INVESTING IN DISASTER RESILIENCE: RISK TRANSFER THROUGH FLOOD INSURANCE IN SOUTH ASIA

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ABSTRACT

Protecting against floods and providing risk cover against losses due to floods has been a major area of concern for the governments around the world. Insurance is an important component in managing agricultural risks from these disaster events. In India, nearly 30 million smallholder farmers are affected by floods every year. For example, Bihar with a population of 100 million, 80% of whom living below the poverty line and mostly depended on agricultural sector lost between 0.5 to 120 million USD to floods every year. While in the agricultural sector, flood insurance is often included as a peril in Multi- Peril Crop Insurance (MPCI), flood insurance so far is not offered as a standalone insurance product in the agriculture sector anywhere in the world. Given the recent experience with designing and implementation of index based insurance products such as Weather Index Based Crop Insurance (WIBCI), an index based flood insurance (IBFI) product with similar features appears most appropriate for insuring crop losses due to floods.

In 2015, IWMI launched its Index-Based Flood Insurance[1] (IBFI) for India and Bangladesh, which is designed to safeguard farmers in locations at high risk of flooding. IBFI combines hydrological modelling and new and freely available high-resolution satellite images from ESA and USGS. Rainfall data for the relevant catchment is added to the model, which shows how runoff will travel and collect. If a trigger level is reached (calculated using 35 years of hydrological data), satellite images are used to verify the depth and duration of the flood. This accurately identifies the farmers that are eligible for compensation. We are testing a subsidized public-private partnership business model at micro level, where individual farmers buy the insurance, and also at meso level, where a group of farmers is insured jointly and receives subsidy support from the government. The insurance scheme is currently being introduced to the communities, with the pilot set to run during the monsoon season from June to October 2017. IBFI initiative promotes a closer linkage between risk transfer, risk reduction could make this a more sustainable, and robust tool for flood affected communities and reducing the burden of post-disaster relief funds for government. IBFI has the potential to be a part of a more wide-ranging and multi-faceted approach to make sure that India remains flood resilient in years to come.

Keywords: Flood insurance, Bihar, satellite data, hydraulic model, business models

1. INTRODUCTION

Increased occurrence of extreme weather events are witnessed around the world attributed to the effect climate variability causing loss of lives and livelihoods. In South Asia, agriculture and allied sector employs about 60 % of the total available labour force and contributes 22 % of the regional GDP (World Bank, 2008). In South Asian countries more than 1 billion people were affected by floods in past 20 years (EMDAT 2015). Considering that most of the rural poor depend on rain fed agriculture for daily sustenance, agricultural sector in South Asia witnessed less than 3 %, far below the growth rates of other economic sectors. Floods are a major source of risk for the agricultural sector and adds to the uncertainty in agricultural production, thus impacting the livelihood of millions of farmers directly. While floods that occur almost every year are referred to as normal floods which deposits essential nutrients in the farmlands and are beneficial to the farming communities, medium, severe and catastrophic floods (5, 20 and 100 year return period; ADPC, 2005) causes economic damages which are beyond the coping capacity of small holding farmer completely depended on agricultural income. South Asia contains three main flood hotspots located in Indus basin – Pakistan, Ganges basin eastern India and Brahmaputra basin - Bangladesh respectively. India has 0.8 % of its $1.87 trillion GDP exposed to flood risk and could increase more than 10-fold by 2030 (WRI 2015). Bihar is the most flood-prone state of India with 76% of population in North Bihar living under the risk of frequent floods (FMISC, 2011). Due to the agricultural depended population, social and economic fabric of North Bihar are woven

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

with the tune of monsoon patterns. In Bangladesh, 20–25% of the country's land area gets flooded in normal years while catastrophic events like 1998 flooded 70% of the country (Ninno et al., 2003).

In their endeavour to mitigate flood damages, Indian and Bangladesh governments like the rest of developing world usually invested in structural measures such as dams, creating storages both above and below ground, embankments, building protection walls etc. In recent years the development community has come to realize that building capacities to withstand shocks from extreme events, which are becoming more frequent across the developing world is key to assisting marginal small holders out of poverty trap. Concurrent with these global efforts, South Asian governments have also been investing in non- structural measures like monitoring mechanisms, early warning, emergency response, providing relief after the disaster, building resilience and increasing coping capacities through risk transfer to enable people likely to be affected by floods to better prepare themselves from these risks and minimise the likely damages caused by floods.

To a large extent governments in India and Bangladesh has relied on providing relief after the disaster as the main mode to increase the coping capacity of the affected communities from flood induced agricultural losses. While it is critically necessary, ex-disaster funding approaches are usually not well coordinated and are often poorly targeted and insufficient (Arnold, 2008). The scale and magnitude of human and financial cost required to carry out relief activities in time bound manner poses additional challenges. Risk transfer through insurance can spread risks while reducing the vulnerability of enrolled population to extreme flood events. This will significantly reduce the total cost of post disaster relief financing and reconstruction while enhancing the recovery of local economy from their flood losses. Financial risk transfer solutions like flood insurance will enable the victims to leverage their initiatives and accelerate the rebuilding process of their lives and livelihoods. Relief and compensation efforts are useful, but not enough; they do not fully compensate or adequately help the poor to recover from all the incurred losses.

1.1 Index based flood insurance

World over, of the various measures for providing risk coverage against natural hazards, insurance has emerged as a key pillar in any comprehensive strategy of adaptation. Insurance nevertheless helps increase resilience against residual risks that cannot be prevented or mitigated. Insurance markets have however struggled to provide affordable flood insurance in high-risk areas. High expected losses impair commercial viability of insurance and many households at risk do not have access to affordable Insurance (Emily, 2011). In flood insurance it is common for the state to at least partially bear the cost of flood risk and therefore state-backed insurance is common in developed countries with established private markets, it is also seen in developing countries. Where insurance penetration is low, governments bear the cost of flood risk through the provision of aid after an event.

India has experimented with several agricultural insurance schemes before launching an umbrella scheme known as the Pradhan Mantri Fasal Bima Yojna (PMFBY). This scheme includes both indemnity based as well as index based crop insurance covering different types of catastrophes. The scale of PMFBY pose many challenges in its effective implementation such as human and capital cost involved in assessment of crop losses and issuing speedy payouts. Index based insurance schemes possess distinct advantages to overcome these challenges, since the insurance payouts are issued for a breach of previously determined thresholds of a specific or composite variable such as temperature, rainfall, NDVI etc. IBFI is a specialized cased of index insurance designed specifically to insurance against flood induced crop losses through innovative use of remote sensing based datasets and numerical hydrologic/hydrodynamic models for determining the flood thresholds.

Freely available optical and SAR based remote sensing datasets from Landsat, Sentinel-1 and 2 were used for mapping flood historic and 2017 flood events to determine spatial extents of floods. Hydrodynamic models was created for a section of Bagmathi river basin covering Muzaffarpur district in India and Sirajganj district in Bangladesh using HEC-RAS and Mike-11 respectively to determine spatio-temporal variability of flood parameters. The flood parameters (Flood depth and duration) at daily time covering IBFI pilot villages for a period of 30 years were used to create IBFI insurance scheme thereby setting up flood depth and duration as proxy for crop losses from paddy crop. The methodology for creating an IBFI scheme followed in the current pilot is shown in Fig. 1. In order to sustain the IBFI product in the long run, multiple business models were developed to explore the possible ways in which some of the challenges associated with this scheme can be efficiently organised in an integrated way to develop and market this insurance product. These business models describe ways in which different stakeholders such as government, private industry, micro-finance companies and NGO's can play key role in taking this insurance product to the end users.

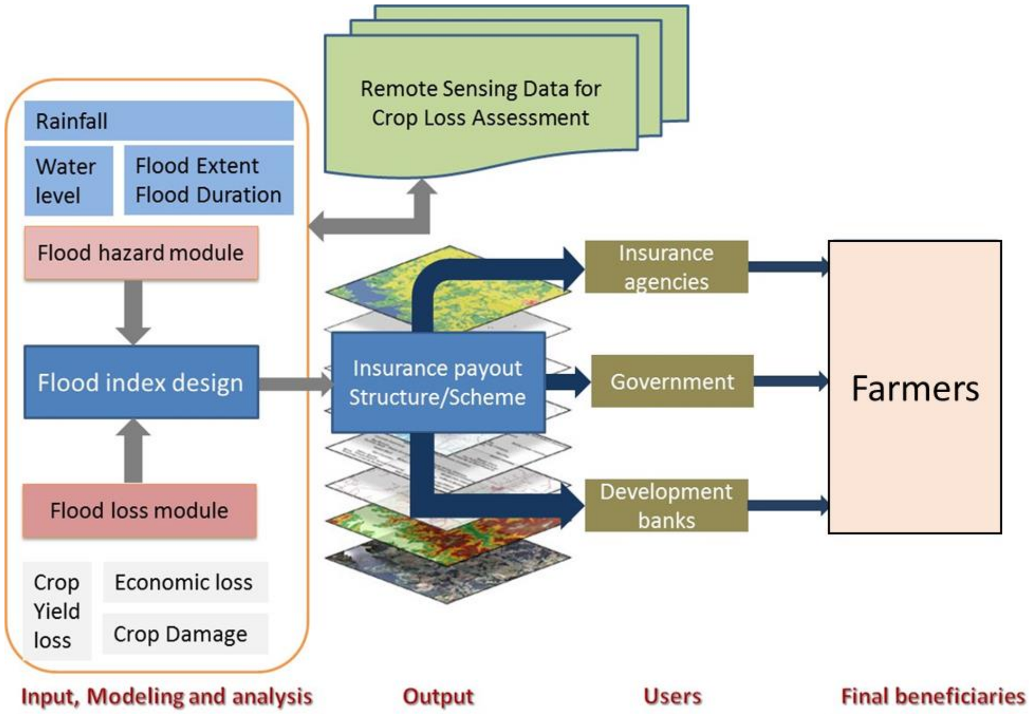

Fig. 1 Methodology of Index Based Flood Insurance scheme piloted in South Asia

2. MATERIALS AND METHODS

2.1 Study area

Two flood hotspots in in Ganges-Brahmaputra river basin were selected for the IBFI pilot. In India, pilot villages are located in southeastern section of Muzzafarpur district, Bihar. These villages are a part of Bagmathi river basin, which has its origin in Nepal. It receives intense rainfall during the monsoon season, thereby flooding settlements and agricultural area along the way from Nepal's hilly region to flat plains of North Bihar. In Bangladesh, pilot villages are located in Sirajganj district, a part of Rajshahi Division. These villages are located on the floodplains of Brahmaputra River. The location of pilot villages in both these countries are shown in Fig. 1.

2.2 Flood mapping using ESA's Sentinel-1 Data

Flood extent maps derived from synthetic aperture radar (SAR) data can be a key information source for an effective disaster management, helping humanitarian relief organizations and decision-makers to obtain spatially explicit information about inundated areas in a time- and cost-efficient manner (Voigt et al. 2007; Amarnath and Rajah, 2016). Several SAR data are available including TerraSAR-X, Cosmo SkyMed, Radarsat-1&2, ALOS-2 PALSAR-2 and the recent launched Sentinel-1 mission operated by the European Space Agency (ESA) was used in the present study for model validation. It consist of two systematically acquiring satellite sensors (Sentine-1A and Sentinel-1B) with a repeat cycle of 6 days for the final constellation. SNAP software (Sentinels Application Platform http://step.esa.int/main/toolboxes/snap/), particulary the S-1 Tool box of the SNAP was utilized to pre-process the SAR imagery. The processing chain is comprised of modules of automatic data ingestion, geometric correction, and radiometric calibration, an initial classification using automatic thresholding. The dynamic range of backscatter changes in the land and water was analyzed using semi-automatic flood mapping approaches. Following the initial water threshold detection, the post-processing step includes elevation-slope mask and land use and land cover to derive the final flood extent for use in model validation.

2.3 Hydrologic/Hydrodynamic modelling

Hydrodynamic models provide a realistic dynamic representation of the flood extent. HEC-RAS (Hydrologic Engineering Center - River Analysis System) model is one of the most widely used model, applied worldwide for simulating flood characteristics. Data representing flow characteristics, river bathymetry, flood plain elevation (from DEM) and land use were used to simulate historical flood patterns in the IBFI pilot area in Bihar. The model was calibrated with remote sensing based flood extent maps from historical flood images. In order to derive river discharge in the near real time for IBFI pilot applications, a Variable Infiltration Capacity (VIC) model was used to simulate discharge at pre-determined locations, which were used as input to HEC-RAS model. The calibrated models were used for mapping flood patterns for the 2017 pilot season in conjunction with remote sensing based flood extents, which are presented in this article.

2.4 Business models

Innovative risk transfer techniques for agriculture needs to be self-sustained in the long run in order to serve an effective tool for farmer to recover from flood induced losses which needs widespread applicability and uptake by different stakeholders involved in the whole life cycle of agriculture insurance schemes. Business models describe different set of pathways in which these stakeholders can take the IBFI product to the end users with varying degree of involvement. Two main business models were analysed as a part of this study, i) provision of IBFI as a part of government funded insurance scheme and ii) direct provision of insurance schemes through private companies. Both these methods are presented below.

3. RESULTS AND DISCUSSION

The extreme rainfall events observed in Bagmathi river basin (both in Nepal and India section) is provided in Fig.3. During the ongoing 2017 monsoon season the first significant rainfall event, which has potential to cause flood inundation in IBFI pilot area was observed on 10/07/2017, 03/08/2017 and 12/08/2017. However, the first two rainfall events didn’t cause any significant over the bank flooding, which was confirmed from the remote sensing images and constant flood reports from Flood Management Information System Center (FMISC), Government of Bihar. The third flood event caused over bank topping of river water level and subsequent inundation in Bagmathi River due to heavy rainfall (78.3 mm) in the basin. This extreme rainfall event caused widespread flooding as observed in the remote sensing images from following days (both optical and SAR) and disaster warning disseminated by the FMISC.

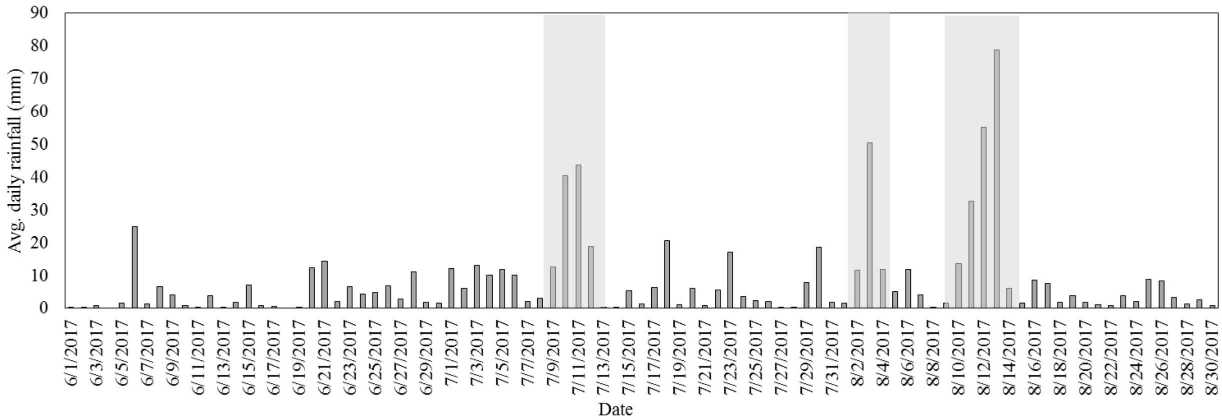

Figure 3. Daily average rainfall in Bagmathi River basin (01/06/2017 to 31/08/2017). Grey shaded area in the bar graph represents significant extreme rainfall event.

3.1 Flood hazard model

The observed flood inundation from the next available remote sensing imageries (Fig. 4 a and c) along with flood model generated inundation pattern (Fig. 4 b and d) for the extreme rainfall event on 13/08/2017 were compared. The flood extents were clipped to show the pattern in six IBFI pilot villages in Muzzafarpur district, Bihar. These villages were located along the Bagmathi River and witnessed significant inundation affecting housing and agriculture areas alike. The model simulated flood patterns were in reasonable agreement with satellite observed flood patterns with similar flood inundation locations. The modelled flood area predicted islands of non-flooded pixels amid flood pixels which were not observed in the mapped flood extent. This is likely to be the artifacts of STRM 30m Digital Elevation Model used in generating the flood inundation patterns from the HEC-RAS model. Quantitative estimates of flood inundated area from the modelled date were estimated and compared with the RS based extents which yields high correlation value of 0.87 (Fig. 5). These model artifacts of non-flooded pixels were corrected based on the RS based observed flood inundation to create seamless dataset on flood depth and duration in agricultural zones in IBFI pilot area. This seamless daily flood depth and duration dataset for the IBFI pilot area was shared with the insurer for determining the breach of previous fixed thresholds based on 30 years of historical data, depending on which the magnitude of payout will be issued for the 2017 monsoon season.

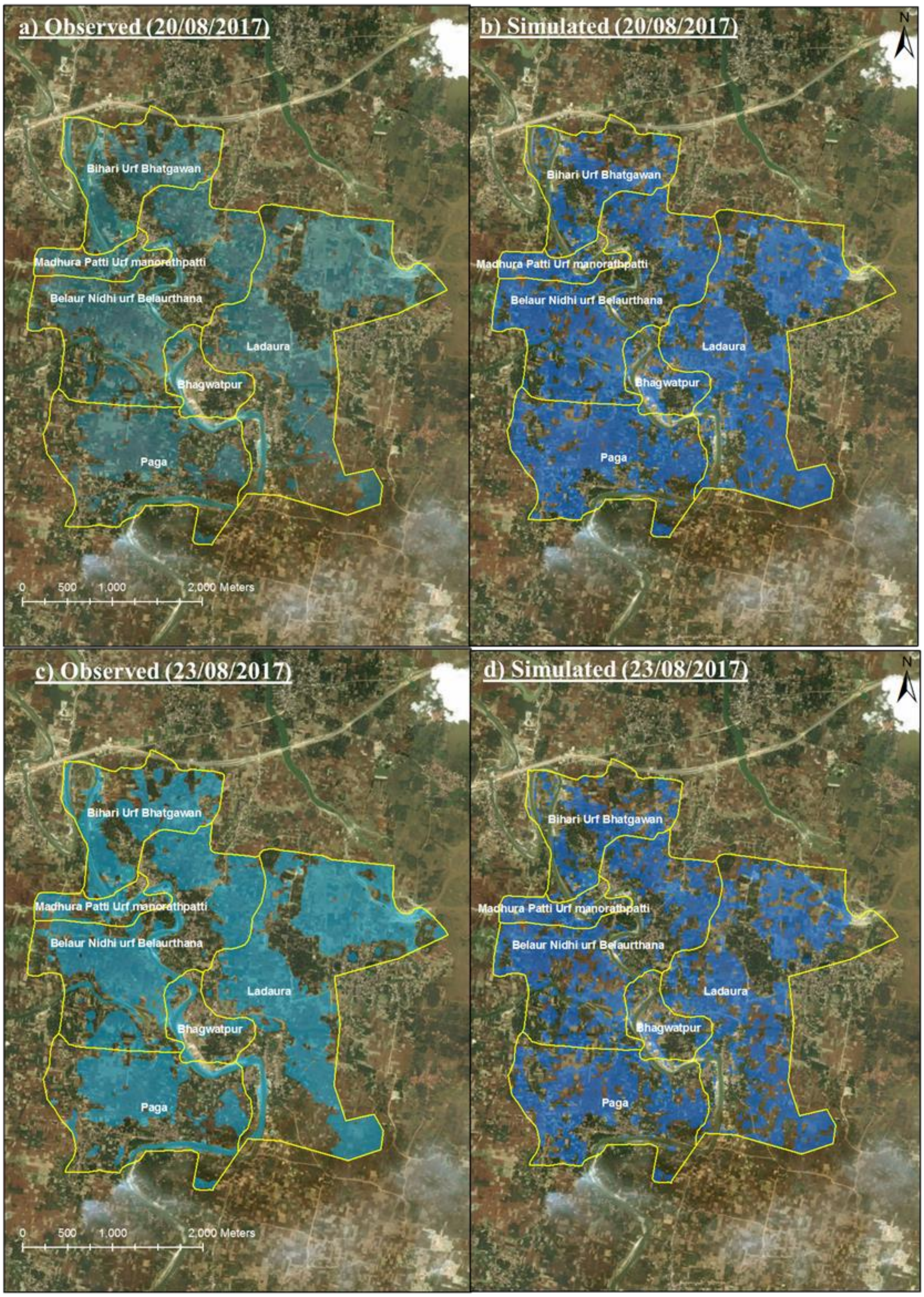

Figure 4. Comparison of remote sensing observed flood extent from Sentinel-1 with model derived flood extent using HEC-RAS model

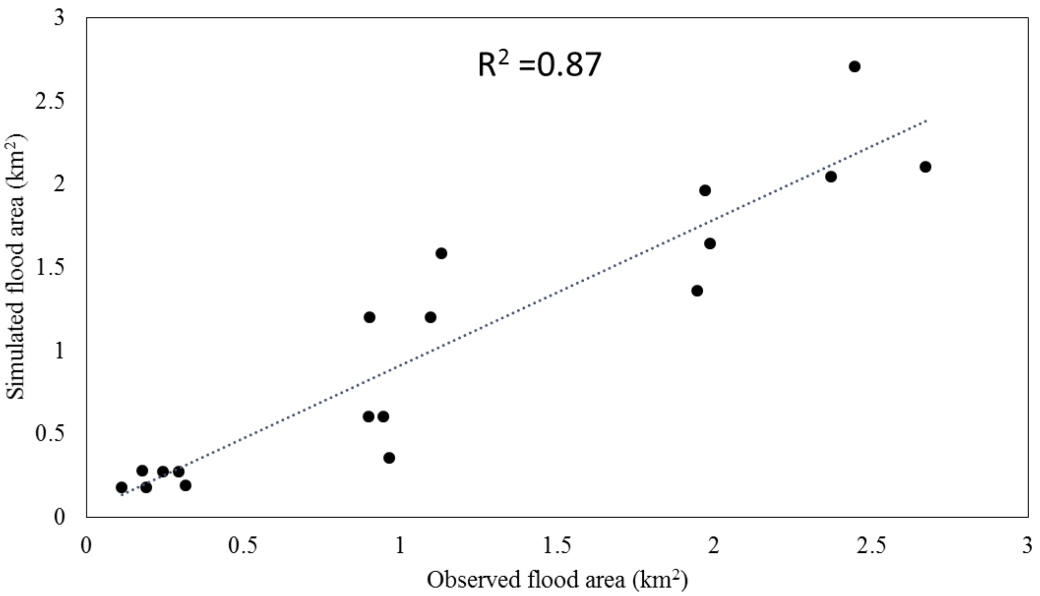

Figure 5. Comparison of remote sensing observed flood extent with HEC-RAS model derived flood extent

3.2 Business model

Out of multiple business model created for IBFI, two business models were created for IBFI product, which are shown in Fig, 5 a and b. Both these models envisage government intervention in reducing the premium as the backbone of these insurance product while differing in the mode of delivery to the farmers. In the first business model, farmers can obtain IBFI directly from the insurance companies. The government directly through the insurance agency subsidizes a part of the premium, while the rest of the insurance premium amount will be borne by the farmer. In the latter case, the farmer's contribution of insurance premium will be directly detected by the bank as a part of agricultural loan. The first business model with serve large and commercial farmers facing flood risk but having necessary finance to pay the premium directly while the latter scheme serve loanee farmers who are depended on the financial support from government and banks for the sustenance of agricultural activities and there by livelihoods. This mode will port the IBFI scheme to suit the requirements of large number of small holder farmers depended on agricultural activities for basic livelihood.

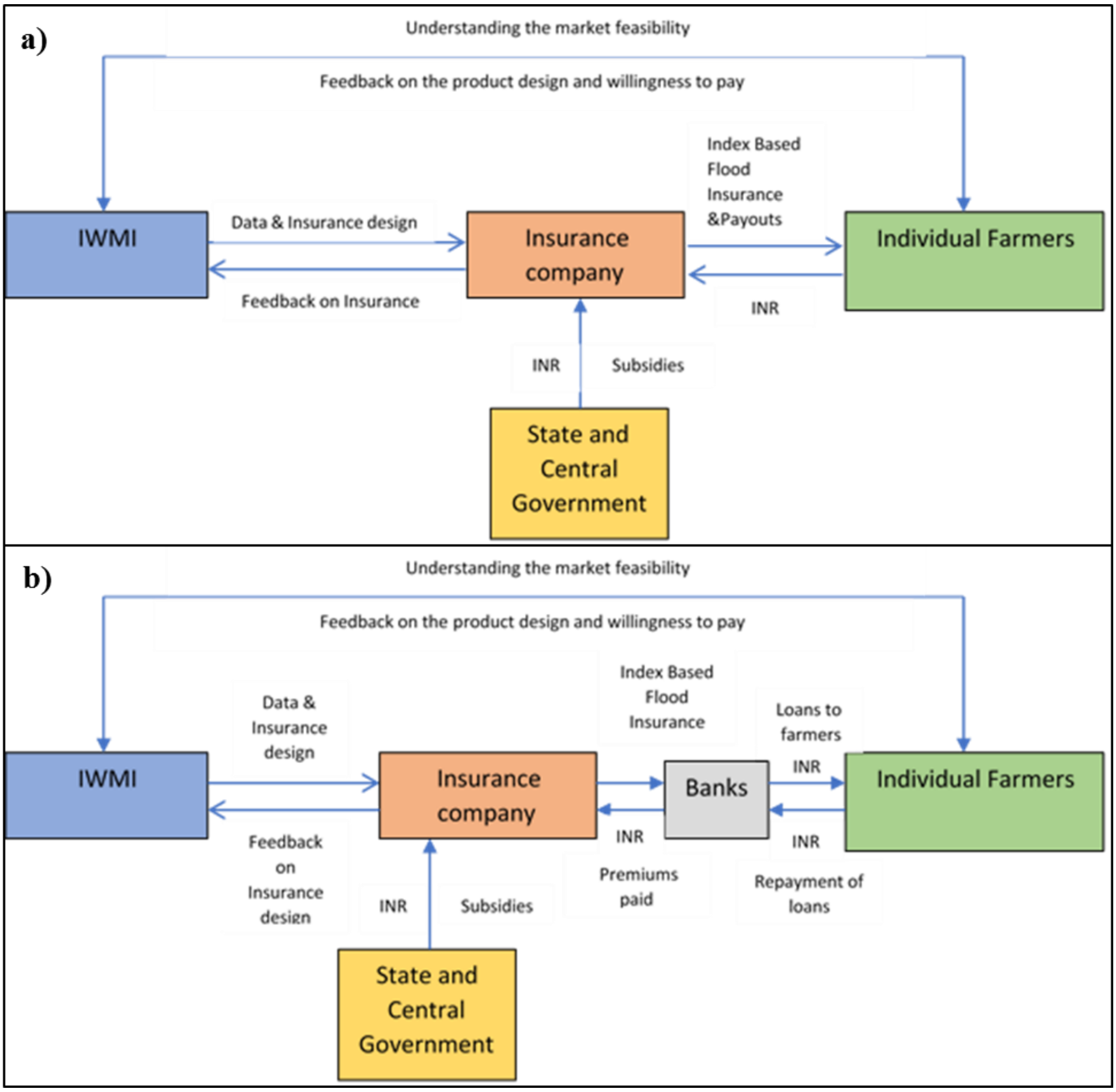

Figure 6 a) Business model for direct provision of IBFI through insurance companies and b) Business model for provision through banks (as part of loan)

4. CONCLUSION

The concept of Index Based Flood Insurance (IBFI) contribute to integrated disaster risk management approaches under certain conditions. Insurance is not a sufficient instrument for achieving effective disaster risk management and disaster risk reduction at a societal level. A widely acknowledged feature of insurance is that by pricing risk, and translating that price into premiums charged to policyholders, it provides an important price signal that can incentivise risk reducing behavior. Insurance has been widely acknowledged as a tool for inducing farmers to take more profitable but riskier activities. It does so by reducing the financial repercussions of volatility, with implications for individuals' ability to plan, save and invest – potentially in more resilient and profitable livelihood opportunities.

There is clearly a useful role for the intelligence provided by remote sensing satellites, both within the insurance sector and for helping to support government schemes such as PMFBY. However, for crop insurance products to be reliable, the underlying data needs to be readily available and robust. Developing IWMI's IBFI, for example, required a high-resolution digital terrain model, observations from gauges on river levels and discharge, and village-level census data on farmer livelihoods. The scientific underpinnings based on flood hazard model and openly available RS data of robust IBFI product makes it ideally suitable for upscaling to large flood risk areas in South Asia and beyond subject to the feasibility and long term suitability. Various business models were created to achieve sustainability of the product under different socio-financial and administrative settings in different countries. New satellites are beginning to solve the resolution constraint, however. The European Space Agency's Sentinel-2 sensor provides 10m-resolution data that can be used to predict smallholder agricultural productivity with roughly the same accuracy as survey-based measures traditionally used in research and policy applications. And multiple 'cubesat' companies are now providing data at a resolution of 5 meters or finer for much of the world at a much lower cost than previously available.

Scaling up pilot insurance schemes so that they can cover several states, or even countries, will require data sharing between water resources, disaster management and agricultural coordination departments, both within states and potentially across state or national boundaries. Insurance products therefore have potential to promote cooperation between departments, states and countries, as well as between public- and private-sector organizations. Governments and the private sector both stand to benefit from successful large-scale public-private partnership insurance schemes. By building farmers' resilience to climate shocks, governments will have a greater chance of reducing risk from disasters and promoting economic growth. This can help them meet global development targets, such as those laid out in the Sendai Framework for Disaster Risk Reduction 2015–2030 and the United Nations Sustainable Development Goals. The private sector will gain from up-scaled agricultural insurance schemes, as they will have a much wider pool of potential clients to sell policies too. The more people they insure, the lower premiums will be, so government subsidies can be reduced too. It's a win-win situation.

However, the real beneficiaries will be the small-scale farmers, like those in enrolled in IWMI's IBFI. For the first time, they will have peace of mind that their families will be OK, come rain or shine. If the harvest is good, they will be well fed and might make some money selling their surplus crops too. Nevertheless, even if they have a disastrous harvest, they will be able to pick themselves up and use their compensation to get by until the next cropping season comes round.

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