two flooding scenarios F1 and F2 with different periodicities of flooding (Table 4). Given the uncertainty about the intensity of flooding in each defined year when floods occur over this 20-year period, we assume that floods of equal intensity occur in each of the years.

Table 4. Flooding scenarios with years when floods occur and do not occur.

Year	Flooding Scenario F1	Flooding Scenario F2
1	0	1
2	1	0
3	0	1
4	0	0
5	1	1
6	0	0
7	0	1
8	1	0
9	0	1
10	1	0
11	0	1
12	1	0
13	0	1
14	1	0
15	0	1
16	0	0
17	1	1
18	0	0
19	1	1
20	0	0

Note: 1 – a year when floods occur; 0 – a year when no floods occur.

We also assume that all other parameters such as the number of farmers buying insurance, crop area, insurance premium, subsidy levels, etc., will remain unchanged over this 20-year period. We consider a discount rate[7] of 6% to convert the monetary stream to present value terms.

Based on the above assumptions, we assess the economics of IBFI from the perspective of the three groups of stakeholders. In the case of an individual farmer (with 0.31 hectares [ha] of land under the insured crop), we compare the cost of buying insurance with the compensation they are likely to receive from the insurer if the flood events and crop damages occur as specified. In the case of an insurance company, we compare the district-level cost to an insurance company[8] engaged in providing insurance in Katihar district with the revenue received from insured farmers and subsidies provided by the government. In the case of the government, we essentially compare the cost of providing subsidies on the insurance premium to farmers who enrol for insurance with the cost of providing ex post compensation in the traditional way up to the funds allocated for this purpose. Generally, the funds allocated for providing ex post compensation are far lower than the cost of the premium subsidy that the government is willing to provide (the cost of the premium subsidy is divided between the state and central government). The economics of IBFI from the perspective of the three groups of stakeholders under flooding and crop damage scenarios are presented in Table 5.

[7] The discount rate refers to the interest rate used in the discounted cash flow (DCF) (https://www.investopedia.com/terms/d/dcf.asp) analysis to determine the present value of future cash flows. Here, we have used a discount rate of 6% to reflect the bank interest rate in the study area. A sensitivity analysis can be conducted around this number to test the robustness of the results derived.

[8] Estimation of overhead costs at the district level is difficult because the insurance companies generally operate at a countrywide level. The general practice is to estimate the total overhead costs of the company for crop insurance as a proportion of the gross premium collected and use the same ratio for the district-level costs.

Table 5. Economics of IBFI from the perspective of the three groups of stakeholders under two flooding and three crop damage scenarios.

Flooding Scenario - Damage Scenario/Stakeholder perspective		
Farmer	Net present value (cost) (INR)	Net present value (benefits) (compensation) (INR)
F1-DS1	10,094	30,446
F1-DS2	10,094	30,446
F1-DS3	10,094	30,446
F2-DS1	10,094	37,054
F2-DS2	10,094	37,054
F2-DS3	10,094	37,054
Insurance company	Net present value (cost) (INR millions)	Net present value (benefits) (revenue) (INR millions)
F1-DS1	492	897
F1-DS2	433	897
F1-DS3	374	897
F2-DS1	598	897
F2-DS2	527	897
F2-DS3	455	897
Government	Net present value of cost (in providing a subsidy on insurance premium) (INR millions)	Net present value of savings (in providing ex post compensation) (INR millions)
F1-DS1	842	171
F1-DS2	842	154
F1-DS3	842	119
F2-DS1	842	208
F2-DS2	842	187
F2-DS3	842	145

Note: The average exchange rate during 2016 was approximately USD 1 = INR 67.18.

From the perspective of an individual farmer, the amount received as compensation for crop losses from the insurance company far exceeds the cost incurred to pay the premium. From the perspective of the insurance company, the district-level estimates of revenue earned exceeds the costs incurred, although the margin between the two changes depending on the flooding-damage scenario that occurred. From the perspective of the government, the cost of providing a subsidy on the insurance premium far exceeds the costs it would incur to provide ex post compensation[9] to those farmers who incur crop losses, although the level of compensation to those affected would differ in the two cases.

As already emphasised, the above costs and benefits are for demonstration purposes only and are explicitly valid only for the values of various parameters assumed in deriving these values for the flooding and crop damage scenarios. Any change in the value of any underlying parameter will change the outcome of the benefits and costs and, therefore, the validity of inference drawn about the economics of insurance. These estimates need to be reworked when better data are available and a final decision about the economics of IBFI could be taken.

[9] Very few empirical studies are available to demonstrate the relative costs to the government in providing ex post versus ex ante support. In a recent study comparing the efficacy of ad hoc crop assistance with the insurance subsidy program in the USA, Zulauf (2016) reported that over the period 1990–2008, spending on crop insurance premium subsidies averaged 1.3% of the value of US crop receipts while spending on ad hoc crop disaster assistance averaged 0.9%. Further, during the 2014 and 2015 fiscal years, while nothing was spent on ad hoc crop disaster assistance, spending on premium subsidies averaged 3.1% of the value of crop receipts. Comparing the two periods, spending on ad hoc crop disaster assistance declined 0.9 percentage points but spending on premium subsidies increased 1.8 percentage points, or twice as much. This simple measure calls into question whether crop insurance is cheaper than ad hoc crop disaster assistance.

Conclusions: Economic Viability of Flood Insurance and Beyond

The financial and economic analysis of any mediation to achieve the stated end objective is important in deciding the appropriateness of the intervention. However, such an analysis obviously has its limitations and methodological confines and, therefore, cannot form the sole basis for decision-making. Decision-making involves consideration of factors beyond the realm of economics. Quite often the non-quantifiable, non-economic impacts and contributions of the intervention being evaluated can far outweigh the quantifiable, economic impacts accounted for in undertaking the economic analysis. Therefore, such impacts need careful consideration before arriving at a final decision.

Notwithstanding the outcome of the economics of flood insurance, access to insurance serves at least two other important useful purposes: (i) it contributes significantly to providing stability to agricultural production and farm incomes, and to enhancing social welfare; and (ii) it encourages the application and use of newer developments in science and technology and advanced methods of information gathering to better prepare and deal with problems related to vagaries of weather and climate variability and their impact on agriculture, and in helping to improve resource use efficiency.

A majority of landholdings in developing countries are small and these small pieces of land generally form the only source of livelihood for a large section of society. The produce from these small pieces of land is barely sufficient for farmers to provide for their families' food requirements, and sometimes there is a marginal surplus to pay off their crop loans, thereby making them eligible for availing fresh credit for cultivation in the next season. However, this only occurs in disaster-prone areas in years when weather conditions are favorable, because these areas are continuously exposed to the vagaries of weather. In years when extreme weather events (droughts, floods, etc.) occur, farmers could lose a significant proportion of their crop, seriously impacting their families' survival and their ability to repay crop loans. As a result of defaulting on loan repayments, a farmer cannot avail fresh credit to buy inputs for sowing the next crop, leading to reduced crop productivity in the next season. Frequent crop failures lead to increased poverty and debt burden, resulting in farmers falling into a debt trap, which could lead to farmer suicides. Such a scenario can also result in the increased vulnerability of rural financial institutions.

With farmers' fortunes closely related to the vagaries of weather, they choose to act wisely to minimize any risk. A farmer has little incentive to adopt yield-enhancing inputs and invest in newer technologies. To minimize the risks faced by farmers and encourage the adoption of yield-enhancing technologies, farmers have to be assured compensation for crop losses that may occur due to factors beyond their control. Making available risk mitigating and risk transfer opportunities, such as through crop insurance, not only provides protection to the farmer against crop losses, but it also provides peace of mind. This could encourage farmers to adopt improved cultivation practices and optimally use the available resources, leading to improved and stabilized farm productivity and increased farm incomes. The stabilized farm production of smallholder farmers as a whole helps provide stability and security to national food production even in years of unfavorable weather.

In addition to providing direct protection to the farmers, the availability of insurance has several backward and forward multiplier impacts on the rural economy. Provision of compensation against crop losses helps improve the farmer's buying power, which indirectly impacts the entire village community and local economy – rural industry, markets, trade, labor, etc. – through strong inter-sectoral linkages. With the compensation received from insurance companies, farmers can repay the crop loans taken from financial institutions, thereby reducing the loan repayments and also strengthening the rural financial infrastructure.

Access to insurance also encourages the use of advanced technologies, hitherto considered outside the realm of agriculture, and in synergizing the expertise available in agricultural, nonagricultural, and public and private sectors to help better prepare and deal with the impacts of climatic uncertainties on farmers' incomes and agricultural production. New insurance business processes require the extensive use of advanced technologies and advanced methods of information gathering, including remote sensing data, plot-specific geo-tagged crop growth data, and crop production data from government departments, in order to create a crop vegetation index to precisely determine the potential crop yield of huge swaths of land. With access to such advanced information, insurance companies and governments can remotely, quickly and accurately determine the potential crop yield on a farm. This will help to set the premiums for crop insurance by looking at an image of the vegetation coverage. Also, insurance companies can quickly determine the potential crop area that was damaged and lost after a flood, drought or other disaster event. Not only can they measure the extent of crop damage, but the specific location in the village or farm can also be identified. This will help to very quickly determine the insurance payout for each area, thereby increasing the confidence of the farmers in insurance companies and encouraging farmers to continue with the insurance scheme and transfer the risk of crop damage to the insurer. For the specific case of IBFI, flood modeling tools that combine inputs from satellite rainfall estimates, river characteristics and digital elevation models have been developed to assess flood depth and duration. These tools would enable insurance companies to develop predetermined thresholds when a payout is due, based on historical data on previous flood events and related economic losses.

The use of advanced technologies by insurance companies also encourages farmers to use advanced technologies to ensure they are better equipped to deal with the vagaries of weather and minimize risks. Access to more reliable and quicker weather forecasts through early warning systems can enable farmers to initiate actions that help to reduce crop losses. This and other related technologies – the use of internet of things (IoT) for availing a wide range of services, digitization of financial services for easy and fast disbursal of credit and payment of compensation to farmers, etc. – can help to boost agricultural productivity in disaster-prone areas, contributing to improvements in food security and a decline in farmer suicides.

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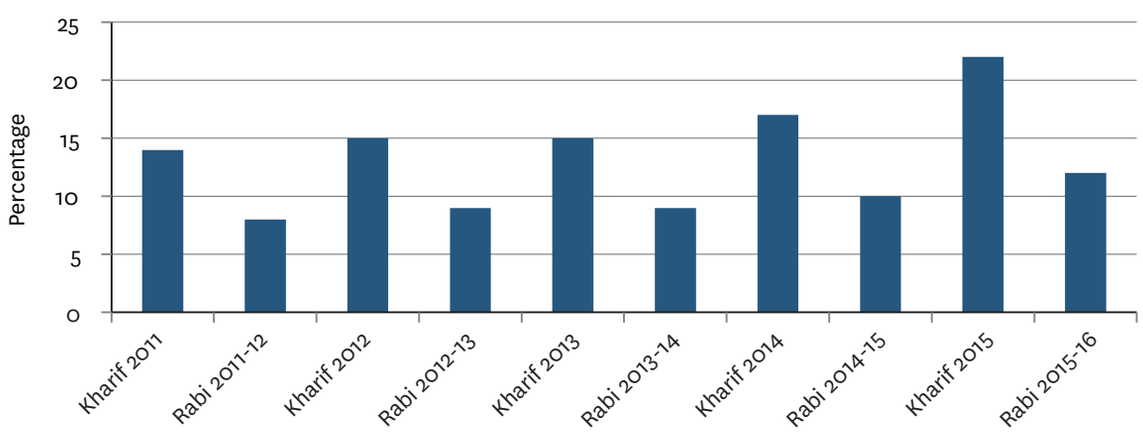
Appendix 1. Experience with Crop Insurance in India: A Brief Summary.

Over the past three decades, India has gained considerable experience in providing agricultural insurance through experimentation with different schemes. The Government of India (GoI) has introduced several crop insurance schemes to insure the farming community against various risks such as natural calamities, pests and diseases that lead to full or partial damage to crops. The Comprehensive Crop Insurance Scheme (CCIS), launched in 1985, was the first nationwide scheme. CCIS was replaced by the National Agricultural Insurance Scheme (NAIS) in 1999. With effect from April 2003, the Agriculture Insurance Company of India Limited (AIC) was designated as the implementing agency (IA) for NAIS. GoI also introduced a pilot Weather Based Crop Insurance Scheme (WBCIS) for the 2007 *kharif* season[10] in 20 states to cover the risks to farmers against extreme climatic conditions such as deficit, excess or untimely rainfall, frost, variations in temperature, etc.

GoI subsequently introduced the Modified National Agricultural Insurance Scheme (MNAIS) and implemented it on a pilot basis in 50 districts for the 2010–2011 *rabi* season. For the 2013–2014 *rabi* season, GoI merged MNAIS and WBCIS into a new program called the National Crop Insurance Programme (NCIP) and this replaced NAIS. However, at the request of different states, NAIS continued until the 2015–2016 *rabi* season. AIC and other impanelled private insurance companies were designated as IAs under NCIP. Unlike NAIS, where GoI and state governments subsidized the insurance premium (over and above the farmers' share) and insurance claims (above a threshold to be borne by AIC), with the introduction of WBCIS, the government subsidy was limited to only the insurance premium. For the 2016 *kharif* season, GoI replaced NAIS and NCIP, and introduced a new insurance scheme called *Pradhan Mantri Fasal Bima Yojana* (PMFBY) (Prime Minister's Crop Insurance Scheme) and restructured WBCIS.

Despite the three decade-long efforts of GoI to provide crop insurance, the performance of crop insurance schemes has been far from satisfactory. The coverage of farmers under these schemes continues to remain low (Figure A1). Coverage of non-loanee farmers[11] continues to be particularly low, primarily because the schemes have been targeted at loanee farmers, for whom the schemes stipulated mandatory coverage (Table A1).

Figure A1. Percentage of the total number of farmers that are insured.



Source: GoI 2017.

Note: The total number of farmers was 138.3 million according to the 2011 census.

[10] There are two crop cultivation seasons in India referred to as *kharif* (summer season) and *rabi* (winter season).

[11] Loanee farmers are those who have availed crop loans from institutional sources while non-loanee farmers are those who may not have obtained loans from institutional sources. Most of the insurance schemes have primarily been aimed at loanee farmers. PMFBY covers all types of farmers, such as loanee farmers, non-loanee farmers, sharecroppers and tenant farmers, but insurance is compulsory for loanee farmers and voluntary for non-loanee farmers.

Table A1. Percentage of the total number of farmers that are non-loanee farmers insured in different insurance schemes.

Season	NAIS	MNAIS	WBCIS
Kharif 2011	26	9.78	6
Rabi 2011–12	27	4.58	2
Kharif 2012	19	5.44	1
Rabi 2012–13	30	0.74	2
Kharif 2013	19	3.38	1
Rabi 2013-14	13	3.37	1
Kharif 2014	47	9.64	10
Rabi 2014-15	22	0.79	2
Kharif 2015	47	0.01	3
Rabi 2015-16	22	0.01	2

Source: GoI 2017.

Appendix 2. Summary of the Performance Assessment Survey of the IBFI Pilot in Bihar, India.[12]

To understand how a new insurance product such as IBFI is likely to perform, IWMI, with assistance from AIC, piloted the product in Muzaffarpur district in the state of Bihar, India, during the 2017 *kharif* cropping season. The product was pilot tested among 200 farmers in six villages of Gaighat Block in Muzaffarpur district. In the pilot, each farmer was permitted to insure up to 1 ha of land under paddy and a maximum indemnity was fixed at INR 20,000 per hectare. The insurance premium was calculated as INR 2,200[13] per hectare. Being a pilot project, this cost was not charged to the farmers and was fully subsidized by the project. IWMI (Aheeyar et al. 2019) recently undertook a restricted ex post performance assessment survey in the pilot area to understand some facets of functioning of the scheme and the reactions and experiences of farmers, and to assess what else needs to be done to commercially market the product on a larger scale. The assessment was based on both qualitative and quantitative data collected from a sample of farmer households, using specially developed questionnaires, undertaking key informant interviews (KIIs) and arranging focus group discussions (FGDs). Sampled farmers included both IBFI non-beneficiary and beneficiary households, and those who received the payouts and those who did not. Interviews were conducted with officials from key institutions and community organizations including government institutions, local leaders/*panchayat* members, etc. The discussions helped to understand their perceptions of the scheme after payouts were made, the roles their institutions can play in helping to roll out and scale up the initiative, and how the program can be further improved and strengthened.

The household survey was conducted using a pretested questionnaire among 155 sample farmers – 95 who had subscribed for insurance and 60 who had not – covering all the six pilot villages, following a stratified sampling design (for further details, refer to Aheeyar et al. 2019). The sample households were selected from the following three strata:

a. Farmers who were insured and received a payout.
b. Farmers who were insured but did not receive a payout.
c. Farmers who were not enrolled in the insurance program.

The distribution of sample households is given in Tables A2.1 and A2.2.

Table A2.1. Distribution of sample households for the 2018 pilot study.

Village	Insured and received a payout	Insured but did not receive a payout	Not insured
Bhatgawan	19	-	10
Madhurapatti	21	-	10
Belaur	0	-	10
Paga	0	-	10
Ladaura	0	-	10
Bhagwatpur	0	-	10
Total	40	-	60

[12] For further details on the methodology used and survey findings, refer to Aheeyar et al. (2019).

[13] The average exchange rate during 2017 was approximately USD 1 = INR 64.94.

Table A2.2. Distribution of sample households for the 2019 pilot study.

Village	Total number of beneficiary (insured) farmers	Sample farmers (received compensation)	Sample farmers (did not receive compensation)	Sample farmers (non-beneficiary farmers)
Ajitpur Bakuchi	11	9	-	1
Andama	38	-	5	-
Barri	32	-	8	6
Bhatgama	159	14	-	1
Gangeya	41	-	9	11
Harkhauli	13	-	12	3
Harpur	30	-	14	3
Kalyanpur	9	-	8	-
Ladaur	34	-	17	6
Madhopur	23	-	9	7
Patari	18	-	7	4
Total	408	23	89	42

Aheeyar et al. (2019, 2020) provides details of the pilot undertaken and findings from the performance assessment survey. Some of the findings related to the factors constraining enrolment of farmers in IBFI, experiences of farmers who had subscribed for IBFI, and factors that could help facilitate greater penetration rates are highlighted below:

- **Flood frequency, nature of crop damage and adaptation measures**
    - The pilot area is a flood-prone area. Farmers in the pilot areas have experienced three major floods during the last 5 years in the months of July/August.
    - The height of the flood in the paddy field can go up to 6-10 feet (approximately 1.8 to 3 meters) and could create a submerged condition for the paddy crop for 15-25 days, resulting in substantial damage to the crop.
    - In 2017, severe floods occurred in the month of August when the paddy crop was at the growing stage (15 days to 2.5 months) and caused severe yield losses in several villages.
    - Farmers, in general, are not used to undertaking any adaptation measures in their fields to minimize the damage caused by floods. Most farmers prefer to avoid cultivation if there is a flood forecast. Although flood-tolerant rice varieties are available and can withstand submerged conditions up to 15 days without yield reduction, adoption of these varieties has been limited to around 12%. The main problem with adoption, as perceived by farmers, is the long growing period of these varieties which delays the following winter season (*rabi*) cultivation.

- **Process of creating product awareness**
    - During the FGDs and KIIs, it was identified that awareness about and experience with crop insurance were relatively low in the study region.
    - About 80% of the sampled farmers were not satisfied with the way the IBFI product was explained during its initiation. This calls for rethinking the strategy on community mobilization and awareness building. In fact, no farmer is fully satisfied with the information provided about the insurance product.
    - Almost all the farmers were motivated to enrol in the IBFI pilot phase primarily because of the subsidized nature of the product (zero premium) rather than understanding the broader concept of insurance in the context of limited insurance literacy. However, 70% of the farmers did perceive insurance as a risk transfer tool.
    - The key message is that farmers have been provided with awareness, but this was insufficient to gain an adequate understanding of the product, especially details related to the trigger points and the scenarios under which payouts are triggered. Farmers admitted that they were informed about the trigger points, but were unable to remember the process given its complexity.

- **Sum insured, floods and payouts**
    - Payout triggers were predetermined and announced based on flood height and duration of inundation. Satellite data on flood inundation, river water levels and rainfall data were collected to determine the trigger points for compensation payment after conducting a ground-level verification exercise.
    - The sum insured was INR 20,000/ha[14] for total crop loss, which was considerably lower than both the investment cost and the value of the crop produced. However, about 80% of the farmers were fully satisfied with the quantum of the sum insured. The premium, paid by the project implementers, was calculated at 9.5% of the sum insured plus taxes amounting to INR 2,200 per hectare.
    - Flood occurrence in 2017 triggered the payout in two pilot villages. In all, 40 insured farmers received compensation for flood damages. While all the 19 insured farmers in Bhatgawan village received 100% of the sum insured, all the 21 insured farmers in Madhurapatti village received 35% of the sum insured as compensation. The compensation amount received by all the farmers in a village was the same despite the actual damage they incurred individually. The remaining 55 farmers in the other four villages, though insured, did not receive any payment because the flood levels did not reach the predetermined trigger points set for these villages.
    - The compensation amount was directly transferred to the individual bank accounts with no requirement of intermediaries. Farmers preferred and appreciated the direct bank transfer due to their past experiences of dealing with banks, where illiterate and less influential farmers had to pay commission and bribes to get the work done.
    - However, there is a delay of 4 months to transfer the money to the farmer's bank account. This did not help the farmers as they could not plan for the next season and pay debts from the previous season. The delay partly occurred due to the need to organize a state-level payout ceremony with the participation of the Bihar state minister.
    - Willingness to pay the premium and continue with IBFI:
        - Fully aware of the cost of the premium and the fact that the project paid this for the current season, insured farmers were asked if they would continue enrolling in IBFI and would be willing to pay the cost of the premium. While all the farmers who received a payout expressed their willingness to continue with IBFI, other farmers who were insured but did not receive a payout were not willing to continue with IBFI. However, those who received a payout and wanted to continue with IBFI were willing to contribute only 1-2%[15] of the cost of the premium.
        - Farmers attributed their unwillingness to contribute a larger proportion of the premium cost to their low incomes and lack of affordability to pay more. Other farmers who enrolled in IBFI but did not receive a payout stated that they do not have trust in the insurance product.
        - Those farmers who were willing to continue with IBFI and contribute towards the cost of the premium were asked what factors they considered to be important in deciding to continue to enrol in the scheme. The majority (80%) of the farmers stated that they would like to carefully study the method followed by the insurance product when making compensation payments. This is due to the fact that under the government sponsored PMFBY insurance scheme, almost 90% of insured farmers did not receive any compensation and the remaining 10% only received compensation after a long delay. Responses from the sampled farmers once again reinforces their primary concern with previous crop insurance schemes.

[14] According to the survey findings, the average cost of paddy cultivation during 2017 *kharif* season was INR 32,640/ha. This is within the range of the cost of cultivation identified from the qualitative assessment, i.e., INR 30,000/ha to 35,000/ha. A similar estimate (INR 33,350) was reported by Pavithra et al. (2018) based on 2013/2014 data from Bihar. Production costs of marginal farmers are lower since they follow low-input agricultural practices, but they receive a lower yield. Average paddy yield in a normal year is between 3,800 kg/ha and 4,500 kg/ha. Paddy cultivated in the highlands provides a relatively higher yield and better quality produce than the produce from lowland fields. The average paddy marketing price in 2017 was INR 14/kg. This is expected to provide a gross income between INR 53,200 and INR 63,000 from a hectare of cultivation. The net return would be between INR 20,560 and INR 30,360.

[15] This figure of 2% probably comes from the larger crop insurance scheme PMFBY which is run by the government. According to this scheme, farmers are expected to pay only 2% of the cost of the premium and the remaining 98% is paid by the government.

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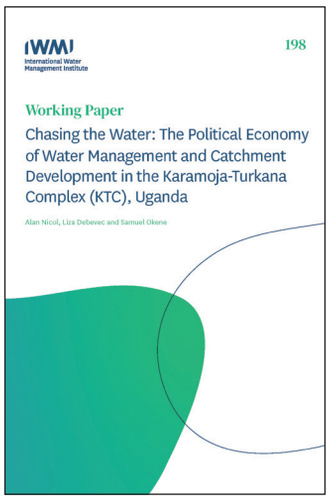

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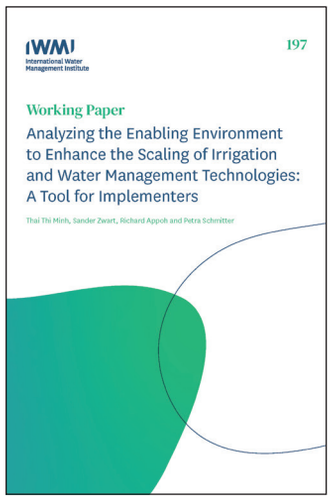

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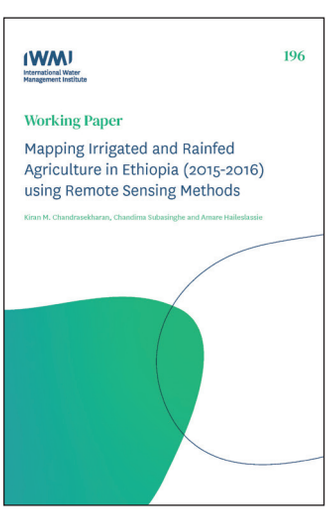

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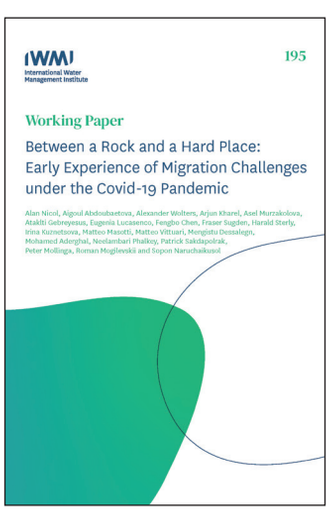

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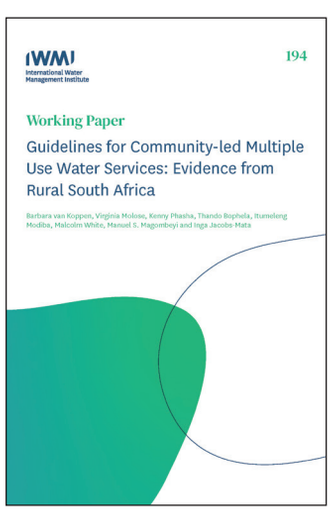

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