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BRIEFING NOTE

Assessment of Innovative Approaches to Flood Risk Management and Financing in Agriculture: The Thailand Case Study[1]

The Commodity Risk Management Group
Agriculture and Rural Development
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[1] This briefing note was prepared by Ornsaran Pomme Manuamorn, Operations Analyst, of the Commodity Risk Management Group, Agricultural and Rural Development Department (ARD), the World Bank. The paper is based on "Assessment of Innovative Approaches to Flood Risk Management and Financing in Agriculture" (forthcoming in 2009), an ARD report authored by Alexander Lotsch, William Dick and Ornsaran Pomme Manuamorn.

1 Introduction

Recent initiatives by the World Bank have promoted agricultural insurance in developing countries. Most of these projects concern protection against severe drought (e.g. India, Malawi, and Central America) and have used simple index-based insurance products that indemnify farmers based on loss proxies such as recorded levels of rainfall at a weather station. These index insurance programs have shown how the index approach can help overcome major supply-side constraints found in traditional multi-peril crop insurance (MPCI) programs including: the difficulty and high transaction costs of operating insurance for many small farmers; adverse selection (only farmers with high risks insure) and moral hazard (farmers can influence the likelihood of payouts); and the difficulty to access reinsurance. These programs also highlighted limitations related to basis risk (potential mismatch between payouts and the index) and high upfront research and development costs for establishing an index-based insurance program.

Building on these experiences, the World Bank recently conducted research and concept-testing activities to investigate the expansion of the index approach from drought to flood. The main objective was to assess prerequisite conditions, as well as practical and efficient methods, to conceptualize and potentially implement index-based insurance for agricultural flood losses. In addition, the work assessed how modern technologies such as flood modeling and remote sensing -- which are widely used to support flood risk mapping, and flood detection, warning and control -- could be harnessed to support the design of such flood insurance programs for rural clients. The World Bank's findings draw on background feasibility studies in three countries: Thailand (the Upper Pasak River Basin, Petchaboon Province), Vietnam (the Mekong Delta) and Bangladesh (country-wide flood risk mapping). The studies were performed jointly with local research centers, agricultural banks and insurance companies, as well as international experts and centers of excellence in remote sensing and flood modeling.

This paper summarizes the findings from work carried out from September 2005 to April 2008 in the Muang Petchaboon District of the Petchaboon Province in Thailand. In the early stage, the technical work in Petchaboon was conducted with a primary objective of designing a program where the insured party would be rice farmers ("micro") in the study area rather than financial institutions ("meso") or the Thai Government ("macro"), which carries the financial consequence of aggregate flood risk. In the second phase of research, the scope of work was broadened to investigate the potential non-insurance applications of flood modeling and remote sensing results, particularly to inform risk management policy at the Bank for Agriculture and Agricultural Cooperatives (BAAC). The experience from Thailand provides key insights into the opportunities and challenges of agricultural flood index insurance, and more broadly, of a disaster risk management policy which complements flood risk mitigation strategies with the proactive application of modern technologies.

The next section illustrates the importance of flood risk in agriculture and challenges in providing flood insurance. The following section describes the flood index insurance concept and methodology that were tested during the feasibility study. Section four highlights the findings from the Petchaboon Province of Thailand, and the final section synthesizes lessons learned and recommends areas for future research and applications.

2 Flood Risk in Agriculture and Challenges for Agricultural Flood Insurance

Flood plains have traditionally supported high population densities due to the advantages for human settlements, economic activities and agricultural practices. At the same time, floods also affect more people than any other weather-related peril worldwide. Six out of the ten worst natural disasters in 2007 were floods[2]. While economic damages and loss of life are pronounced in urban and coastal areas due to the concentration of infrastructure and people, floods in rural areas are both closely linked to agricultural production and livelihoods of rural populations.

Table 1: Number of events and economic losses due to disasters worldwide, 1980-2008.

DISASTER PERIOD (1980-2008)	**EVENTS**	**LOSSES** (billion $)	**DEATHS** (thousands)	**AFFECTED** (millions)
Drought	417	79.9	558.5	1567.3
Flood	2888	397.8	195.9	2740.9
Windstorm*	2385	669.2	427.6	684.7
Other**	1303	370.9	663.9	123.1
Total	6993	1517.8	1846.0	5116.1

**A portion of windstorm loss is due to flooding.*

***"Other" combines earthquake, volcano, landslide, and mudslide.*

Source EM-DAT

Floods are an important source of risk for the agricultural sector. While normal seasonal flooding is often beneficial to farmers, extreme and unpredictable floods expose agricultural producers, rural financial institutions, and governments to financial risks. In **Thailand**, the most frequent and severe hazard that affects the country and its agricultural sector is flood. Floods mainly occur in the monsoon seasons between June and September. Many river basins, such as the Chao Phraya and the Pasak basins in Central Thailand, are sites of intensive agricultural activities while being very prone to flooding due to river swelling and overflowing during the rainy seasons. Data from 2002-2006 show that flood is a major risk for agriculture in Thailand, annually damaging not only large acreage of crop land but also livestock, poultry and fishery sectors.

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[2] Measured in terms of the number of deaths. See GFDRR (2007), "Integrating Disaster Risk Reduction into Fight Against Poverty", *Global Facility for Disaster Reduction and Recovery (GFDRR) Annual Report 2007*, the World Bank and the International Strategy for Disaster Reduction. Results presented in the report were based on data from EM-DAT- the OFDA/CRED International Disaster Database - Université catholique de Louvain - Brussels - Belgium" (http://www.em-dat.net/)

Table 2: Thailand's Agricultural Flood Losses from 2002 to 2006.

	2002	2003	2004	2005	2006
Agricultural land (hectares)	1,669,618	255,289	527,797	272,232	896,889
Livestock (number of animals)	2,955,577	301,343	71,889	222,600	142,211
Poultry (number of animals)	n/a	n/a	n/a	473,523	261,850
Fish and shrimp (number of ponds)	103,533	22,339	12,884	13,664	113,260

Source: Data from Department of Disaster Prevention and Mitigation, Ministry of Interior, Thailand

While there are ways to manage seasonal flooding through water and crop cycle management, as well as to mitigate (reduce) risk through planning and engineering, extreme flood risk still remains and little is often done in developing countries to be financially prepared for the catastrophic impact of floods. The costs associated with these damages are often directly absorbed by resources of farm households. Rural financial institutions also absorb the cost of floods through loan rescheduling and cancellation. In many countries, governments share these costs by providing disaster compensation to agricultural producers and/or public agricultural banks. Such a reactive approach is costly and inadequate in most cases.

Flood insurance can provide financial protection that complements the traditional flood risk management measures and *ex post* interventions, thereby alleviating key constraints for agricultural production and financing. However, the application of agricultural insurance in developing countries is relatively low and flood risk is generally not insured. Even in developed countries where flood is included in standard urban property insurance, experience in agricultural flood insurance is limited to only a few high income countries, such as the United States and Spain, where flood is included as a peril within MPCI programs. The rare availability of flood insurance results from the complex nature of flood hazard, which is influenced by its type, location, topography, origins of the flood waters, and adequacy of flood control infrastructure and flood management. It also reflects technical and operational difficulties in insuring flood especially in the agricultural context. Key supply-side challenges for flood insurance include: delineation of losses caused by flooding; modeling and quantification of the risk and the impact of floods; determination of flood risk zones for enrollment of the insured and premium calculations; operating flood insurance, including loss adjustment and underwriting; and managing financial challenges related to risk transfer and reinsurance.

3 Key Concepts and Methodology for Flood Index Insurance Development

The principle of **weather index insurance** is to use measurements made at weather stations, such as rainfall or temperature, to make payouts to clients based on an index scale, without the need to measure crop losses in the field. The index must be established to correlate, as closely as possible, the loss of crop with the payout made by the weather measurement. This simplified product can have major advantages of transparency, elimination of loss adjustment, and rapid settlement of claims. In theory, flood index insurance could potentially offer the same benefits as weather index insurance for other perils such as drought and erratic temperature.

But extending the index approach from drought risk to flood risk requires concept adaptation as well as expansion into new technical frontiers. While drought indexes can be constructed with rainfall data using relatively established methods, the complicated nature of flood requires using **a combination of data sources**, including river gauge and rainfall data, flood modeling, satellite remote sensing, and other geo-information technology in order to design flood indexes that accurately proxy crop losses. Technologies are required to support the operation of an insurance scheme based on such indexes. It is also important to emphasize that **the type of flood** strongly impacts the feasibility of flood index insurance. Current experience suggests that the index approach may be more applicable to **river inundation flooding** affecting large geographic areas. For example, an inundation flood in a relatively flat plain surrounding a river delta is more amenable to indexing than a high velocity flash flood in mountainous valleys.

The following are key elements of the conceptual framework for the World Bank's research in applying the index approach to agricultural flood insurance.

1) Defining the hazard

Unlike rainfall or temperature risks, floods are more complex and a single parameter is not sufficient to fully describe the event. For the purposes of flood index insurance, it is necessary to define a flood event as **a combination of various measureable parameters** such as extent, peak flows, duration of discharge, volume of discharge, depth of inundation, etc. One or a combination of the above flood parameters could be chosen to form a proxy for crop loss. Once the key parameters are identified, a flood index insurance policy would also need to define the level of index that triggers payout (for example flood depth of above 50 cm. and/or flood duration of more than five days), and the method by which the index is measured. The payout can be triggered by river gauge and/or remote sensing measurements. While it is theoretically possible to design a flood index which combines many aspects of a flood event, such a composite index would also be more complicated to construct and administer. A balance needs to be struck between the technical complexity of the flood index and its practical application for insurance.

2) Modeling the hazard

The objective of hazard modeling is to understand the spatial patterns and the frequency of floods. Flood modeling is a well established technology and different modeling approaches can be employed. Results of modeling can include flood duration and flood depth. In flood index insurance, flood modeling can be used to define homogenous risk zones which can be used to group farmers for the purpose of risk pricing and program administration. When combined with vulnerability analysis and index payout scales, flood modeling can estimate required premiums in such zones. Both quantitative and qualitative information are required to calibrate the chosen flood model. Rainfall, upstream river gauge, digital elevation and land use data are typical inputs for flood models. In many cases, farmers are also interviewed about the window of risk within a given crop season. They are often asked to recollect the most catastrophic flood years in memory. Such information is useful for the purpose of setting some benchmark years in the flood model or to validate the model's results in the form of flood hazard maps.

3) Defining the index

Once the extent and probability of flooding is determined, a quantitative relationship between the characteristics of the flood and the resulting crop damage has to be established. Like for drought, a flood index has to define a triggering event, payout thresholds, payout rules, and payout limits. The insured values can be set based on available economic data, risk management needs of the insured and affordability of the insurance. Further, the index design needs to be based on the level of aggregation of the flood index insurance scheme being considered: a micro-level (farm clients) or a macro-level (government-level) scheme. In theory, two types of index designs can be considered -- either binary (all or nothing payout) or graduated. The following table provides an example of a graduated flood index.

Table 3: Example of a flood index insurance structure with total production cost as sum insured.

Days of inundation of 60 cm. flood	Yield damage	Insurance payout
3 days	No damage	No payout
4 days	20% loss	20% of total production cost
5 days	60% loss	60% of total production cost
6 days	80% loss	80% of total production cost
7 days	100% loss	100% of total production cost

4) Defining an operational system and supporting procedure

To implement a flood insurance scheme, an operational system must be created with appropriate support technologies. The system can be designed to serve many critical functions before, during and after the insured period. For example, **remote sensing** is a very powerful technology that could support flood index insurance. Large-scale flood is easy to detect using remote sensing, and use of radar-based remote sensing (SAR-Synthetic Aperture Radar) allows floods to be detected through cloud cover. Based on regularly captured remote sensing images, a system can be created to monitor the stage of crop growth and detect an onset of the flood event.

Operationally, insured farmers should be grouped per flood risk zone defined based on flood modeling results. **A Geographical Information System (GIS) database** can be created which contains information on the number and location of insured farmers within each zone. When a flood event occurs, farmers in the same zone will be treated as having been damaged homogenously. As a result, flood index insurance payouts can be made on a zonal basis, as in the case of rainfall index payouts per weather station. The satellite images can also be continuously captured from sensors with high visit frequency and analyzed in relation to the GIS database of flood zones to determine whether a flood event of payout-triggering duration has occurred.

4 Results of Flood Index Insurance Development Research in Thailand

Thailand was the first country where the flood index concept and methodology were applied through research and feasibility assessment. The activities were launched in response to strong demand from local institutions for innovative solutions to flood risk management and financing. Based on consultation with stakeholders, particularly BAAC, **the Maung Petchaboon District of Petchaboon Province, located in the Upper Pasak River Basin, was selected as the activity**

site and rice as a focal crop. This site was selected because of the area's widespread rice production, its high exposure to river inundation, and BAAC's extensive local client base. International and local consultants were contracted to assess flood risk during the rice production season in the Maung Petchaboon District using flood modeling and remote sensing techniques. The risk assessment was expected to form a basis for designing a rice flood index. The project also assessed non-insurance applications for the technologies in support of risk management policy at BAAC.

1) Insurance application

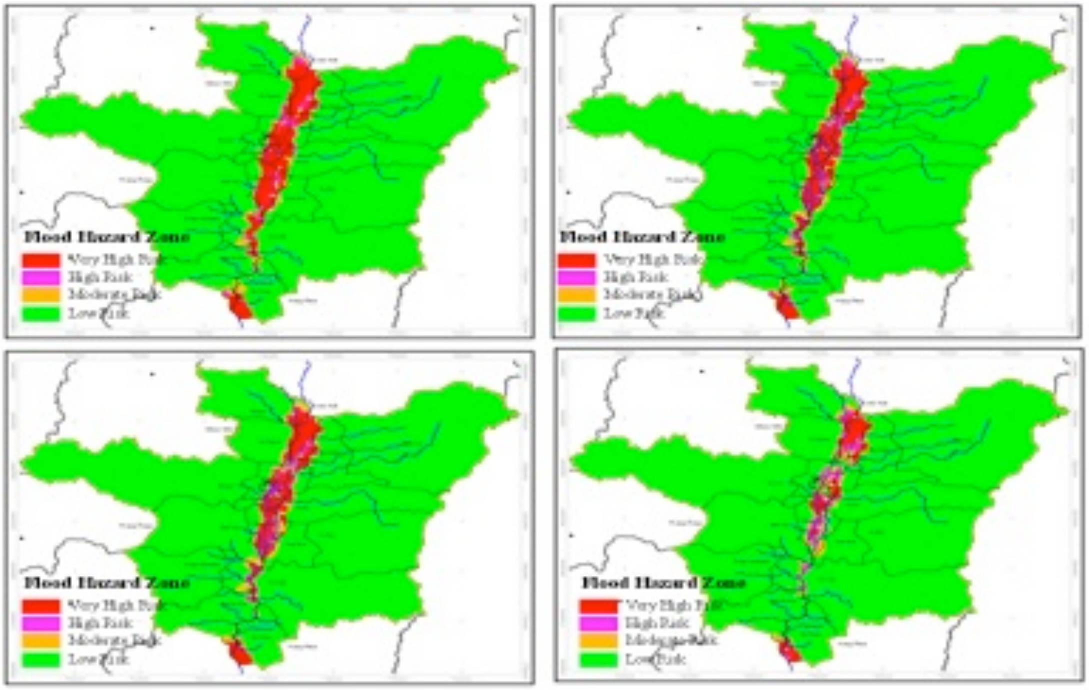
The modeling of inundation flood risk in Petchaboon could not be completed at a high enough resolution to enable the zoning of risk areas for purposes of micro-level insurance. While this first attempt at flood modeling in Petchaboon resulted in a prototype "flood duration index" for the flowering and pre-harvest rice crop, the index could not be implemented in a real pilot scheme due to several limitations in the results from the flood model. The key limitations included: 1) insufficient quality of topographic data (mainly digital elevation model) and hydro-meteorological data to parameterize and validate the chosen flood model; and 2) the chosen modeling approach, which was computationally too expensive to generate a sufficiently long-term series of results for the purpose of premium rating.

Possible solutions were identified to overcome these limitations. In the second phase of research, the team decided to use a simplified modeling approach (i.e., a hydraulic model - MIKE 11) which is widely used by local agencies and researchers. This new approach would allow: 1) better and more reliable quantification of the long-term historical patterns of flood in the region (which is required for actuarial evaluation); and 2) better characterization of the spatial flood patterns in the flood plain of the Upper Pasak River basin, in particular with respect to flood depth and duration. In addition, more information was gathered with regards to farming practices, flood regime and management, and socioeconomic impacts of flood on rice farmers to better understand the dynamic of flood losses for rice farmers in the study area.

However, technical outcomes of this second phase research still demonstrated that flood index insurance would be very challenging to implement in the study area, especially at a micro level. The main reasons can be summarized as follows:

First, the Upper Pasak Basin in Petchaboon is affected by flash floods and inundation floods that occur in a narrow valley, a characteristic that does not lend itself to insurance. The model results showed that flood risk in the Petchaboon River valley is rather dichotomous; the region is characterized by a large area prone to relatively frequent localized flooding (for example, once in three to five years), while the area prone to infrequent flooding (for example, only once in 10 years) is small. In Figure 1, very high risk zones (with a flood once in three to five years) are in red and moderate risk zones (with a flood once in 10 years) are in yellow, while the green areas represent low to no flood risk. Such concentration of risk lends itself to the adverse selection problem (whereby only farmers in high risk zones would insure), while frequent flooding would lead to extremely high premiums, making the insurance scheme unsustainable.

Figure 1: Flood risk zones for rice production in the Maung District of Petchaboon, Thailand.



Source: ASDECON 2008[3]

Second, the timing of flooding is critical in relation to the actual damage to crop production concerned. Further division of flood risk per different crop growth phases along the crop calendar pushes the limits of flood modeling. This issue became evident from experts' assessment of the crop calendar in the study area during field visits and farmer interviews. With diverse and complex crop calendars even within a small valley area, defining loss criteria for each phase of rice production also became complex. With local knowledge of the flooding pattern, farmers can, to some extent, manage their own risk exposure by shifting their crop calendar due to the regularity and timing of flood events. This could also reduce the demand for insurance amongst farmers. An insurance system is only feasible where there is the possibility of infrequent, and widespread, flood which is outside of the farmers' ability to influence by management decisions.

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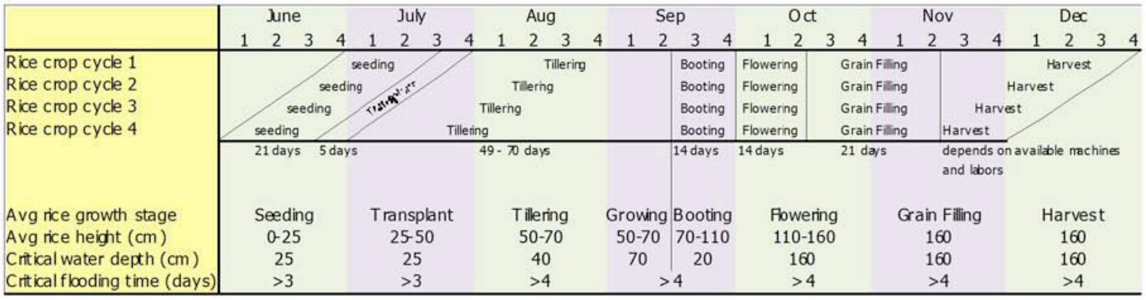
[3] ASDECON (2008) "Flood Modeling in Upper Pasak River Basin in Phetchaboon/Thailand," Bangkok Thailand, April 2008. This was presented as a Final Project Report of the feasibility study in Petchaboon commissioned by the World Bank.

Figure 2: Example of rice crop cycles of the Maung Petchaboon District, Petchaboon Province, Thailand.



	June	July	Aug	Sep		Oct	Nov	Dec
Avg rice growth stage	Seeding	Transplant	Tillering	Growing	Booting	Flowering	Grain Filling	Harvest
Avg rice height (cm)	0-25	25-50	50-70	50-70	70-110	110-160	160	160
Critical water depth (cm)	25	25	40	70	20	160	160	160
Critical flooding time (days)	>3	>3	>4	>4		>4	>4	>4

Source: ASDECON (2008)

Finally, despite its good database system, BAAC has no detailed GIS database of locations of farmers in the flood prone areas of the Maung Petchaboon District. The information related to borrowers is usually only collected at the administrative district level, which serves the current operational needs of BAAC; village-level data were not available. This makes geo-locating farmers into different homogenously defined flood risk zones, which are smaller than an administrative district and a cornerstone of a micro-level flood insurance scheme, a very difficult prospect.

2) Potential non-insurance applications

It was found that the stakeholders are interested in non-insurance benefits of this technical work in Petchaboon, though they are not of immediate application in the study area. At the moment, BAAC cannot directly use the flood risk maps to inform *ex ante* planning of lending for rice crops, and/or *ex post* rescheduling of loans following a flood event. This is because, as a state bank, BAAC cannot alter lending criteria, policy, or practices in specific areas due to one particular risk since it would result in changing advantages and disadvantages in borrowing among customers nationwide. In addition, both non-farm income and government compensation seem to have played a key role in good loan recovery rates despite the frequent flood events in the study area.

However, experience from the flood risk mapping exercise has strengthened the already increased risk awareness at BAAC, especially on how agricultural lending could benefit from the broader use of weather, agronomic and geographical data. It also highlighted the importance of creating a comprehensive GIS database to support the bank's operation. At the corporate level, BAAC is in the process of introducing **a credit scoring system**. The system is being developed with outside experts to create a systematic ranking of factors affecting credit worthiness. So far, socioeconomic factors (i.e., incomes, saving rates, household expenses, and repayment history) have been included and allow BAAC to separate customers into 10 grades. BAAC plans to adopt the system nationally in 2009 in order to form a basis for risk-based loan pricing in the future. BAAC is interested in eventually integrating disaster risks into the system in a holistic manner, which implies a need for national assessment and mapping of key disaster risks such as drought and floods. As BAAC does not develop its own database on disaster zones, the bank will use data collected by various government departments as input into the credit scoring system. This flood risk assessment and index design exercise is therefore a relevant experience both for BAAC and government agencies to collaborate on flood risk identification, the quantification of agricultural flood losses and impact on loans, and the use of coordinated technologies to support the process.

5 Lessons Learned, Conclusions and the Way Forward

Although the research and development outcomes from Thailand were mixed, this was the very first feasibility assessment experience in agricultural flood index insurance in a developing country, thereby providing many valuable insights and lessons learned for future work.

The Thailand experience demonstrates that characteristics of specific river flood plains (in terms of localization of risk, and frequency of flood) determine whether flood insurance is likely to be feasible. In the case of the Upper Pasak River valley, flood risk was localized and the topography was complicated. Other alluvial plains open to widespread, but less frequent flood may be more feasible for insurance. Institutionally, insurance is more likely developed in a circumstance where there is a direct linkage between insurance and production needs, for example, when a bank requires that farmers have insurance in order to access credit.

More importantly, the Petchaboon project significantly informs a broader assessment of future potential for flood index insurance for agriculture. In principle, parametric flood insurance can be developed for micro-, meso- and macro-levels of risks and policyholders. In practice, the technical feasibility at each level depends on a variety of factors such as the specific characteristics of each flood plain; the availability, quality and resolution of data; and the level at which demand for insurance is expressed or aggregated. The experience from Petchaboon highlighted the complexity in flood modeling for the purpose of risk quantification at very high resolution which in turn affects the feasibility of an insurance program which targets individual farmers. The situation is likely to be common in a large number of flood plains in developing countries. **Within the current data and technological environment, there seems to be a higher potential for meso-level and macro-level flood index insurance schemes to be developed in the near future.**

As data limitations can severely constrain the reliability of flood model results, in future projects these constraints can be partially overcome by more reliance on direct observations of floods from remote sensing, which can provide timely estimates of flood extent and duration. While remote sensing uses sophisticated data and models, most of these have become more readily available today in a reprocessed form and can be easily applied by local institutions in a geographic information system to support flood risk mapping. For example, the Geo-Informatics and Space Technology Development Agency (GISTDA) in Thailand has already operated an e-floodmap system which provides post-flood inundation maps for the government. The system should be fully supported and expand to other applications.

Going forward, agricultural insurance options for flood risk are best explored and piloted in the context of integration with other activities in the rural domain. For instance, insurance could be part of projects related to rural finance, land reform, disaster risk management, and development of agricultural supply-chains (this equally applies to drought risk). It is equally important that any pilot-testing of agricultural flood insurance is accompanied by activities to systematically identify and assess flood risk and by targeted interventions to reduce flood risk through structural measures, crop management and planning. Without such parallel measures any insurance scheme is unlikely to be sustainable, both financially and operationally.

Both governments and donors have to strengthen to the provision of public goods to support future initiatives. Flood risk assessment requires high-quality data on geophysical characteristics including hydrology, topography, climate, vegetation and soils. The collection of such data is generally done for purposes other than insurance; however, to make agricultural flood insurance possible, the systematic collection, updating and provisioning of such data is essential. Donors and government alike can play an instrumental role in strengthening the capacity of the respective agencies and institutions. In addition to scientific data, socioeconomic data are also required to assess the potential risk arising from floods on the agricultural assets; key efforts on farm-related data should include a systematic inventory of planted crops, planting dates, planted and harvested acreages, and collection of agricultural loss data. For agricultural banks and governments alike, mapping key assets at risk is critical to assess their exposure to flood risk.

Finally, it is important to recognize that the process of quantifying weather risk, and of creating an operational system which combines risk and asset information, have much broader applications than simply for index-based weather insurance or other risk transfer solutions. The availability of real time and historical weather data presents a powerful opportunity for actors exposed to agricultural weather risk to identify and quantify the risk they face and make informed business, management and investment decisions as a result. At the government level, the system could also provide early warning before disasters, support objective public disaster payments outside formal insurance, and provide information for food security and climate change monitoring. Experience has shown that many of these actors do not have such tools available to them in a simple-to-interpret format. Therefore, there is a general public good rationale for governments to invest in research and development of such information systems regardless of its linkage to insurance programs. The resulting ability to monitor risks and agricultural production in real time would enable various agricultural sector participants to take effective proactive measures to manage any developing risks and thereby avoid the full losses that can be incurred if no actions are taken in mitigation.