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# Review and Synthesis of IFPRI's PIM Funded Program of Work on Agricultural Insurance, 2012-2020

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## INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), a CGIAR Research Center established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

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**Keywords:** Agricultural insurance, Impact evaluation

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# ACRONYMS

| | |
|---|---|
| *3ie* | International Initiative for Impact Evaluation, Inc. |
| ACRE | Agriculture and Climate Risk Enterprise |
| AI | Artificial Intelligence |
| ARC | Africa Risk Capacity |
| CCEs | Crop-Cutting Experiments |
| CHIRPS | Climate Hazards Group InfraRed Precipitation with Station data |
| CSA | Climate-Smart Agriculture |
| IBI | Index-Based Insurance |
| IBLI | Index-Based Livestock Insurance |
| KALRO | Kenya Agricultural and Livestock Research Organization |
| MGAP | Ministry of Livestock, Agriculture and Fisheries, Uruguay |
| ML | Machine Learning |
| MNCFC | Mahalanobis National Crop Forecast Center |
| MPCI | Multiple Peril Crop Insurance |
| NDVI | Normalized Difference Vegetation Index |
| PBA | Picture-Based Advisory |
| PBI | Picture Based Insurance |
| PMFBY | Pradhan Mantri Fasal Bima Yojana |
| RCC | Risk Contingent Credit |
| RCT | Randomized control trial |
| SATISFy | Satellite Technologies, Innovative and Smart Financing for Food Security |
| WII | Weather Index Insurance |
| WTP | Willingness to pay |

## SUMMARY

This paper reviews and synthesizes IFPRI's research program on agricultural insurance since 2009, a period that encompasses all the activities for which financial support from PIM was obtained during 2012-2020. The paper reviews activities that were undertaken, synthesizes and evaluates the research outputs, and uses case studies to assess some of the program's development outcomes. The study also identifies knowledge gaps and suggests priorities for future research for IFPRI and the OneCGIAR on risk management and agricultural insurance. The methods used in this study were: a desk review of project documents, research outputs, and metrics on the use and influence of research outputs; and remotely conducted interviews with some IFPRI and PIM staff and individuals in partner organizations for select case studies.

It is found that IFPRI's activities up to 2015 made important contributions to the literature on understanding factors constraining farmer's demand for agricultural insurance. Most of IFPRI's publications from this work are well cited, more so on average than the publications of a more senior group of peer researchers working on agricultural insurance during the same period. This work also laid the foundations for a second phase of research at IFPRI on developing new forms of insurance that can help reduce the common problem of basis risk that arises with index based insurance at farm levels and make insurance more attractive to farmers. This work involved pioneering research on flexible weather index contracts, gap insurance, and picture-based insurance (PBI), work that has led to well cited publications with very little comparable literature from non-IFPRI researchers. IFPRI has also investigated bundling these new forms of insurance with credit, improved seeds, and other agricultural services as ways to enhance the value of insurance and to improve its impact on farm productivity and welfare. IFPRI's work on combining different datasets (remotely sensed data, weather data, picture-based data, etc.) is innovative and becoming well cited, and newly started research on using machine learning (ML) and artificial intelligence (AI) to improve the quality of insurance products, especially PBI, is cutting edge.

An important feature of IFPRI's insurance work, particularly since 2015, is that it has gone beyond initial experimental research and morphed into pilot programs with implementing partners who have a commercial interest in the insurance. This approach is helping to design and test on-the-ground insurance pilots that, when successful, have the potential to scale up through the partners leading to real development impacts. The approach also enables IFPRI to contribute to local capacity strengthening through its choice of partners, and case study evidence (e.g., Uruguay and Kenya) shows that local capacity to design and improve insurance programs often continues after IFPRI has exited a pilot project. The approach works best when IFPRI can sustain its support over sufficiently long periods to fine-tune the insurance design to local needs, establish it within a local institution, and properly assess its impacts on farm households. Unfortunately, the time frame required can extend beyond that possible with most bilateral funding projects. In Uruguay, for example, although the insurance program IFPRI helped design is still operating today, IFPRI was unable to complete a rigorous impact assessment within the time frame provided by the main bilateral donor, the completion of which might have led to further improvements in the design of the program. There are concerns that something similar may happen with the ACRE Africa and Equity Bank pilots in Kenya unless new bilateral funding is found.

IFPRI's insurance work has made several valuable contributions towards PIM's strategic goals for strengthening value chains. These include contributions through the design and delivery of agricultural insurance products that are more attractive to smallholders, insurers and intermediaries like financial institutions and agrodealers who can bundle insurance with other value adding inputs and services. Apart from Uruguay, where IFPRI contributed to the design of a now established flexible index insurance program for horticultural farmers, other projects have been limited to pilot programs affecting just a few thousand smallholders in each of four countries (Bangladesh, Ethiopia, India, and Kenya). However, if these pilots are successful then there is real scope for the approaches to be scaled up by national partners, leading to an eventual surge in IFPRI's contributions to PIM's strategic development goals. IFPRI's insurance work is now at a critical stage in which the impact of the new approaches on farm household productivity and welfare are being assessed within pilot programs, and continued funding is needed to complete this critical stage of work.

Turning to the future, IFPRI needs to decide how much further it wishes to take PBI, and what its exit strategy will be as PIM is ending, especially for some of its longer-term engagements with partners in India, Ethiopia and Kenya. IFPRI should also consider ways of better integrating its work on PBI and risk contingent credit (RCC) to capture synergies between the two approaches, especially in overcoming basis risk.

For OneCGIAR, there are important gaps in past agricultural insurance research at IFPRI and other CGIAR Centers that deserve priority research. These include:

- Greater attention to the design of insurance products and delivery systems tailored to the needs of the many poor and women farmers who are excluded from insurance even when insurance markets are well developed.
- More research is needed to better understand why private insurers and the intermediaries needed for bundling insurance with credit and other agricultural services do not see insurance as a more attractive business proposition, and what changes are needed to encourage them to be more venturesome.
- Many tail-end risks are too expensive for farmers to insure, a problem that is worsening with climate change. The public sector needs to help finance their removal from the agricultural sector. Subsidies are inevitable, and the real question is whether heavily subsidized insurance for farmers would improve on other forms of disaster assistance or safety net transfers in terms of encouraging better *ex-ante* risk management, reducing future dependence on disaster assistance, and crowding-in insurance for remaining risks.
- Given the key role the public sector seems to play in scaling up agricultural insurance, and the large amounts of public money spent on insurance subsidies in the developing world, comprehensive cost-benefit analyses of subsidized insurance programs are needed for guiding public spending decisions. IFPRI is collecting the data for such analyses in some of its ongoing pilot programs, but there is urgent need for more research studies on the net value of subsidies, including the design of smarter targeting methods, especially for otherwise excluded groups. In some cases there is need for comparisons between the cost-benefit ratio of using insurance subsidies to assist these groups verses alternatives like safety net programs and disaster assistance.
- Most of the CGIAR research studies on agricultural insurance abstract from the larger risk management problem that farmers face. Many risks cannot be insured, and farmers

use a broader portfolio of tools to manage and cope with risk - insurance is at best just part of the solution. Ignoring the wider risk problem can lead to second best advice for farmers, and it can contribute to over-estimating farmers' potential demand for insurance. There is need to broaden out the research agenda to take on more holistic risk management strategies that include coverage against other agricultural and even some non-agricultural risks.

## 1. INTRODUCTION

The CGIAR Research Program on Policies, Institutions, and Markets (PIM) leads action-oriented research to provide support for policies that help poor farmers improve their lives, produce nutritious and affordable foods, and protect the soil, water, and biodiversity in rural landscapes. PIM is a global program with special emphasis on Africa south of the Sahara, Southeast Asia, Central Asia, and Latin America. PIM research activities are carried out through six flagship programs (FPs): FP1–Technological Innovation and Sustainable Intensification; FP2 – Economywide Factors Affecting Agricultural Growth and Rural Transformation; FP3 –Inclusive and Efficient Value Chains; FP4 –Social Protection for Agriculture and Resilience; FP5 – Governance of Natural Resources; and FP6 –Cross-cutting Gender Research and Coordination.

Farm households face a host of market and production risks that make their incomes volatile from year to year, undermine their food security and make them hesitant to adopt new technologies or undertake new investments that might increase their long-term productivity and household welfare. Major shocks can also lead to loss of capital assets and episodic humanitarian crises that require large-scale relief interventions. Climate change is worsening the problem for many farmers, increasing both the frequency and severity of some risks. Recognizing the importance of risk for smallholders in developing countries, PIM has since 2012 provided financial support to IFPRI for action-oriented research on risk management and agricultural insurance. PIM's contributions during 2012 to 2015 were provided through FP4, but after 2016 through FP3.

This paper reviews the activities undertaken by IFPRI as part of the research program (Section 2), synthesizes and evaluates the findings, highlights contributions and influence of the research outputs (Sections 3 and 4), and uses case studies to assess some of the program's development outcomes (Section 5). The study also identifies knowledge gaps and suggests priorities for future research within the CGIAR on risk management and agricultural insurance (Section 6). The methods used in this study were a desk review of project documents, research outputs, and metrics on the use and influence of research outputs, and remotely conducted interviews with some IFPRI and PIM staff and individuals in partner organizations. The study does not attempt to assess possible development impacts from the research program, only research and development outcomes. As this was an independent evaluation, ongoing research activities that had not yet resulted in research outputs were excluded from this study, except for case studies, where we were able to use interviews to document ongoing activities and early-stage results.

## 2. OVERVIEW OF IFPRI WORK ON AGRICULTURAL INSURANCE

The PIM financial resources provided towards this research program were in principle available for research on the broad topic of risk management for smallholder producers in developing countries, but the modest amounts of money involved and the short timeframe for producing

action-oriented results meant that the funds were mostly used to leverage innovations within an ongoing research program at IFPRI on agricultural insurance[1].

This section reviews the activities undertaken within the research program from their inception in 2009 through 2020. Discussion of research findings is deferred to Section 3.

### *2.1. Context and Overview of Program Activities on Agricultural Insurance*

Although IFPRI had undertaken significant research on agricultural insurance in the 1980s, there was a long lag before new insurance work was launched at IFPRI in 2009. A key difference was that while the earlier work had focused on publicly provided multiple peril crop insurance (MPCI) programs that were prevalent at the time[2], the more recent work was launched to explore newer forms of insurance like index-based insurance (IBI) and Picture Based Insurance (PBI) that can, in principle, overcome many of the problems that plagued the old-style MPCI programs. The situation in 2009 was that despite many innovations, research studies and pilot programs were demonstrating limited demand for agricultural insurance by farmers, even when subsidized. Researchers at universities and the World Bank had already begun to investigate the reasons for this low demand, and some of the key constraints like basis risk, cost, trust, and cash flow problems had already been identified (e.g., Gine et al. 2009; Skees et el., 2007). Building on this work, IFPRI researchers began by exploring factors constraining farmers' demand for insurance within selected research project sites in Ethiopia and Bangladesh. After prioritizing key constraints in project sites, the research moved quickly to exploring innovative ways of designing and delivering agricultural insurance in ways that would make it more attractive to local farmers. This led to innovative and original research contributions on flexible forms of weather index products, gap insurance, PBI, and bundling insurance with other value-adding propositions like credit, drought-tolerant seeds, and agricultural extension advice. The research also moved beyond research trials to action-oriented piloting of new approaches with commercially oriented implementing partners in several countries.

### *2.2 Early work and flexible forms of weather index insurance, 2009 - 2016*

Initial research began in Ethiopia and Bangladesh where fieldwork and randomized trials helped identify and prioritize factors constraining demand by farmers in the selected study areas, and then went on to explore several options for addressing those constraints. These options included: providing credit for premium payments; linking agricultural insurance to credit for purchasing farm inputs, household savings, and personal insurance; and bundling insurance with stress-tolerant varieties of crops and other climate-smart farming practices to improve adaptation to climate change. A study was also undertaken in China 2010-11 to determine the importance of liquidity constraints and the value of delaying premium payments until after harvest. In 2012, IFPRI also started testing whether selling weather index insurance (WII) to groups of farmers, such as savings groups or funeral insurance groups, would elicit a stronger demand response than selling WII directly to individual farmers.

[1] From an interview with Frank Place, Director of PIM.

[2] See, for example, Hazell et al.(1986).

Despite these innovations, basis risk remained a serious impediment to demand, and this led IFPRI researchers to develop the concept of flexible WII or flexible "weather tickets" (Hill and Robles, 2011). The idea was to offer smallholders a range of simple, transparent, and affordable weather contracts that span a variety of common weather risks in their region as an alternative to a single WII contract calibrated to the standard risk profile of an average farmer for the region. Flexible WII can potentially remove significant basis risk if a farmer is offered and is adept at picking the right portfolio of contracts.

Ethiopia

An initial randomized trial of flexible WII was undertaken in Ethiopia in 2009. Given favorable results from the trial, in 2010 IFPRI partnered with the Nyala Insurance Company to implement a pilot program with 774 farmers for a total insured sum of about $52,500. This work was funded in part with an award-winning grant from 3ie. In 2012, to further reduce basis risk, the work was extended to test the impact of "gap" insurance, which instead of flexible weather contracts offered a side contract based on area-yield estimates as a complement to a standard WII product. Several important research findings resulted from this work (see Section 3), both on aspects of local farmers' demand for WII as well as the benefits of flexible and gap insurance, and which helped lay the foundations for the subsequent IFPRI research program. In 2010, the Markets, Trade, and Institutions Division (MTID) at IFPRI, which houses the insurance work, reported that the research on flexible weather tickets "sparked considerable interest among a variety of private and public sector institutions working in this area: Allianz, the World Bank, IFC, WWF-US, IADB, IICA, Oxfam America, BASIX, Caribbean Risk Managers Ltd, Endurance Reinsurance Corporation of America."[3]

Bangladesh

Research on flexible forms of insurance was extended to Bangladesh in 2011. In partnership with BRAC, an NGO, IFPRI tested a hybrid mix of area-yield, deficit rain, and flood insurance contracts in Bogra district in the northwest during the 2013 monsoon season. This research involved a sample of 2,300 farms in 120 villages. In 2014 this work was expanded to evaluate the demand for flexible WII when linked to savings accounts, when bundled with drought-tolerant seeds, and to a comparison of the impact of premium discounts versus rebates paid later in the season.

India

In India, a trial of flexible WII was launched in 2011 in partnership with HDFC ERGO General Insurance, Ltd., one of India's major insurance companies servicing the agricultural sector. The trial targeted 60 villages (approximately 7,000 households) in three districts of Madhya Pradesh. Farmers were offered a menu of very simple weather insurance options each with a flat payment but different triggers and for different coverage periods. This product was tested during two consecutive summer agricultural seasons (known as *Kharif* in India) in 2011 and 2012 among the farmers who were cultivating rainfed soya beans. In addition to assessing the impact of the product on the production and consumption behaviour of smallholder farmers, the trial tested the

[3] MTID report for RISE2010.

impact on demand of offering the insurance in conjunction with intensive insurance literacy training, the allocation of different discount vouchers, and the installation of additional weather stations to reduce basis risk. This work continued into 2013 and showed that demand could be increased through the trialed interventions.

Another study was undertaken in the state of Odisha to test farmers' demand for weather index insurance linked to drought-tolerant rice cultivars. This involved a multi-year randomized control trial conducted during the *kharif* rice-growing seasons in 2015 and 2016, with a sample of 1,460 households in 111 villages, and a comparison of uptake rates for the cultivar itself and for the joint product across two years, alongside an analysis of factors that predict uptake.

Uruguay

As part of its investigation of flexible forms of WII, IFPRI partnered with the Ministry of Livestock, Agriculture and Fisheries (MGAP) and the State Insurance Bank (BSE) in Uruguay on the design and evaluation of a pilot WII scheme. The project involved identifying a target population –small family horticultural farms in the Canelones region, identifying their key production risks, designing a set of flexible weather indices, establishing needed weather stations and data systems for the insurance, and rationalizing a government subsidy. IFPRI also designed and implemented an evaluation plan for the pilot scheme, undertook a baseline survey of 700 farms between September and December 2013 and an end-line survey by phone in late 2014. Unfortunately, a rigorous impact evaluation of the pilot became untenable (more details are discussed under the case study in section 5). The MGAP and BSE continued the program at a larger scale in the 2014/15 crop season, and IFPRI continued to be involved in testing its proposed flexible WII approach. IFPRI's involvement with the program terminated in 2015 with its funding from the main donor (the Inter-American Development Bank) but the insurance program was still ongoing in 2021 and retains many of the key design features introduced by IFPRI. Given this favorable outcome, we analyze the experience in more detail as a case study in section 5.

### *2.3. Development of PBI, 2016-2021*

Flexible insurance contracts were shown to improve demand for WII products, but by 2015 it was clear that further innovations were still needed if demand was to scale up and which was becoming possible with new technological advances. So, in 2016 the IFPRI team launched new research on an innovative approach called Picture Based Insurance. PBI works as follows: a farmer installs an application into her smartphone, takes an initial picture of the crop parcel she wishes to insure, and documents how the crop develops in this site by taking repeat pictures throughout the growing season. The app facilitates this task through geotags and visual aids that ensure the farmer takes the pictures throughout the season at the same location as the initial picture, and with an almost identical view frame. All pictures are automatically uploaded to a server, with the farmer unable to manipulate them in the phone. At the end of the season, agronomy experts use the photos to evaluate the time-lapse of the plot and estimate a percentage of crop damage and the main reason for that loss. The insurance company uses these loss assessments to verify claims that trigger payouts to the farmer.

PBI has the potential to reduce basis risk. The picture-based evidence of crop damage over a season could enable insurers to adjust payments to individual farmers in years when they have losses due to insured risks that are not systemic enough to trigger a more general payout – so-called "gap insurance". PBI also has the potential to overcome many of the problems associated with more traditional indemnity insurance. By providing accurate, objective, and timely information about crop losses at plot levels, it can reduce inspection costs, moral hazard and adverse selection, problems that have plagued most form of indemnity insurance. A challenge is obtaining the information needed about the probability distribution of losses at such micro levels to enable insurance contracts to be priced correctly.

Initial testing of PBI began in India in 2017, and after encouraging results were obtained, research soon began in Ethiopia and Kenya.

PBI in India

IFPRI began testing PBI in India in 2017 in collaboration with the insurance partner from previous trials on the flexible weather units, HDFC ERGO General Insurance. PBI was first piloted amongst a sample of 750 wheat farmers in the Indian states of Punjab and Haryana. The project also developed a smartphone app (WheatCam, later renamed KisanCam as the project expanded to crops beyond wheat) to implement the collection of geo-referenced pictures taken by farmers at high frequency (every three days). Results showed that the picture-based insurance model is both feasible and sustainable for smallholder farmers in India. The team found that farmers are generally able to follow the prescribed picture-taking procedure, and that agronomists are able to use farmers' pictures to accurately assess serious crop damage. The team also found that PBI payouts are better correlated with yields than WII payouts, indicating that the pictures captured crop damage better than the indices behind WII products. In addition, the product did not appear to be subject to moral hazard or adverse selection problems.

In 2018, PBI was bundled with picture-based advisory (PBA) services, provided by the Center for Agriculture and Biosciences International (CABi). The project broadcasted IVR and SMS messages to a total of 32,237 wheat farmers. Results show that the advisory messages increased knowledge on best practices and revealed strong complementarities between PBA and PBI. Engagement in the PBA services measured as the number of pictures submitted and farmers' satisfaction was significantly higher when bundled with PBI, and while willingness to pay for PBA alone was negligible, respondents were willing to pay an extra 8.7% of the insurance premium when PBA was embedded in the PBI product. The project's product and results were shared at several local and regional events, including a regional dialogue in Dhaka and a workshop in Delhi. The project has also received local media attention in India, and the concept was awarded an Inspire Challenge grant in 2018 and won the Inspire Challenge Scaling Award in 2019, enabling a partnership between IFPRI, CABi and the M.S. Swaminathan Research Foundation to test PBA and PBI in Tamil Nadu.

One of the limitations of PBI is the need for and time taken by agronomic experts in interpreting crop damage from picture-based evidence, and the research team has started exploring the potential of using artificial intelligence (AI) and machine learning (ML) as decision aids. In this area, the team has been partnering first with collaborators from different universities, and later has firmed up a partnership with Dvara E-Registry (an ag-fintech startup), to help take the AI

and ML components to a higher level, and move towards more scalable models for implementing PBI.

In 2016 the Indian government at the behest of the Prime Minister launched a nationwide area-yield crop insurance scheme called the Pradhan Mantri Fasal Bima Yojana (PMFBY). Insurance is available for the two main farming seasons and covers standard costs of production as estimated for each crop at district levels. Average yields are determined each season for clusters of villages through state-operated crop-cutting experiments (CCEs). The insurance is heavily subsidized and although tied to credit for borrowers from state agricultural banks, it is also available as a stand-alone product. The PMFBY now insures about one-third of all farmers in India and 25% of the crop area, but it is not scaling up to the levels desired by the government. Basis risk is seen as an important constraint, and some states are looking for modifications to the program to help resolve this problem.

Within this context, the Mahalanobis National Crop Forecast Center (MNCFC), a government agency that acts as a technical service provider to PMFBY, asked IFPRI to test the use of smartphone images in estimating yields and crop damage in support of crop settlement claims. In response, in 2019 IFPRI began new research around collecting ground-truth information on yields along with smartphone images in Haryana, Odisha and Tamil Nadu. In Odisha, the state government seemed especially keen to explore innovations for reducing basis risk. A pilot study was launched in partnership with HDFC Ergo General Insurance and Dvara E-Registry, IFPRI's partner on the AI and ML side. This project collected yields, satellite imagery and smartphone pictures of targeted crops, comparing yields with outputs from crop models that incorporated satellite and smartphone images. Eventually, this work led to an impact evaluation in which a sample of 450 farmers are provided digital credit insured through PBI, allowing for a comparison of the standard PMFBY payout system based on local CCEs, with a PBI gap insurance system whereby the insurance payouts are adjusted where necessary based on picture-based evidence of crop damage. If successful, the approach could be adopted at the state level, and possibly also within other states. IFPRI is currently undertaking the data collection and analysis needed for an impact assessment of the pilot, and is not yet ready to make any recommendations for scaling up.

PBI in Ethiopia

In Ethiopia, IFPRI is partnering with the World Food Program (WFP) and the R4 Rural Resilience Initiative in a trial of the use of PBI (also called 'near-surface remote sensing') as a tool to strengthen seasonal monitoring of crop health and damage in Ethiopia. As in the Odisha study in India, the aim is to see if PBI can provide a useful way of reducing basis risk in an index-based crop insurance program. The study began its first season with a focus on testing equipment and assessing to what extent picture-based evidence corroborates and complements information captured through existing seasonal monitoring procedures and satellite indices. Starting in March 2019, fieldwork began in six villages pre-selected by the R4 implementing partners from two regions - Tigray and Amhara. In each village, the implementing partners selected 10 teff farmers to be included in the study, resulting in a total sample of 60 farmers. An agent from the implementing partner enrolled farmers and selected, together with the farmer, one plot to be monitored through weekly follow-up pictures of the plot, from sowing to harvest. At the end of the season estimates made by farmers and local agronomists of crop damage and its causes in the selected plots were compared against measurements from local area weather

stations and area CCEs. While there was more variation than expected amongst the crop damage estimates provided by farmers and different experts, still there was sufficient evidence to show that PBI can improve upon local area yield estimates and weather indices to reduce basis risk. Further work is continuing to obtain better insights into the discrepancies between the different data sources, and on how to make optimal use of the images as an objective source of data that can help resolve the gaps between farmer reports, insurance indices and yield data. The USAID FTF Innovation Lab for Markets, Risk and Resilience has recently joined the project as a funder. If the pilot is successful there is potential for it to be scaled up across the R4 Rural Resilience Initiative.

PBI in Kenya

Since 2009, the Agriculture and Climate Risk Enterprise (ACRE) organization has been working with local insurance companies to provide farmers in East Africa with varied agricultural insurance products. ACRE however faced the challenge of basis risk in their index-insurance model which reduced insurance uptake. Following IFPRI's successful pilot of the PBI program in India, ACRE reached out to IFPRI to support them in designing a similar product for the Kenyan market. Beginning 2019, ACRE, in partnership with IFPRI, the Kenya Agricultural and Livestock Research Organization (KALRO), and researchers from the University of Groningen and Wageningen University designed and piloted a program developing PBI products, and bundling these products with seeds of stress-tolerant varieties in Kenya. PBI pays farmers when there is visible evidence of crop failure, while the use of stress-tolerant varieties reduces farmers' *ex-ante* risk exposure. Besides reducing basis risk, bundling PBI with stress-tolerant seed varieties reduces the investment risk associated with the adoption of new seed varieties thereby unlocking further agricultural investments. IFPRI provides support to ACRE's evolving project by providing technical assistance around the design and implementation of PBI and the sustainability and inclusivity of alternative business models to deliver PBI, facilitating knowledge exchanges between the India and Kenya teams, conducting surveys, randomized trials, and an ongoing impact assessment. In 2021, IFPRI boosted its support by placing one of its senior researchers in Nairobi, who will spend part of her time directly working with the project. This program is co-funded by PIM, ACIAR-IDRC's Cultivate Africa's Future program (Phase 2), and NWO-WOTRO.

The partnership with ACRE is unusual for IFPRI and requires balancing a research agenda (with RCTs) with a commercially oriented aggregator that requires the resultant bundled insurance program to be commercially viable within a tight time frame. Given the unusual nature of the partnership and the potential for scaling up within ACRE's Kenyan and regional portfolio, we analyze the project in more depth as a case study in section 5.

### *2.4. Risk Contingent Credit in Kenya*

A separate research team at IFPRI that specializes in the use of remote sensing data for assessing climate and production risks began, in 2016, to undertake research on risk contingent credit (RCC) in Machakos County, Kenya. The IFPRI research team partnered with researchers from Columbia University, Cornell University, University of Greenwich, Swiss Re, a local insurer (APA), and the Equity Bank for this project, which is called the Satellite Technologies, Innovative and Smart Financing for Food Security (SATISFy) Project. The program was funded

by PIM and the Global Resilience Partnership. SATISFy bundles IBI with farm loans, and the insurance, when triggered, offsets the loan payment obligations of farmers, which in turn removes, or at least reduces, the credit exposure of lenders. By linking repayments to the underlying risk, RCC avoids the stringent bank collateral requirements making credit available to small-scale farmers. In addition, the structure of RCC reduces the probability of default on loans by producers and improves their risk-bearing ability, thereby facilitating investment and development. RCC is not a new concept and had been tried over decades with mixed results (for a recent review see Meyer et al., 2017). The key innovation in the RCC trial in Kenya lay with the specialized skills of the IFPRI team in its ability to minimize basis risk in product design by incorporating key environmental variables such as vegetation phenology, evapotranspiration, and soil moisture from state-of-the-art remote sensors, along with measurements from weather stations into the indices that trigger payments. We examine the program in more detail as a case study in Section 5.

### *2.5 Other Research Activities*

The IFPRI program has undertaken some studies that are more loosely tied to the main research agenda outlined above.

Impact of COVID-19 pandemic on farmers in India

The disruptions caused by the world-wide COVID-19 pandemic, and especially the resultant uncertainties for farmers, agricultural value chains and national food supplies, led to a plethora of quick studies to try and assess what was happening in many developing countries. IFPRI was at the forefront of much of this work and organized numerous case studies (e.g., see edited book by Swinnen and McDermott, 2020). Within that context the insurance team was able to take advantage of its ongoing field work in Haryana and Odisha to provide one such study. Specifically, they monitored the impact of the 2020 Indian national lockdown on wheat and tomato farmers' access to inputs, labor, machinery, and markets, and made a comparison between farmers in Haryana and Odisha (Ceballos et al., 2021).

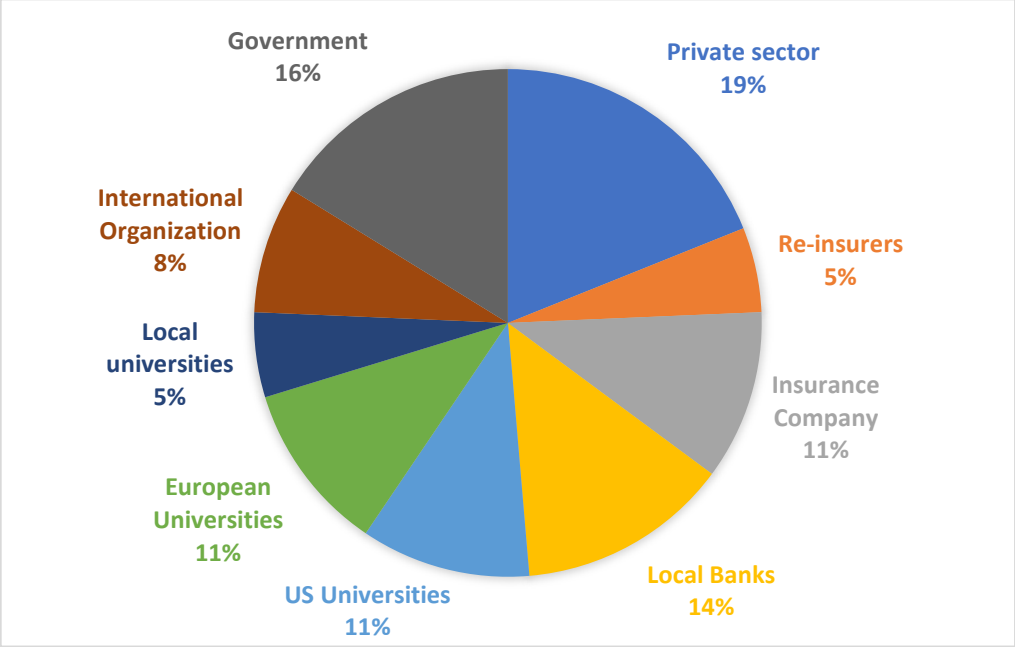
Cost-Benefit Analyses of African Risk Capacity (ARC)

Although there is widespread public interest in agricultural insurance and many governments now spend significant amounts of public resources supporting insurance, especially through subsidies, there have been hardly any recent studies that compare the private and social benefits from insurance with the cost of public support. In an important contribution, the IFPRI team undertook an analysis of the Africa Risk Capacity (ARC) in 2013 (Clarke and Hill, 2013), and found a favorable benefit-cost ratio. The analysis was updated in 2020 to reflect changes in the way the program was run, and again found a favorable benefit-cost ratio, but not as high as in the previous study (Kramer et al., 2020). While encouraging, it should be noted that ARC is not an agricultural insurance program itself, but is an insurance intermediary that a) provides countries with macro insurance for humanitarian disasters, and b) helps countries develop contingency plans for using their insurance payouts when disasters strike. Its benefit and cost structure is therefore very different from those of an agricultural insurance program within a country.

### *2.6 IFPRI Partners*

IFPRI's PIM-funded insurance work has engaged with a diverse mix of partners. Table 1 provides a list of partners and Figure 1 provides a summary by type of partner. The financial sector (30 percent) and public universities (27 percent) are the key partners. IFPRI relies on local insurance firms to underwrite agricultural risks while international reinsures handle the risks that are too large for local insurance companies. IFPRI's main re-insurance partners are Swiss Re and Africa Re. IFPRI also works with local banks and microfinance institutions to address supply-side constraints and bundling approaches. In Kenya for example, IFPRI's partnered with the Equity Bank to bundle formal credit with insurance for the RCC program. Universities play a major role in supporting product development and impact assessment activities. However, most of the partner universities are based in the US and Europe. Government institutions such as ministries of agriculture, meteorological departments, agricultural research organizations and statistics departments are also key IFPRI partners (16 percent). IFPRI programs have leveraged on government infrastructure to access public extension services and data. The partnerships with local government institutions illustrate the capillarity of IFPRI work, its potential to develop wider-reaching macro-insurance products and realize high-level policy impacts. IFPRI also partners with the local private sector (19 percent); this includes research and outreach firms, agro-vets, seed companies, and seed suppliers, and insurance aggregators who are familiar with the local environments. The private sector provides extension and outreach activities, avail agricultural inputs for insurance bundling, and research support. IFPRI also works with international institutions and NGOs (8 percent). The international organizations might provide established infrastructure related to data, extension, and research. For example, IFPRI has partnered with the R4 Rural Resilience Initiative of the World Food Program (WFP), to test the PBI program in Ethiopia.

**Figure 1: PIM-funded Program Partnerships by Type**



The majority of the IFPRI partnership activities are conducted remotely with occasional field visits to pilot sites. However, in some cases (such as PBI in Kenya) IFPRI researchers have had long stints in the pilot countries. The PBI program has also hired national full-time employees to support its activities in Kenya and India.

**Table 1: IFPRI PIM-Funded Agricultural Risk Program Partners**

| Organization | Country | Type |
|---|---|---|
| ACRE Africa | Kenya | Private sector |
| Africa Re | Kenya, Ethiopia | Re-insurer |
| APA insurance | Kenya | Insurance Company |
| African Risk Capacity (Agency and Limited) | African Union member states | International Organization and Insurance Company |
| Bahir Dar University | Ethiopia | Local university |
| Banco de Seguro del Estado | Uruguay | Insurance Company |
| Bureau of Statistics | Bangladesh | Government |
| Boston University | India | US University |
| Borlaug Institute for South Asia (BISA) | India | Local Research Institute |
| BRAC | Bangladesh | International Organization |
| Buusaa Gonofaa | Ethiopia | MFI |
| Center for Agriculture and Biosciences International (CABi) | India | International Organization |
| Centre for Insurance and Risk Management (CIRM) | India | Private sector |
| Columbia University | Kenya | US University |
| Cornell University | Kenya | US University |
| Data Analysis and Technical Assistance (DATA) | Bangladesh | Private sector |
| Dvara E-Registry | India | Private sector |
| Equity Bank | Kenya | Local Bank |
| Ghent University | India | European University |
| Gram Unnayan Karma (GUK) | Bangladesh | Private sector |
| Greenwich University | Kenya | European University |
| Grupo Radar | Uruguay | Private sector |
| HDFC Ergo General Insurance | India | Insurance Company |
| Kenya Agricultural and Livestock Research Organization (KALRO) | Kenya | Government / Local Research Institute |
| Mahalanobis National Crop Forecast Center (MNCFC) | India | Government / Local Research Institute |
| Meteorological Department | Uruguay | Government |
| Buusaa Gonofaa Micro Finance Institution (MFI) | Ethiopia | Local Bank |

| | | |
|---|---|---|
| Ministry of Finance | Bangladesh | Government |
| Ministerio de Ganadería | Uruguay | Government |
| Ministry Livestock, Agriculture and Fisheries (MGAP) | Uruguay | Government |
| Oromia insurance | Ethiopia | Insurance Company |
| Planet Finance | - | Private sector |
| R4 Rural Resilience Scheme (WFP), Oxfam | Ethiopia | International Organization |
| State Insurance Bank (BSE) | Uruguay | Local Bank |
| Swiss Re | Kenya | Re-insurer |
| The George Washington University | India | US University |
| University of Groningen | Kenya | European Universities |
| University ORT | Uruguay | Local university |
| Wageningen University | Kenya | European University |

## 3. RESEARCH FINDINGS AND CONTRIBUTIONS TO THE LITERATURE

This section reviews and synthesizes the main research findings from the IFPRI research program as revealed in their published outputs. To help assess their originality, we also juxtapose the IFPRI findings against the published findings of other researchers working on agricultural insurance at about the same time.

### *3.1 Agricultural Insurance Demand and Determinants of Uptake*

As noted earlier, at the time IFPRI began its research on agricultural insurance there was already a growing literature showing that the uptake of agricultural insurance products had been extremely low, with many schemes failing or requiring heavy subsidies to induce and sustain adoption (e.g., Gine et al. 2008). Beginning in 2009, research at IFPRI contributed to a deeper understanding of the factors behind the low uptake rates, and this section summarizes the main findings. Key driving factors studied included: high cost of premiums, basis risk, credit and liquidity constraints, risk aversion, financial literacy and education, and lack of trust in the product and product providers.

Premiums

IFPRI research on the role of premium prices on insurance uptake decisions shows that demand for agricultural insurance products is price-sensitive but usually price inelastic. Clarke et al (2016) use a choice experiment to evaluate farmer preference for different hypothetical agricultural insurance products; to estimate demand elasticities, they vary the price of area-yield insurance across the experiment sessions. They find that the increase in the area-yield insurance premium corresponds with a decline in demand. Hill et al. (2015) conduct an experiment to evaluate the demand for a weather-index insurance product in India. To create exogenous variation in the prices faced by the households, they offer varying price discounts. They find that the demand for insurance decreases with a price increase. They report own demand elasticities of

-0.58, moreover, they find that price sensitivity increases with an increase in basis risk. In a different study, Hill et al. (2019) offer both price discounts and rebates to farmers in the Bogra district of Bangladesh. They find that farmers prefer price discounts to the rebates. They also find that demand is sensitive to premium prices and the own price elasticities were estimated at -0.65. IFPRI findings on the effect of premium prices on insurance demand are similar to those reported in other studies (for instance; Mobarak and Rosenzweig 2013; Cole et al. 2013; Karlan et al. 2014; Bageant and Barrett, 2017; Jensen et al. 2018), however, the demand in the later studies is more elastic with own price elasticities ranging between -1.04 to -2[4].

The low demand elasticities reported by IFPRI researchers suggest that lowering premium prices with subsidies might not be sufficient to increase agricultural insurance demand to desirable levels. An interesting finding by Clarke and Kumar (2016) shows that women in Bangladesh bought more insurance units when the insurance was offered at a higher price, similarly, the demand for catastrophic event insurance increased with the price. Although this observation could be loosely associated with the belief that high prices signalled good quality coverage, it could also signal that non-price factors matter more than price. Other researchers - Mobarak and Rosenzweig (2012) and Cole et al. (2013), also show that even when premiums are set significantly below estimated expected payouts, demand for agricultural insurance remains low.

Basis risk

Besides premium prices, basis risk has been cited as one of the main constraints to index-insurance uptake. Hill et al (2013) and Hill et al. (2016) conduct an experiment to assess the demand for hypothetical index-insurance products in Ethiopia and India. To evaluate the role of basis risk on insurance uptake decisions, the researchers randomly vary the village distance to the nearest weather station. Both studies indicate that the demand for insurance products decreased with an increase in the distance to the weather station (a proxy for an increase in basis risk). Hill and Robles (2011) also show how the heterogeneity found among farmers highlights the degree to which basis risk will continue to be a problem for any weather-index product. Overall, these findings are consistent with other studies that find an inverse relationship between basis risk and insurance demand (Gine et al, 2008; Mobarak and Rosenzweig, 2012; Clarke, 2016; Jensen et al. 2018).

However, some IFPRI research shows that even though basis risk is present, it might not be large enough to fully explain the low demand for index-insurance products. For instance, Ceballos (2016) combines a stochastic rainfall generator model and spatial rainfall distribution to estimate the extent of basis risk for an arbitrary rainfall index-insurance product in Uruguay. The author shows that due to information asymmetries associated with spatial properties of rainfall, farmers tend to overestimate the degree of basis risk. This largely stems from the complexity of the index-insurance products, combined with the low level of education in the target population. The author highlights the need to complement the introduction of new insurance products with extensive training on the spatial properties of rain and basis risk.

[4] Except Bageant and Barrett, (2017) and Mobarak and Rosenzweig (2012) who report own price elasticities of between −0.33 to −0.46.

Credit and liquidity constraints

Most agricultural insurance field experiments and pilots are conducted among small-holder farmers facing significant resource constraints, and/or in regions with thinly developed financial markets. Even in regions where financial markets are available, the service providers are reluctant to lend to smallholder farmers due to the systemic risks involved (Meyer et al. 2017; Shee et al.2019). Constrained resources coupled with the high cost of insurance premiums and the upfront premium payment requirements make liquidity an important determinant of insurance uptake decisions. IFPRI researchers have extensively evaluated the role of liquidity and wealth in insurance uptake decisions. Hill et al. (2013) find that in Ethiopia, wealthy individuals, and individuals with higher access to financial services are more likely to purchase an insurance product than their relatively poor counterparts. In Bangladesh, Clarke and Kumar (2016) find that although women generally had lower demand for insurance, wealthier women (measured by the total land area owned) tend to purchase more insurance units. The role of liquidity can also be inferred from received payouts, as indicated in Hill et al. (2019): households that receive insurance payouts are more likely to purchase insurance in subsequent periods[5]. Similar findings on the role of credit access, wealth, and liquidity have been reported by other researchers (Gine et al. 2008; Gine and Yang, 2009; Cole et al. 2013; Casaburi and Willis 2018).

In contrast, some non-IFPRI studies have indicated that liquidity may not be a major constraint to adoption. They argue that if agricultural insurance meets safe minimum quality standards and farmers see value in it, they will independently find the required liquidity to purchase the premiums (Karlan et al. 2015; Carter et al. 2017).

Risk aversion

IFPRI researchers have conducted field experiments to elicit the risk preference of their farmer subjects using various risk elicitation methods[6]. The empirical findings of the impact of risk aversion on agricultural insurance uptake decisions have been mixed; Hill et al. (2013) and Clarke and Kumar (2016) find that farmers with a higher degree of risk aversion have reduced willingness to pay (WTP) for insurance and they buy fewer units of an actual weather index-insurance product. Hill et al. (2016) test the Clarke (2016) prediction that in the presence of basis risk and when premiums are above their actuarially fair price, a hump-shaped demand with respect to risk aversion is expected. Consistent with this hypothesis, Hill et al. (2016) report that for products with above-actuarially fair premiums, the demand increases at low risk levels and then falls at high risk levels, while for actuarially fair products, demand is negatively related to risk aversion. In contrast, Clarke et al. (2015) report a positive relationship between the degree of risk aversion and uptake of an area-yield insurance product. The mixed IFPRI findings on the role of risk-aversion on insurance demand are matched by related findings reported in the literature. For instance, Gine et al (2008) and Cole et al. (2013) find that risk-averse individuals

[5] Increased post-payout uptake could be attributed trust and behavioral changes as discussed later in the study

[6] Hill et al. (2013), Hill et al. (2016), Clarke and Kumar (2016) administered Binswanger-style lottery choices to each individual in the survey (Binswanger, 1980). Clarke et al (2015) elicit risk preference by asking the participants to select their preferred gamble from a set of options increasing in risk and expected income.

are less likely to purchase an insurance product, while Belissa et al. (2019a) finds that an increase in the degree of risk-aversion increases index-insurance uptake.

Financial literacy and education

As noted in Schultz (1981), education increases the ability of farmers to perceive, interpret and respond to new events. The average education level of the population in the agricultural insurance pilot target regions barely goes beyond six years of formal schooling (Gine et al. 2008; Hill et al. 2013; Cole et al. 2013; Takahashi et al. 2016). The limited education and financial literacy of target clients limits farmers' ability to independently evaluate the piloted, mostly complex financial instruments. IFPRI researchers have consistently shown that agricultural insurance demand increases with an increase in the level of education and financial literacy. Hill et al. (2013) show that individuals with higher education levels are more likely to purchase insurance. Clarke and Kumar (2016) also show that the number of insurance units bought increased with an increase in the level of education, but in a surprising twist, they find that women with lower financial literacy tend to buy more insurance units.

Research conducted by IFPRI researchers also shows that intense training and learning through experience can be effective in inducing insurance uptake (Hill et al. 2016; 2019). Finally, insurance providers can leverage educated individuals to improve financial education and influence community decisions around insurance uptake (Clarke et al. 2015).

Lack of trust in the product and product providers

When agricultural insurance products are targeted at clients with limited financial literacy (with reduced ability to independently evaluate the product), and very little experience with insurance products and insurance providers, trust becomes an important component in the decision-making process. The role of trust is even larger when dealing with an index insurance product since payouts are based on an exogenous reading as opposed to individual losses. Hill et al. (2016; 2019) use a positive prior experience with an insurance product—captured by payout receipt—as a proxy for trust. Both studies show that individuals who receive a payout are more likely to purchase insurance in the subsequent periods. The studies attribute the improved post-payout uptake to improved trust in the product and/or the insurance company. The results are similar to those from a long-run experiment conducted in India in which Cole et al. (2013) finds that payouts play a key role in engendering farmer trust in the product. Stein (2018), however, argues that the payout effects cannot be accounted for by neo-classical explanations, such as improved liquidity and trust, rather, it is due to behavioral effects such as recency bias, shifting reference points, and viewing insurance as a system of balanced reciprocity.

### *3.2 Gender Heterogeneity in Insurance Demand*

Research shows that women in the rural areas of developing countries (and insurance pilot target regions) are poorer with disproportionately lower control of productive resources, access to financial markets, education and financial literacy levels, and high degrees of risk aversion (Doss 2001; Quisumbing and Mallucio 2003; Clarke and Kumar, 2016). As such, it is expected that insurance demand will systematically differ between men and women, and this has been confirmed by IFPRI researchers. For instance, Hill et al. (2013) find that compared to men, women in Ethiopia are less likely to purchase an agricultural insurance product. Moreover, they

show that insurance uptake is significantly higher among individuals with greater agency (power to make decisions), a group that is most likely to consist of men (Quisumbing and Mallucio, 2003). Clarke and Kumar (2016) find that in Bangladesh, men are more likely to buy more units of insurance than women. Men and women might also have different degrees of risk perception, and this could impact on their purchase decisions; in their experiment, Clarke et al. (2015) find that women participants were more likely to purchase life insurance for their spouses to protect their consumption should the main income earner die. These findings suggest that women care more about idiosyncratic than covariate risks, which reduces their demand for climate-related insurance products.

The findings on gender and uptake are similar to those found in comparable experimental studies found in the literature (Akter et al. 2016). In southern Ethiopia, although index insurance is accessed equally by men and women (Bageant and Barrett, 2017), women are more likely to buy lower-value insurance policies than men (Takahashi et al. 2016).

### *3.3 Impacts of Agricultural Insurance on Household Welfare*

From a development perspective, agricultural insurance products can only be deemed beneficial if they positively contribute to improved consumer welfare *ex-ante* and *ex-post*. Evaluating consumer welfare changes due to insurance requires longer period observations and financial resources, and only a handful of PIM-funded studies exist in this space. The studies show that agricultural insurance might induce investment in higher-yielding but more risky agricultural technologies which could increase farm productivity and revenues. Hill and Viceiza (2012) conducted a framed field experiment in rural southern Ethiopia to observe farmer fertilizer purchase decisions under uncertainty with and without insurance, and find that insurance has a positive effect on fertilizer purchases. In a different study, Hill et al. (2019) use two-wave panel data to evaluate the impact of insurance among Bangladesh farmers. They find that farmers with insurance have significantly higher expenditures on fertilizer, hired labor, irrigation, and pesticides. Although the PIM-funded studies are either hypothetical or based on short-term observation, the findings are comparable with empirical studies from long-run simulations and field experiments from the Index-Based Livestock Insurance (IBLI) project in Kenya and Ethiopia (Jensen et al, 2017; Janzen and Carter, 2018; Matsuda et al. 2019; Janzen et al. 2021).

### *3.4 PIM-Funded Innovations to Address Low Insurance Demand*

IFPRI researchers have worked on developing and piloting innovations to address the various constraints along the agricultural insurance value chain. The innovations range from non-technical approaches such as the provision of heterogeneous insurance products, intensive farmer training, group insurance, and delayed premium payments, to more technological approaches that are aimed at reducing basis risks and improving product quality. This section provides a detailed review of PIM-funded research and innovations and their corresponding successes/potential in addressing the different uptake constraints.

Delayed premium payment

Typical agricultural insurance contracts require that the premium be paid upfront with a promise of later payment conditional on the weather outcomes. Upfront payment can result in liquidity constraints and liquidity loss (at least in the short run), while the uncertainty with the weather outcomes and how it is measured can create trust issues. Liu et al (2020) note that contrary to the upfront payment requirements in developing countries, most of the agricultural insurance sold in the US is paid for at the end of the insured period. They experiment with farmers in China to test whether a change in the timing of premium payment—payment at the end of the insured period, at the cost of interest charge—can improve insurance demand. The new product was designed such that if the insured farmers suffer a significant loss, insurers deduct the premium from the payout, if not, the premium is still required to be paid with interest. Their analysis shows that farmers were 10 percent more likely to purchase insurance under the delayed payment scheme than the conventional upfront payment scheme. Paying at the end of the insurance cycle is aimed at not only addressing the liquidity constraints, but also the initial trust issues associated with initial experience with insurance products.

Although Liu et al's experiment significantly contributes to the agricultural insurance literature, their work is not new; similar products have been tried in Kenya and Ethiopia (Casaburi and Willis, 2018; Belissa et al. 2019b), both studies show higher demand under the delayed premium payment scheme. Promising as this design may seem, however, it is akin to providing the farmer with a loan equivalent to the insurance premium for the duration of the season. Introducing such a credit dimension into the contract brings the possibility of farmer default. Farmer defaults can lead to an increase in the cost of premiums, making insurance unaffordable, and in extreme cases, it can lead to the collapse of insurance markets (Liu and Myers, 2016). In addition, while the above studies were embedded in an existing structure where farmers could be held accountable at the end of the season, such as contract farming or strong ties with farmer associations, it is an open question whether this kind of design can be extended to other settings where such contract enforcement mechanism is absent (Kramer et al, 2021b).

Group insurance

Besides offering individual insurance contracts, insurers can offer group contracts. Group contracts have several advantages: groups could internalize many problems of understanding the product and they are better placed to enforce insurance contracts; group contracts reduce the cost of marketing for the insurer (perhaps thereby reducing the cost of premiums); group contracts could help manage basis risk—to the extent that not all basis risk is perfectly correlated among group members: and finally, when combined with informal risk-sharing mechanisms, it allows group members to manage idiosyncratic risks while insurers cover more covariate risks (Dercon et al. 2012; Hill et al. 2013).

IFPRI researchers have conducted experiments to evaluate the benefits of offering group contracts as opposed to individual contracts. Hill et al. (2013) extend their study to evaluate how willingness to pay for a hypothetical insurance product would vary were it to be offered through a local risk-sharing group. Specifically, they consider local funeral association groups called *iddirs.* They find that women and individuals with lower education levels prefer insurance offered through groups. Clarke et al. (2015) design an indemnity-based life and disability

insurance product to offer protection against household-level shocks. Individuals were allowed to choose between individual or group saving accounts. They found that the decision to participate in the insurance markets was higher when decisions were made as a group. In a different study Janssens and Kramer (2016) conduct an experiment to evaluate the demand for group versus individual health insurance among rural households in Tanzania. They find that under group insurance, nearly all participants opt for insurance, indicating that insurance optimizes group welfare. Under individual insurance, demand is high only among more risk averse clients. They conclude that group insurance aligns individual and group incentives and can thereby help microfinance groups coordinate on their social optimum and potentially increase low take-up rates. These findings complement an earlier study by Dercon et al. (2014), and they collectively reiterate the possibility that offering insurance via groups may ensure that insurance is offered to society members who would otherwise not purchase (such as women), improve trust, and contribute to insurance understanding.

Provision of heterogenous insurance products

Most index insurance products have been characterized by a one-size-fits-all payout structure, intended for a representative farmer within a region (Ceballos and Robles, 2020). However, even at a localized level, insurance demand is heterogeneous and varies with the farmers' risk profile and exposure, gender, wealth, financial literacy, among others. The heterogeneity in demand and farmer characteristics calls for tailored insurance products to meet farmer's needs. IFPRI researchers have experimented with providing multiple or flexible insurance products as opposed to the standard unique package approach for a region. In an experiment in Ethiopia, Hill and Robles (2011) offer multiple weather derivatives — referred to as weather securities—whereby farmers have the flexibility to choose the type and number of securities to buy depending on their crop portfolios and production practices in a given year. They show that, unlike standard weather-index insurance, weather securities are easily understood by farmers, and they provide the heterogenous coverage needed. The authors however note that the weather security tools are not perfect; the heterogeneity among farmers compounds the challenges of basis risk, and decision making about which products to purchase remains a challenge.

Using data from a set of index insurance products in Uruguay, Ceballos and Robles (2020) evaluate how farmer heterogeneity may affect demand for insurance. They offer multiple but independent insurance units covering against specific risks to accommodate the heterogeneity in farmer risk profiles[7]. They find that providing flexibility through multiple insurance schemes marginally improves farmer welfare as opposed to the alternative of providing a composite product.

IFPRI's research contributions on flexible insurance appear to be unique and there is no comparable literature.

[7] Various factors including differences in the mix of crops, planting dates, soil drainage, distance to the weather station, and understanding of the product significantly determinants of the type of insurance portfolio purchased by a farmer (Ceballos and Robles 2020).

Picture-based insurance (PBI)

IFPRI researchers have developed and piloted Picture-Based Insurance (PBI) products as an alternative to both conventional indemnity insurance and index insurance products in India and Kenya. PBI provides insurance coverage for damages detected from a time-lapse of the insured crop, built from the pre- and post-damage georeferenced pictures that farmers take using regular, low-cost smartphones[8]. Kramer et al. (2017) conduct an experiment in rural India to evaluate the extent of information asymmetries associated with the PBI product (specifically moral hazard and adverse selection), and the farmers' willingness to pay (WTP) for the product as opposed to a weather index-based insurance product. They do not find any evidence of moral hazard or adverse selection. In addition, farmers reported that regular field trips to take pictures improved their crop management practices. The WTP for PBI was higher than that of a hypothetical premium calculated from the previous seasons' average payouts from a weather index-based insurance product. The findings provide anecdotal evidence that PBI can reduce the costs of loss verification and information asymmetry while providing product ownership among small-scale farmers.

Ceballos et al. (2020) conduct a study to evaluate the extent of farmer compliance with PBI protocols, the ability of smartphone picture data to capture crop damage, and the extent to which PBI reduces downward basis risk. All farmers in the sample were provided with free weather-index insurance, while a sub-sample was provided with PBI alongside the weather-index-based insurance. The authors also used the average farm harvest to simulate an area yield insurance product. They find that PBI compliance was relatively good; 67 percent of the trained farmers uploaded pictures as required[9]. They also find important reductions in basis risk from PBI. In contrast to the 9 percent of farmers for whom PBI triggered a payment, weather index-based insurance triggered payouts for a significantly higher proportion of farmers, but the average payout for PBI was higher than for weather index-based insurance. In addition, while PBI was unable to identify sites with moderate degrees of damage, it did identify 71.4 percent of sites with severe crop losses, reducing severe cases of downside basis risk and outperforming both weather index-based insurance and the simulated area-yield index.

IFPRI's research contributions on PBI appear to be unique and there is no comparable literature.

Machine learning and artificial intelligence

Both PBI and traditional satellite imageries require detailed data processing and interpretation to determine the level of payouts when an insured event has occurred. This might delay the payouts and diminish the effectiveness of insurance as a risk coping tool, and human error might compound the problem of basis risk. Machine Learning (ML) and Artificial Intelligence (AI) can help to closely track individual losses thereby reducing basis risk while at the same time fast-tracking insurance payouts. IFPRI researchers have explored the possibility of leveraging ML and AI to track individual losses.

[8] See details of PBI in the Case Study Section

[9] Using PBI activities as a proxy for product-based engagement, the authors analyze whether farmers' ability and willingness to take picture for insurance purposes depend on observable farmer characteristics. They find a negative relationship between belonging to lower caste and the probability of taking pictures. Farmers sowing smaller lands and those who do not own the insured plot took more pictures on average. Farmers whose plots are located father from their home tended to take more pictures. In terms of age, there was similar level of participation across all farmers.

Based on the PBI images collected from wheat farmers in India, Hufkens et al. (2019) quantify the capacity of "near-surface remote sensing imagery" generated through the PBI approach to accurately monitor crop phenology and physical disturbance to crop growth as compared to the traditional satellite-based products. They show that smartphone-based near-surface remote sensing can capture the progression of the crop growth season in a way that improves upon the level of information captured by the traditional satellite-based data. A visual assessment of the smartphone imagery showed that well-constrained amplitude thresholds on vegetation greenness correlate with the timing of key phenological phases during wheat development. On the other hand, satellite remote-sensing techniques were unable to capture the significant degree of spatial heterogeneity in crop phenology that was observed both within and between smallholder fields in the sample. They conclude that the greenness index curves derived from smartphone-based crop pictures can predict the onset of growth stages during which crops are more vulnerable to weather risk, outperforming satellite vegetation indices.

As a next step, Parkes et al (2019) develop a range of statistical yield models for rice and wheat that predict yields as a function of weather indices, using alternative sources of gridded weather data. They find that the statistical yield models depend heavily on the source of weather data. To circumvent this problem, and to address challenges around the availability of high-quality yields data in many developing country settings, the team moves to a process-based crop simulation approach to derive statistical yield models in follow-up work. Using data on rice yield estimation from India, Afshar et al. (2021) evaluate how the integration of crop models, phenological monitoring through satellite remote sensing, and ML techniques can support the design and implementation of smart phenology-based index insurance products with reduced basis risks. Based on the Hufkens et al (2019) paper, the authors start with the idea that one can use smartphone-based crop images to determine crop growth stages, and that this can in turn be used as ground truth data to improve predicted growth stages based on satellite imagery. They then show that when accounting for field-level heterogeneity in crop development and timing of extreme weather events, it is possible to reliably estimate rice yield without the need for extensive observational yield training datasets and without having to apply real-time data-demanding plot-level yield simulations. This study highlights the opportunity for combining ML and satellite-based crop phenology data to provide a scalable solution for deriving the relationship between yields and proxy indices, thereby reducing basis risk.

Bundling insurance with other risk reduction instruments

Bundling insurance with other risk management tools has been promoted as an alternative to making insurance more attractive to small-scale farmers. Bundling might help small-scale farmers to overcome the initial investment associated with the adoption of new varieties, improved access to credit and agricultural advisory services, and improve climate-friendly agricultural production activities. The value from these bundled investments and services also adds to the value of the insurance beyond its purely risk-reducing role, making it more attractive to farmers. Bundling is not a new approach and there are many applications in the literature (e.g., see Hess et al, 2016). An innovative feature of IFPRI's approach is the use of PBI as the primary type of insurance that is included in the bundles.

Bundling weather index-based insurance, PBI and climate-smart agriculture

According to FAO (2013), Climate-Smart Agriculture (CSA) is a form of agricultural production that combines various sustainable production methods to tackle specific climate challenges while improving farm productivity. Using both theory and experimental data, Kramer and Ceballos (2018) evaluate how to combine CSA technologies with weather index insurance such that the two instruments form a complementary risk management package. First, they analyze the impact of bundling on the demand for index insurance and CSA. Second, to remove basis risk, they analyze the effect of bundling indemnity insurance with CSA and explicitly conditioning insurance payouts on CSA adoption[10]. They find that in the absence of basis risk, bundling improves the demand for insurance while adopting CSA improves wellbeing, showing complementarities between the two products. The analysis further shows that requiring farmers not to burn crop residues in order to qualify for insurance significantly reduced residual burning rates by 10-34 percent. These findings suggest that conditioning insurance payouts on CSA adoption would encourage farmers to adopt conservational agricultural practices and improve adaptation to climate change in the long run[11]. In 2018, this work was awarded the the T.C. Schultz Prize at the International Conference for Agricultural Economists (ICAE) in Vancouver.

Bundling PBI with picture-based advisory services

Agricultural advisory services can help farmers improve their farm production and management, it can also help in the provision of personalized insurance information and bolstering trust between the farmer and service provider. Ceballos et al. (2018) evaluate the impact of bundling PBI with personalized picture-based advisory (PBA) services among farmers in rural India[12]. They find that while bundling had no significant impact on farm investment in the short-run, PBA increased farmers' knowledge on best agricultural practices, suggesting that the tangibility of pictures and the personalization of the advice can potentially serve to encourage take-up of the recommended practices reducing risk exposure. They also found that the WTP for PBA services significantly improved when bundled with PBI. Ceballos et al. (2019) conducted a follow-up focus group discussion (FDG) to understand the farmers' value-proposition, perception, and willingness to engage in the bundled product. They show that the bundled service could be beneficial to poor farmers, however, due to farmers' low WTP and low smartphone ownership, it might be unsustainable to provide the product. Farmers in other areas expressed interest in the bundled product.

Bundling PBI with improved seeds

The formal seed sector in Africa is most accessible to relatively large-scale (often male) farmers who have the finances to invest in more expensive seeds of improved and more stress-tolerant

[10] In this experiment, farmers were divided into three groups; the first group received only free weather index-based insurance (control group), the second group received weather index-based insurance alongside an add-on PBI (placebo group), while the third group received weather index-based insurance alongside an add-on PBI, but the payouts were conditional on no crop residue burning (treatment group).

[11] Many farmers in the treatment group chose to burn their residual, they therefore lost out on their insurance cover.

[12] The researchers randomly assign villages to one of three interventions: the first group received conventional interactive voice response (IVR) and SMS messages (control group); the second group received personalized, picture-based advisory messages (placebo group); and the third group was provided with PBI coverage alongside IVR, SMS, and the personalized, picture-based advisory services (treatment group).

varieties. Smaller-scale farmers (often women) cannot take the risk of investing their scarce cash in these seeds and are more likely to obtain seeds from informal sources, including local networks and relatives. A project by Kilimo Salama/ACRE Africa that bundles insurance with fertilizer and seed purchases has achieved considerable scale in East Africa (GIZ 2021). Building on the project's success, IFPRI researchers in partnership with ACRE Africa and other local and international stakeholders have piloted a project that seeks to evaluate the effectiveness of bundling PBI with stress-tolerant seed varieties and with remote advisory services in Kenya. Findings from a trial conducted in Eastern Kenya showed: drought was the major production risk; farmers highly value drought-tolerant seed varieties; and PBI could play a major role in resolving disputes in claims settlement and misunderstanding around coverage (Cecchi et al. 2019). The actual demand for the bundled product in a first implementation season has however been very low, which is attributed to a lack of trust in the product, competition from government seed interventions, and low agent commissions; but in a subsequent season, improving the implementation model based on these initial lessons learnt, take-up of the bundled products improved substantially (Kramer et al. 2021a).

Risk-contingent credit (RCC)

Small-scale farmers are often credit constrained, in part because lenders' see them as too risky to serve but also because many farm households 'risk-ration' themselves out of the markets for fear of losing collateral and livelihoods when natural or economic adversity hits. Bundling insurance and credit has been promoted as an alternative to improving financial inclusion for rural populations, with potential benefits not only to farmers, but also to the credit and service providers (Hess et al. 2016; Meyers, et al.2017). IFPRI researchers have designed and piloted Risk-Contingent Credit (RCC), a product that bundles rainfall index-insurance and agricultural credit. RCC takes the form of a short-term loan with a payoff structure that is linked to shortfalls in cumulative seasonal rainfall below a target. When triggered, the insurance offsets part of the loan repayment obligations of farmers, which in turn removes, or at least reduces, the credit exposure of lenders. On the other hand, if the underlying risk is not triggered the loan has to be repaid at the risk-contingent interest rate (Shee et al. 2019)[13]. Using data from an RCC pilot in Kenya, Ndegwa et al. (2020) find bundling credit and insurance significantly increased farmer credit uptake.

Although IFPRI's RCC work is not new in the agricultural insurance space (Gine and Yang, 2009; Meyer et al. 2017), the pilot provides a detailed understanding of the demand for an actual bundled product. Despite being a desirable innovation, insurance-credit bundling struggles with coordination and market failure problems, information asymmetries, and high initial set-up problems (Meyer et al. 2017). This is mainly because the insurance coverage included in the bundle is generally limited to the cost of the bundled product, such as the credit borrowed or the input cost, implicitly shifting the benefits of insurance coverage away from farmers —since in the event of a catastrophic loss they are still subject to large income losses— and towards input providers or financial institutions (Kramer et al. 2021b).

[13] More details are provided in the case studies section.

### *3.5. Other PIM-Funded Studies*

Cost Benefit analysis of agricultural insurance

Clarke and Vargas Hill (2013) calculate the economic benefit from African Risk Capacity (ARC) for every USD 1 million spent. They find that a combination of improved risk financing and contingency planning could increase benefits to the poor by up to $ 1.90 per dollar invested in ARC, relative to the status quo of an ad hoc delayed response. This number was however derived under the hypothesis that contingency planning improves speed, targeting, and costs at which humanitarian assistance is delivered. Kramer et al (2020) revisit the assumptions underpinning the initial CBA to reflect current ARC operations, and they update the CBA using new methods for evaluating the costs and benefits of regional risk pooling to finance disaster risk management. They find that under the revised assumptions, the increase in benefits to the poor will have exceeded the costs of regional risk pooling, but not by as much as US$ 1.90 per dollar invested as indicated in Clarke and Vargas Hill, (2013). This is because ARC premiums have been higher than assumed in the initial CBA, despite advanced modelling efforts basis risk remains a concern, and insured countries have used ARC payouts mainly to distribute food aid instead of leveraging state-contingent welfare schemes with potentially larger speed, cost, and targeting gains. The updated CBA also highlights the potential benefits of increasing awareness *ex ante* among prospective beneficiaries. If reducing beneficiaries' perceived risk exposure, this could enhance investments and thereby create additional welfare gains.

Covid-19 pandemic and agricultural production risks

The COVID-19 pandemic and the measures put in place to curtail it took a toll on economies worldwide. These include mobility restrictions that interrupted the normal functioning of the agricultural value chains. IFPRI's insurance team was able to take advantage of its ongoing field work in India to monitor the impact of the 2020 national lockdown on agricultural production and farmer livelihoods. Ceballos et al. (2021) analyze how the lockdown impacted on wheat and tomato farmers' access to inputs, labor, machinery, and markets to produce, harvest, and sell their crops. When the Indian lockdown was announced, wheat producers were about to harvest their crop, while tomato farmers were in the process of growing their crops. As such, the farmers were likely to face market and production challenges. The study shows that wheat producers, for whom state-led procurement guaranteed market access at fixed prices, suffered minimal declines in income. On the other hand, the income of tomato farmers fell by 50% relative to their expected income in a normal year. This was largely due to a steep fall in tomato prices as they shifted from wholesale markets to local retail markets, resulting in a sharp increase in local supply. The reduced income for tomato producers increased borrowing and reduced food security. The authors conclude that targeting producers of crops that face substantial price risk and introducing policies that stabilize market prices are important in efforts to aid recovery and build the resilience of smallholder farmers. In a different study evaluating the impacts of the lockdown by state, Ceballos et al. 2020a find that in states where mechanization is limited, farmers spent more on labor to harvest their crops, and distress selling was more prevalent due to the absence of a well-functioning procurement system for their crops. In states with well-developed market structures, the government was able to sustain procurement at stable prices, limiting negative lockdown impacts on smallholder production.

## 4. QUANTITATIVE ASSESSMENT OF THE PROGRAM'S INFLUENCE

An important step in assessing any policy or development outcome from the research program being evaluated is an assessment of the quality of the research itself and the extent to which it may have influenced relevant research and policy communities. The previous section was devoted to an assessment of the main findings from the research program and their contributions to the state of knowledge within the broader literature on agricultural insurance. In this section, we review the extent to which research and outreach outputs from the research program have influenced the research and development communities as evidenced through available quantitative data on citations, downloads, Altmetric scores, web page views, and the like.

### *4.1 Types and Number of Research Outputs*

The main research outputs from the program have been released as peer reviewed journal papers, but other outputs include discussion/working papers, conference papers, project briefs and notes, and postings on the IFPRI Web site of household data sets, blogs, videos, and podcasts.

In terms of written research outputs for which data are available, a total of 16 journal papers and 16 other written outputs were produced between 2011 and 2020 (see Annex I for a full listing). Most of these outputs were produced during 2018-2020 and relatively few were produced in earlier years (Figures 2 and 3). This probably reflects the fairly long gestation periods involved between fieldwork and publication for research involving RCTs over 1-3 years. A shift in research priorities in 2015 from a focus on flexible insurance approaches to PBI, an entirely new approach, and to a more action-oriented approach with implementing partners may also have contributed to further lags in output.

**Figure 2: Number Journal papers by year, 2011-2020**

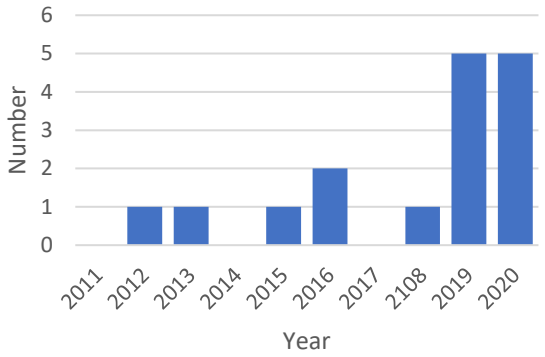
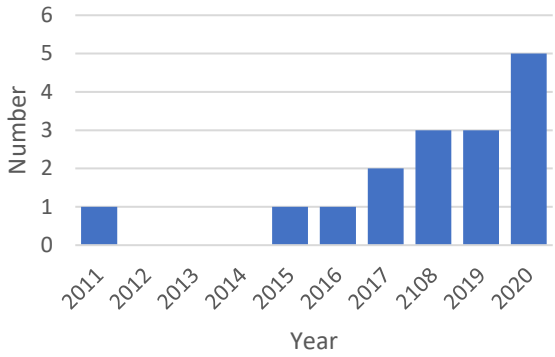



**Figure 3: Number other outputs by year, 2011-2020**




Below we first consider measures of influence for the written research outputs from the research program, and then consider measures of influence for other types of research and outreach outputs.

### *4.2 Statistical Measures of Influence for Written Outputs*

ISI Web of Science citations

Web of Science is an online scientific citation indexing service whose metrics are based solely on articles in the journals indexed by Web of Science and do not include citations of books, chapters, patents, reports, etc. Thus, they primarily capture influence within the scientific community. Compilations by the IFPRI CPA Division as of August 25, 2021 show there had been a total of 221 ISI Web citations over the period 2011-2020 for 16 citable journal papers, or 13.8 citations per paper and 22.1 per year. Only one paper had zero citations, the maximum was 56, and 7 of the 16 papers received more than 10 citations (Figure 4 and Annex I). Most of the citations were concentrated in the two periods 2019-20 and 2012-13 (Figure 5). Citation counts typically accumulate over time for research papers, so the high accumulated citation counts for papers published in 2012 and 2013 are to be expected, but the high counts for papers published in 2019 and 2020 are unusual and suggest the research team has produced some recent cutting-edge results that are attracting attention amongst peer researchers.

**Figure 4: Number ISI Web citations by paper, 2011-20**

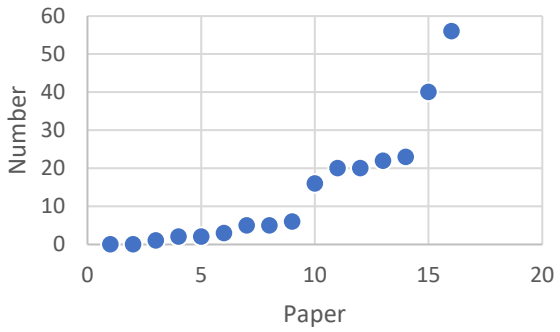
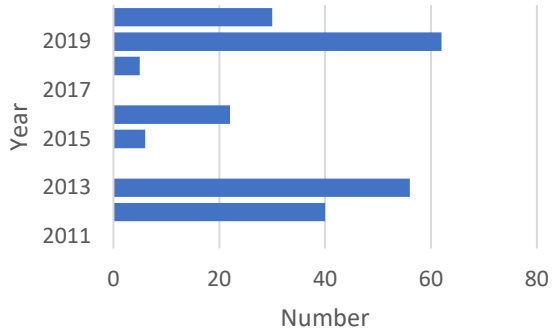



**Figure 5. Number ISI Web citations by year, 2011-20**




Google Scholar citations

Google Scholar citation counts capture a wider range of written research outputs than just journal papers and also a wider range of users than just researchers, and are more indicative of the wider influence of a written output than the ISI Web citations. As of August 25, 2021, the same 16 journal papers that received a total of 221 ISI Web citations also received a total of 668 Google Scholar citations over 2011-2020, averaging 41.8 per paper and 66.8 per year. All the papers received some citations with a range of 6 to 222, and ten of the papers (63%) received at least 10 citations and four received at least 50 citations (Figure 6).

The 15 other outputs received a total of 93 citations over 2011-2020, with a range of 0 to 70, averaging 6.2 per output and 9.3 per year. But the distribution was very skewed with one output accounting for 75% of the total citations (Figure 7).

As with the ISI Web of Science citations, the Google Scholar citations are concentrated in the early and later years of the evaluation period (Figure 8), and likely for the same reasons.

**Figure 6: Number Google citations by journal paper, 2011-20**

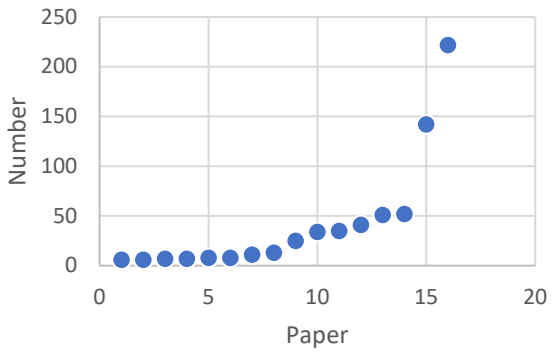



**Figure 7: Number Google citations by other output, 2011-20**

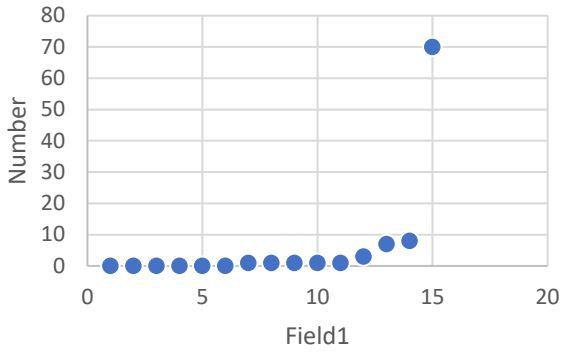
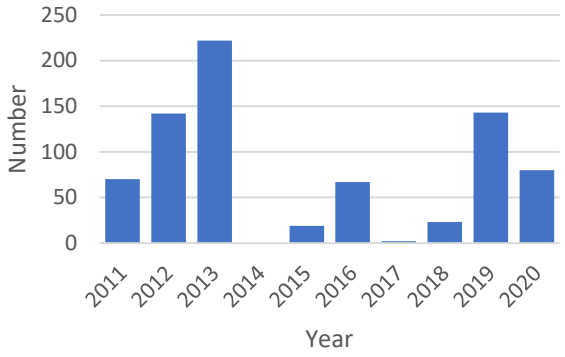


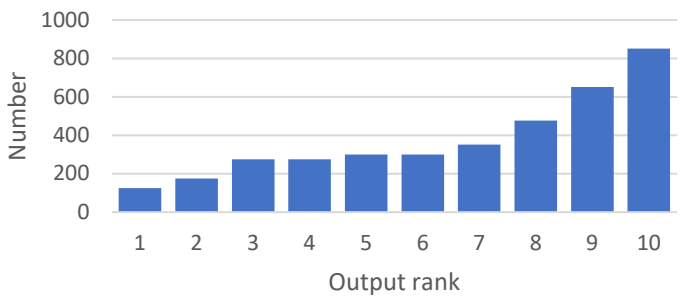

**Figure 8. Number Google citations by year, all outputs, 2011-20**




Download statistics

Even though most of the other written research outputs attracted few Google citations, they still received a reasonable level of attention as indicated by the number of downloads from the IFPRI Web site. Eighty percent of the outputs were downloaded at least 200 times between 2011-20, with a range of 125-851 and an average of 368 per output (Figure 9). The most downloaded outputs were about PBI (see Annex I).

**Figure 9. Number downloads of other outputs**




Altmetric scores

Altmetric scores are a weighted count of the amount of attention an item receives from social media and mainstream news media, such as news stories, blogs, Wikipedia, policy documents, Facebook, YouTube, Reddit/Pinterest, and Q&A. It is considered a useful measure of the amount of attention or interest that a research output has generated. The IFPRI CPA Division provided Altmetrics for 31 research papers over 2011-2020. These had a mean of 9.8 and a range of 0 to 58 (Figure 11). Most of the scores were obtained in 2019 and 2020 (Figure 10) for papers published in those two years.

**Figure 10. Total Altmetric scores by year, 2011-20**

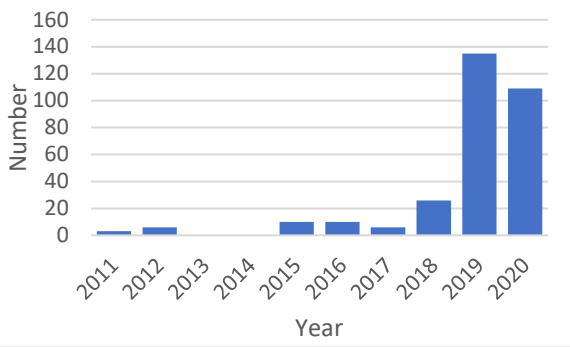
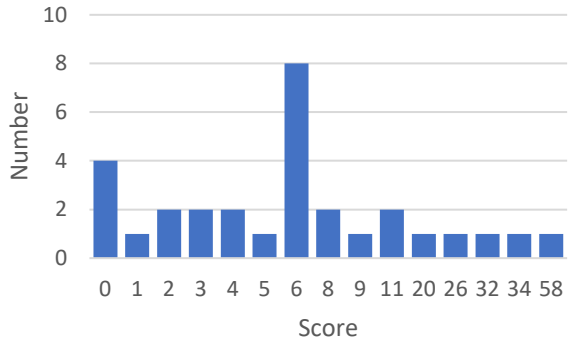



**Figure 11. Altmetric scores by paper, 2011-20**




The top ten written outputs

A useful way of combining the different quantitative indicators above is to examine the top ten research papers. These were selected based on ranking each written output on its accumulated Google Scholar citations over 2011-2020 (Table 2). Table 2 also shows the comparable rankings for each output based on its accumulated ISI Web of Science citations, and its current Altmetric score. The rankings based on Google and ISI citations are very similar, but both are inversely related to the Altmetric scores; the most cited papers have some of the lowest Altmetric scores and vice versa. A plausible explanation is that the older papers have accumulated more citations over time, but because they are less fresh they are not capturing as much online attention today.

Of the ten most cited papers, three are based on earlier research about farmers' demand for insurance, three are based on the design and testing of flexible forms of index insurance, and three are based on PBI. The 4$^{th}$ most cited paper is a 2020 journal paper that resulted from an opportunistic study of the impact of India's national COVID lockdown on farmers in ongoing PBI research sites in Haryana and Odisha. While not directly related to insurance, the study did help identify different vulnerabilities amongst farmers both within and across the two states, which helped prioritize future research activities. This paper also achieved the highest Altmetric score, a reflection of the current high level of international interest in the impact of COVID on food systems within developing countries. Other papers with high Altmetric rankings were on PBI and flexible forms of WII, suggestive that IFPRIs work on these topics is cutting edge and attracting attention.

**Table 2. Top Ten Papers (Ranked by number Google Scholar citations**

| Year | Authors | Title | Where Published | Google Scholar citations | | ISI Web of Science Citations | | Altmetric Score | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | No. | Rank | No. | Rank | No. | Rank |
| 2013 | Ruth Vargas Hill, John Hoddinott, Neha Kumar | Adoption of Weather-index Insurance: Learning from Willingness to Pay among a Panel of Households in Rural Ethiopia | Agricultural Economics 44 (2013) 385–398 | 222 | 1 | 56 | 1 | 0 | 16 |
| 2012 | Ruth Vargas Hill, Angelino Viceiza | A field experiment on the impact of weather shocks and insurance on risky investment | Experimental Economics 15, 341–371 | 142 | 2 | 40 | 2 | 6 | 10 |
| 2011 | Ruth Vargas Hill, Miguel Robles | Flexible Insurance for Heterogeneous Farmers Results from a Small-Scale Pilot in Ethiopia | IFPRI Discussion Paper 01092 June 2011 | 70 | 3 | N/A | N/A | 3 | 13 |
| 2020 | Francisco Ceballos, Samyuktha Kannan, Berber Kramer | Impacts of a national lockdown on smallholder farmers' income and food security: Empirical evidence from two states in India | World Development 136 (2020) 105069 | 52 | 4 | 22 | 4 | 58 | 1 |
| 2016 | Ruth Vargas Hill, Miguel Robles, Francisco Ceballos | Demand for a Simple Weather Insurance Product in India: Theory and Evidence | Amer. J. Agr. Econ. 98(4): 1250–1270 | 51 | 5 | 20 | 5 | 2 | 14 |
| 2019 | Koen Hufkens, Eli K. Melaas, Michael L. Mann, Timothy Foster, Francisco Ceballos, Miguel Robles, Berber Kramer | Monitoring crop phenology using a smartphone based near-surface remote sensing approach | Agricultural and Forest Meteorology 265 (2019) 327–337 | 41 | 6 | 23 | 3 | 32 | 3 |
| 2019 | Francisco Ceballos, Berber Kram er, Miguel Robles | The feasibility of picture-based insurance (PBI): Smartphone | Development Engineering 4 (2019) 100042 | 35 | 7 | N/A | N/A | 20 | 5 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | pictures for affordable crop insurance | | | | | | | |
| 2019 | Ruth Vargas Hill, Neha Kumar, Nicholas Magnan, Simrin Makhija; Francesca de Nicola, David J. Spielman, Patrick S. Ward | Ex ante and ex post effects of hybrid index insurance in Bangladesh | Journal of Development Economics 136 (2019) 1–17 | 34 | 8 | 20 | 5 | 34 | 2 |
| 2019 | B Parkes, T P Higginbottom, K. Hufkens, F. Ceballos, B Kramer, T Foster | Weather dataset choice introduces uncertainty to estimates of crop yield responses to climate variability and change | Environ. Res. Lett. 14 (2019) 124089 | 25 | 9 | 16 | 7 | 26 | 4 |
| 2016 | Daniel J. Clarke, Neha Kumar | Microinsurance Decisions: Gendered Evidence from Rural Bangladesh | Gender, Technology and Development 20(2) | 13 | 10 | 2 | 10 | 2 | 14 |

Note: Papers ranked as top ten on Google score, and scores for ISI Web and Altmetrics are from the full set of papers in Annex I.

Comparison with outputs from other researchers working on agricultural insurance

On their own, the quantitative measures discussed above do not tell us much about the quality or influence of the research team's published outputs compared to the quality and influence of published outputs from non-IFPRI researchers who also worked on agricultural insurance over the same period. To make such comparisons we created a comparator group of seven non-IFPRI researchers who have published consistently on agricultural insurance over our evaluation period 2011-2020. The chosen comparators are Profs. Barry Barnett, Christopher B. Barrett, Michael R. Carter, Daniel J. Clarke, Alain de Janvry, Mario Miranda, and Jerry Skees. In Table 3 we show the aggregate Google Scholar citations over 2011-2020 for all the written outputs that the comparator group has produced on agricultural insurance, divided into two periods 2011-2015 and 2016-2020, and segregated into two groups – journal papers and other written outputs listed in Google Scholar. Note that we have not included any papers these authors have written on other topic and have only included insurance papers listed in 2011-2020. Table 2 also shows the comparable data for the IFPRI research team.

**Table 3. Comparison of Google Scholar citations for IFPRI team and a comparator group of researchers working on agricultural insurance**

| Year/Author | Number outputs | | Number citations per paper | | |
|---|---|---|---|---|---|
| | Total | Per researcher | Minimum | Maximum | Average |
| ***2011-2015*** | | | | | |
| IFPRI team – journal papers | 3 | 1 | 11 | 222 | 125.0 |
| Comparators – journal papers | 28 | 4 | 2 | 340 | 98.3 |
| IFPRI team – other outputs | 2 | 0.7 | 8 | 70 | 39.0 |
| Comparators – other outputs | 98 | 14 | 0 | 166 | 12.3 |
| ***2016-2020*** | | | | | |
| IFPRI team – journal papers | 13 | 4.3 | 6 | 52 | 22.5 |
| Comparators – journal papers | 28 | 4 | 1 | 363 | 55.5 |
| IFPRI team – other outputs | 13 | 4.3 | 0 | 7 | 1.3 |
| Comparators – other outputs | 51 | 7.3 | 0 | 134 | 9.5 |

Note: Other outputs include working papers, briefs and conference papers listed in Google Scholar.

The comparator group is arguably more senior and established than the IFPRI research team, and there was sufficient staff turnover amongst the IFPRI team over 2011-2020 that it retained a younger age profile than the comparator group. The comparator group is also about twice as large as the IFPRI team and may have had more research resources at its disposal. Yet despite these differences, the IFPRI team performed relatively well. The number of journal papers and other outputs per researcher were lower for IFPRI than the comparator group during 2011-2015, which is not too surprising given that the team only began its research in 2009 and needed to build up some momentum. However, by 2016-2020 the IFPRI team was producing similar numbers of outputs per researcher as the comparator team. Importantly, the IFPRI team scored better than the comparator group in terms of average citations per output during 2011-15: 125 to 98.3 for journal papers and 39 to 12.3 for other research outputs. But this advantage was lost in the second period when the IFPRI papers were cited less than half as often as the comparators' outputs. The comparator group also achieved higher maximum citation counts in both periods, for example, 340 compared to 222 in the first period for journal papers, and 363 compared to 52 in the second period. It should be noted that the comparator group did not include the authors of two of the most cited papers on agricultural insurance. A 2013 paper by Cole et al which has been cited 957 times[14], and a 2014 paper by Karlan et al which has been cited 1006 times[15]. These authors were not included in the comparator group because they produced few other papers on agricultural insurance during our period of evaluation.

### *4.3 Measures of Use of Other Research Outputs*

Downloads of project data sets

The IFPRI insurance team posted data sets online in 2019 and 2020 (Table 4). As of August 25, 2021, the first two data sets had attracted considerable attention with about 240 downloads each.

[14] https://www.aeaweb.org/articles?id=10.1257/app.5.1.104
[15] https://academic.oup.com/qje/article-abstract/129/2/597/1867065?redirectedFrom=fulltext

**Table 4: Data sets released and download statistics, 2011-20**

| Year | Authors | Title | Where Published | Downloads | Altmetric Score |
|---|---|---|---|---|---|
| 2019 | International Food Policy Research Institute (IFPRI) | Picture Based Insurance (PBI) in India, 2016-17 | Harvard Dataverse | 238 | 4 |
| 2020 | International Food Policy Research Institute (IFPRI); Ghent University; University of Manchester | Crop Monitoring Using Smartphone Based Near-Surface Remote Sensing: Ground Pictures of Wheat and Auxiliary Data from Northern India | Harvard Dataverse | 248 | |

PBI project Web page

A project Web page was created in 2016 dedicated to PBI. During the period June 1, 2020 to July 31, 2021 this page received 1,467 sessions, which compares favorably with an IFPRI average of 485 sessions per project Web page over the same period.

Videos, Blogs and Podcasts

The IFPRI insurance team has been active in its global outreach and has produced a variety of videos, blogs, and podcasts all of which are receiving reasonable attention according to data provided by IFPRI's CPA division on August 26, 2021 (Table 5).

**Table 5: Data on videos, blogs and podcasts**

| Video | Pageviews |
|---|---|
| Picture-Based Crop Insurance (uploaded July 2017) | 1,408 |
| Helping smallholder farmers manage risks | 273 |

| Blog Post | Unique Pageviews |
|---|---|
| Can weather index insurance help farmers adapt to climate change? | 1,412 |
| Seeing really is believing: Farmers' photos revolutionize insurance and advisory services | 313 |
| Research for agricultural insurance in South Asia: A regional dialogue | 2,612 |
| Picture-based crop insurance: Is it feasible? Is it sustainable? | 886 |

| Podcast | Times played | Unique page views |
|---|---|---|
| https://soundcloud.com/ifpri-researchtalks/episode-5-picturing-a-better-crop-insurance | 560 | |
| https://www.ifpri.org/podcast/research-talks/episode-5-picturing-better-crop-insurance | | 582 |
| https://www.ifpri.org/podcast/research-talks/episode-7-road-financial-inclusion-kenya | | |

## 5. CASE STUDIES

In order to assess possible development outcomes from IFPRI's insurance work, we selected three case studies for more in-depth analysis. We chose to focus on the more action-oriented research projects in which IFPRI partnered with implementing agencies to help design and pilot improved insurance programs. The three cases are flexible WII with BSE in Uruguay, PBI bundled with improved seeds with ACRE Africa in Kenya, and RCC with Equity Bank in Kenya. We also examined the partnerships IFPRI has developed in its work, and the extent to which these may have helped strengthen local capacity for designing relevant agricultural insurance products.

### *5.1 Flexible Weather Insurance Contracts in Uruguay*

As part of its investigation of conditions for the development of effective and sustainable micro-insurance markets for small and medium-sized farms, IFPRI in partnership with MGAP, and BSE, piloted a WII product in Uruguay. The insurance was offered from December 2013 to March 2014 to cover excess rain during the period January 2014 to April 2014. In practice, there were very heavy rains during early 2014 leading to severe crop losses, the index was triggered, and the insured farmers received compensation. Unfortunately, an evaluation of the impact of the insurance pilot became untenable for two major reasons. First, only about one percent of the target farmers purchased insurance, even though about 30% had indicated interest during the baseline survey. This meant that of the household sample of 700 farms, only 7 were "treated", too small a sample size for any statistical analysis. The experiment was also undermined by the government which, because of the severity of the regional losses, declared an emergency and compensated all farmers in the region for 30% of their declared losses, and made available 3-year interest free loans for the remaining 70% - a classic case of a government disaster assistance program undermining its own subsidized agricultural insurance program. This meant that there was no longer an effective "control" group for comparison.

Despite the lost opportunity to evaluate the pilot insurance program, MGAP and BSE decided to press ahead and continue the program at a larger scale for the 2014/15 crop season. The subsidy was raised from 30% to 90% (but capped at US$400/producer), insurance was offered on additional horticultural crops, and additional regions were added to the program. IFPRI was involved in this phase and trialed its proposed flexible IBI approach. Twelve different insurance units were offered to farmers calibrated to their nearest weather station, all with the 90% MGAP premium subsidy. The insurance was purchased by 128 farmers with an average of 8.5 contracts each. Pre and post-season farm surveys were undertaken of a sample of 91 insured farmers. Given the near impossibility of comparing treated and nontreated farms econometrically, IFPRI researchers estimated a farm decision model to simulate the optimal choice of contracts and their impact for the 91 insured farms that were surveyed. The model aimed to explain differences in farmers' insurance choices taking into account their heterogenous risk and cropping situations.

IFPRI's involvement with the program terminated in 2015 with its IDB financing, but the insurance program was still ongoing in 2021 and is sold in parallel with an older and more established hail insurance product. It still retains many of the key design features introduced by

IFPRI, such as flexible rainfall contracts and their triggers and pricing. The program is also still heavily subsidized on a graduated basis by farm size, with the smallest category of farmers receiving a 90% subsidy and the largest 35%, but with a cap of $400/farm. The program operated with a healthy loss ratio of 0.64 over the eight years 2013/14 to 2020/21 (Table 6). The BSE clearly has the capacity to sustain the program, but it is doubtful if they could redesign the insurance contracts if that became necessary. Some capacity to redesign the contracts may remain with Prof. Néstor Gandelman of the Universidad ORT, who was a partner in the original research.

**Table 6: Performance of the Horticultural Insurance Program operated by the State Insurance Bank (BSE) of Uruguay, 2013/14 to 2020/21**

| Crop Season | Sum insured US$ | Area insured HA | Total premium US$ | Indemnities paid US$ |
|---|---|---|---|---|
| 2020-2021 | 405,353.60 | 109.91 | 37,830.16 | - |
| 2019-2020 | 633,572.00 | 163.45 | 56,623.06 | - |
| 2018-2019 | 733,785.00 | 195.71 | 41,278.00 | 153,900.00 |
| 2017-2018 | 125,679.00 | 32.13 | 7,168.53 | - |
| 2016-2017 | 138,500.00 | 146.00 | 16,369.15 | - |
| 2015-2016 | 199,000.00 | 162.77 | 22,091.47 | - |
| 2014-2015 | 560,000.00 | 503.00 | 58,176.35 | - |
| 2013-2014 | 18,000.00 | 20.00 | 1,129.70 | - |
| Annual average | 351,736.10 | 166.62 | 30,083.80 | 19,237.50 |

Source: Banco de Seguros del Estado, Uruguay

One limitation of the research project was that apart from the simulated analysis of how the insurance affected farmers' cropping choices, funding problems prevented the IFPRI team from collecting panel data and undertaking a longer-term assessment of how the insurance impacted on farm productivity, the stability of farm income, or household welfare.

### *5.2 Bundling PBI and Seeds of Stress-Tolerant Varieties in Kenya*

The PBI program in Kenya uses a network of local farmers as extension service providers (also called 'champion farmers'). Since 2019, ACRE has recruited and trained about 199 champion farmers. The champions were equipped with smartphones and trained on farmer registration and an agent network was set up that can sell and distribute agricultural insurance products. The champions registered approximately 36,307 regular farmers. About 60 percent of the champions and regular farmers were female, in line with ACRE's objective of improving women's access to improved seed varieties. Baseline data were collected from all the registered farmers and champion farmers. About 3,000 of the registered farmers were randomly issued with a trial pack of stress-tolerant maize and sorghum varieties (the intervention group). Within the intervention

group, farmers were further randomized into three sub-treatments arms: no insurance, weather index-based insurance (WBI), and PBI. Champions were incentivized to send in regular images of the farmer's plot with the seeds from the trial pack, capturing images of both the new variety and the farmer's regular variety, via a smartphone app called 'SeeItGrow'. The trials were aimed at increasing farmer awareness of improved seed variety use, evaluating the performance of the improved seeds on a larger scale, and testing farmers' PBI compliance. A follow-up midline survey was conducted with approximately 2,900 farmers.

Based on the experience from the trials, the consortium piloted a new approach of marketing and distributing seeds on a commercial basis. In the new approach, champions take an inventory of demand for different types of seeds (both regular and stress-tolerant varieties) from farmers in their area, ACRE places orders with seed companies at negotiated prices and bundles with insurance, the seeds are delivered to locations convenient for both champions and farmers. In a first season, despite the improved seed access under the new approach, only 4 champions (less than one percent) were able to sell seeds. A total of 69 bags of maize and sorghum were sold, this is against the 2,091 bags that had been registered in the original demand inventory. The researchers attribute the gap in demand to lack of trust, competition from other government interventions, and a small difference between the negotiated wholesale price and the retail price (implying low champion commissions). In a second season, to address the low demand challenge ACRE made several adjustments to their model including engaging with seed companies to directly distribute seeds to champions (thereby bypassing distributors and increasing champion commissions). This strategy led to a significant increase in improved seed demand. To deal with liquidity challenges, the consortium has instituted a revolving fund to finance early seed purchase and delivery, ACRE has also established a strategic partnership with financial institutions to leverage on their existing infrastructure to avail credit to farmers.

From an insurer's perspective, the program presents a promising approach to reduce basis risk. In addition, using local farmers as extension officers and participation through field pictures has improved farmers' trust in the program. Reduced basis risk and improved trust are expected to increase demand on a commercial basis. Preliminary analysis of the data also indicates that the program increased on farm investment and the use of complementary risk mitigation strategies (e.g., crop diversification as opposed to a monoculture of maize). The financial results for ACRE are also encouraging so far, with an average loss ratio over the first three seasons of 0.64 (Table 7).

**In the future**, it will be important to complete the impact assessment of the program to assess its net benefits for farm household productivity and welfare,. This will require additional rounds of household surveys and data analaysis. The consortium is also planning to test alternative approaches to increasing demand for stress-tolerant varieties. For instance, to date, ACRE fully subsidized insurance premiums and did not condition providing insurance on purchasing seeds. It would be interesting to see if—as ACRE phases out full subsidies—providing insurance at a discounted rate to farmers who purchase seeds of stress-tolerant varieties makes the bundle more attractive to farmers. As the new varieties are more widely adopted, an added advantage of making the connection with picture-based insurance more explicit is that the crop images provide ACRE and partnering seed companies with ground data to verify that the stress-tolerant varieties work as promised (or not) and indeed reduce smallholder farmers' exposure to risks. The

consortium is also working towards the automation of field image processing and interpretation using machine learning (ML) and artificial intelligence (AI) modules to allow local partners to seamlessly integrate the product into their portfolio without the need for regular technical support.

**Table 7: Performance of ACRE-IFPRI program, 2019-2021**

| | *Short rains October 2019 to February 2020* | *Long rains March to September 2020* | *Short rains October 2020 to February 2021* | *Long rains March to September 2021* |
|---|---|---|---|---|
| Total payout (USD) | 293.02 | 1,382.78 | 3,641.22 | Under review |
| Total Premiums paid (USD) | 3,955.45 | 865.36 | 3,546.14 | 2,832.56 |
| Total sum insured (USD) | 39,554.47 | 12,360.77 | 35,461.38 | 28325.64 |
| Loss ratio | 0.07 | 1.60 | 1.03 | Under review |
| Proportion of sites for which payouts were triggered | 35 sites out of 38 | 45 sites out of 193 | 203 out of 560 | Under review |
| Sum insured (USD) | 18.11 | 135.83 | 18.11 | 18.11 |
| Average payout (% of sum insured) | 0.43 | 0.37 | 0.17 | Under review |
| Total images submitted | - | 4,765.00 | 18,033.00 | 18,567.00 |

### *5.3 RCC in Kenya*

The RCC program was piloted in 11 divisions in Machakos county, and it ran from July 2016 to June 2020. The insurance index was based on Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) rainfall measures for the traditional long rain season in Machakos County from October 15th to January 15th. The historical dekadal (10-daily) rainfall data from 1981 were collected for each of the 11 divisions and the cumulative rainfall measures were fit to a PERT distribution[16], with a cumulative rainfall 'trigger' set at the 20th percentile for each division. Actuarial premium rates were then computed using a correlated Monte Carlo simulation.

Each division had a unique trigger value based on historical rainfall distribution while the actual premiums averaged about 12% across all divisions. If the drought risk worsened and crossed the trigger, the total repayment obligation of a farmer falls, and the difference is deposited directly into the borrowers' loan account. On the other hand, if the index is not triggered the loan has to be repaid at the risk-contingent interest rate.

The baseline data were collected from 1170 households between May 16 to June 2, 2017. After the baseline survey, about 1053 households received training on RCC, its costs and benefits, and the payment structures. The trained households were randomly assigned into three experimental groups: traditional credit (placebo), RCC (treatment group), and no credit (control group).

Treatment and placebo farmers received further training on the bank's loan processes and, where necessary, opened a bank account. It should however be noted that not all households in the placebo and treatment groups qualified for credit, the bank issued credit based on individual creditworthiness. To ensure that credit was used only in production processes, farmers were provided vouchers which they used to collect inputs from local Agrovet supply shops within their communities. For the RCC group, a 14 percent insurance premium was added to the base loan. The interest rate applied to the loan balance was 14% per annum. RCC subsidies were issued to randomly selected households in the treatment.

A study evaluating credit uptake shows that the uptake of RCC was significantly higher (40 percent) than that of traditional credit (30 percent) (Ndegwa et al., 2020). In addition, preliminary analysis of program impacts shows that households with RCC are likely to increase investment in farms (e.g., significantly higher use of improved seeds and fertilizer). RCC households also exhibit significantly higher levels of dietary diversity, reduced food insecurity, and resilience (Ndegwa et al., 2021). Besides the direct impacts of RCC, households in the treatment received extra program benefits such as training on agronomic practices, financial literacy, and digital bank account management. Under the program sponsorship, one local partner received PhD-level training at the University of Greenwich and he is expected to continue providing technical support for future RCC work in Kenya.

RCC implementation faced challenges related to basis risk; the 2017 growing season was characterized by torrential rains at the beginning of the season and a severe drought towards the end of the season. But since RCC was designed to trigger based on average seasonal rainfall, the index failed to trigger despite severe crop loss. Since the insurance company had no obligation to pay for the loss, project money was used to pay the farmer loans. The setback led to a change in the model design to a more refined and dynamic weather index that integrates key agronomic indicators of crop phenology. The setback however had some unexpected benefits: the farmers whose loans were repaid by the program promoted the product to their neighbours, improving subsequent RCC uptake.

IFPRI researchers and partners have received additional funding from German BMZ tto expand RCC work in Kenya and have plans to expand into Ethiopia. Future work will: (1) seek to reduce basis risk further by incorporating key environmental variables such as vegetation phenology, evapotranspiration, and soil moisture from state-of-the-art remote sensors, along with measurements from weather stations, to create an advanced composite weather index at high spatial and daily resolution that synthesizes ground data with satellite observations and that has been quantitatively validated; (2) integrate a gender dimension into the analysis by including intra-household and cluster-level randomized controlled trials (RCTs) to reach, benefit, and empower women farmers; (3) develop formal relations with an increasing number of RCC service providers for piloting RCC in Kenya and Ethiopia and, ultimately, other developing countries that suffer from escalating risks due to higher weather volatility induced by climate change; and (4) build capacity on risk management through finance and agronomy trainings for farmers in Kenya and Ethiopia.

## 6. DISCUSSION OF FINDINGS AND RECOMMENDATIONS

This section first summarizes our findings of the research and development contributions of IFPRI's PIM-funded work on agricultural insurance, both for the research community and towards meeting the strategic goals of PIM. We then briefly review work on agricultural insurance undertaken by other CGIAR Centers and any links they had with IFPRI's work, which completes the background needed for our final section on recommendations for future research on agricultural risk management and insurance within the OneCGIAR.

### *6.1 Discussion of Findings*

Research contributions

IFPRI's research up until 2015 added importantly to a growing literature on agricultural insurance, and helped clarify the roles of basis risk, liquidity constraints, trust, premium prices, financial literacy, and prior payout experience on farmers' demand for insurance products. IFPRI also made important contributions towards quantifying differences in insurance demand by gender, and in evaluating the potential of group insurance for inclusive insurance coverage. Most of IFPRI's publications from this work are well cited, more so on average than the publications of a group of peer researchers working on agricultural insurance during the same period.

Since 2015, IFPRI work has focused more exclusively on developing new forms of insurance like flexible index contracts, gap insurance, and PBI that can help reduce basis risk at farm levels and make insurance more attractive to farmers. This work has been cutting edge and there has been very little comparable literature from non-IFPRI researchers. IFPRI has also investigated bundling these new forms of insurance with credit, improved seeds, and other agricultural services as ways to enhance the value of insurance and to improve its impact on farm productivity and welfare. Although most publications from this phase of work are quite recent, they are already well cited and have attracted a high level of attention as indicated by Altmetric scores and download statistics. IFPRI's work on comparing different datasets and evaluating their potential to reduce basis risk, such as comparing rainfall and NDVI data, near-surface remote sensing imagery and traditional satellite imageries and combining daily rainfall weather data with localized weather data, is also cutting edge and becoming well cited. Newly started research on using machine learning (ML) and artificial intelligence (AI) to improve the quality of insurance products, especially PBI, is also cutting edge.

An important feature of IFPRI's insurance work, particularly since 2015, is that it has gone beyond initial experimental research and morphed into pilot programs with implementing partners who have a commercial interest in the insurance. If successful, this action-oriented approach has the potential to scale up through the partners leading to real development impacts.

IFPRI has also contributed to capacity strengthening through its research and choice of partners, and case study evidence (e.g., Uruguay and Kenya) shows that local capacity to continue implementing and improving insurance programs often continues after IFPRI has exited a pilot project. IFPRI's longer-term relationships with partners like ACRE, Equity Bank, and the R4 Rural Resilience Scheme have also helped in this regard.

Contributions to PIM's strategic goals

The insurance work at IFPRI was co-funded by PIM as part of Flagship Program 4 (Social Protection for Agriculture and Resilience) during 2012 to 2015. As discussed in section 2, this phase of work was largely exploratory and aimed at a better understanding of why smallholders seemed reluctant to purchase agricultural insurance even when available. Since 2015, PIM has funded the insurance work through Flagship Program 3 (Inclusive and Efficient Value Chains), and this phase of work has been part of a more proactive development agenda that includes the design of more attractive forms of insurance and testing them in partnership with commercially oriented partners in several countries. This second phase of work has contributed more directly to PIM's strategic development goals, as well as to the more specific goals established for Flagship Program 3. Table 7 summarizes relevant goals available on the PIM website, and indicates areas where IFPRI's agricultural insurance work has made direct contributions.

**Table 8: Contributions of the insurance program to PIM's goals**

| PIM targets | Achievments of insurance research |
|---|---|
| ***Program-level outcomes (from PIM's TOC)[a/]:*** | |
| i) Improved prioritization of agricultural research for development in global strategies and programs. Increased investment in national agricultural research and development systems<br>ii) Increased adoption of superior agricultural technologies and practices innovations that address technology delivery, market constraints, governance, social protection, and gender constraints are used by the private sector, development organizations, and governments<br>iii) A conducive policy and public expenditure environment for inclusive and sustainable agricultural growth.<br>iv) Reduction in price, trade, and other policy distortions that penalize producers and harm consumers.<br>v) Strengthened capacity of policy, institutions, and market researchers | On ii), bundling insurance with credit, improved seeds and other services has been demonstrated to encourage greater adoption of superior agricultural technologies and practices in terms of productivity and resilience to climate shocks.<br><br>On iii), insurance and credit has been made more accessible to smallholders in pilot projects in four countries.<br><br>On v), local capacity to design and implement relevant insurance programs for smallholders has been strengthened through partnerships around pilot programs in four countries. |
| ***Research questions for FP3[b/]:*** | |
| i) How do changes in trade policies or institutions affect poor producers and consumers, which nodes of the value chain do they affect, and are men and women affected differently?<br>ii) How large are postharvest losses, and where do they affect specific value chains?<br>iii) Where do bottlenecks impede value chains, who is most affected, and what interventions can overcome these bottlenecks?<br>iv) Can innovative insurance products combine demand from smallholders and attractiveness for private insurance companies?<br>v) Which models and mechanisms work best to promote scaling up of | On iii), bottlenecks in supply of credit and insurance for smallholders have been addressed and relevant insurance solutions demonstrated through pilot programs in three countries.<br><br>On iv), bundling insurance with credit, seeds and other services has increased demand for insurance and provided a product that is attractive to intermediaries like seed dealers and financial institutions in four countries.<br><br>On v), partnering insurers with intermediaries like financial institutions, seed dealers and extension services enables insurance to scale up . |

| | |
|---|---|
| interventions to improve the efficiency and inclusiveness of value chains? | |
| ***In 2019–2021, the following areas will be given more emphasis across the PIM portfolio[c/]:*** | |
| i) Improved nutrition<br>ii) Effects of and responses to climate change<br>iii) Gender equality and women's empowerment<br>iv) Employment opportunities for rural people, especially for the youth<br>v) Transformation of agrifood systems<br><br>Specific priorities for FP3:<br><br>vi) Testing interventions that strengthen inclusiveness and value chain performance<br>vii) Support to global and national policies on trade and private sector incentives | On i), the program in Uruguay has helped grow the smallhiolder horticultural sector which produces nutritious foods for own farm household consumption as well as for the market.<br><br>On ii), the insurance pilots that have been set up in Kenya, Ethiopia and India are helping farmers manage climate risks while adopting climate smart technologies and management practices (e.g, drought tolerant seeds).<br><br>On iii) and vi), IFPRI has undertaken research to better understand the constraints that women farmers face in accessing insurance. In Bangladesh and Ethiopia it was found that women farmers are less likely to purchase agricultural insurance than male farmers, partly because of access problems, but also because they have different degrees of risk perception than men. These gender differences need to be considered when designing insurance products. In the ongoing pilot programs in Ethiopia, India and Kenya, about half the participating farmers are women, and impact evaluations are tracking outcome and impact variables for both male and female household members of beneficiary households.<br><br>Also on vi), IFPRI's risk contingent credit (RCC) work in Kenya is showing that insurance linked to credit can sometimes facilitate increased bank lending to smallholders. |
| ***Insurance related target outcomes for 2022[d/]:*** | |
| New insurance products are being used by smallholder farmers in 3 countries, including 2 CGIAR countries of collaboration | A mature insurance program has been established since 2015 in Uruguay for smallholders growing horticultural crops, and ongoing pilot programs in Kenya, India and Ethiopia show promise for future scaling up. |

a/ From PIM website: https://pim.cgiar.org/impact/theory-of-change-impact-pathways/
b/ From PIM website: https://pim.cgiar.org/research/f3/
c/ From PIM website: https://www.ifpri.org/publication/cgiar-research-program-policies-institutions-and-markets-priorities-20192021
d/ From Annex 10 of CAS Secretariat (CGIAR Advisory Services Shared Secretariat). (2020). CGIAR Research Program 2020 Reviews: Policies, Institutions, and Markets. Rome: CAS Secretariat Evaluation Function. https://cas.cgiar.org/sites/default/files/images/Publications/PIM%20CRP%20Review%202020%20Annex.pdf

As shown in Table 8, IFPRI's insurance work has made several valuable contributions towards PIM's strategic goals through the design and delivery of agricultural insurance products that are more attractive to smallholders, insurers and intermediaries like financial institutions and

agrodealers who can bundle insurance with other value adding inputs and services. Apart from Uruguay, where IFPRI contributed to the design of a now established flexible index insurance program for horticultural farms, the other work has been limited to pilot programs affecting just a few thousand smallholders in each of four countries (Bangladesh, Ethiopia, India, and Kenya). Howver, if the pilots are successful in these countries then there is real scope for the approaches to be scaled up by national partners, leading to an eventual surge in FP3's contributions to PIM's development goals. IFPRI's insurance work is now at a critical stage in which the impact of the new approaches on farm household productivity and welfare is being assessed within the pilot programs, and continued funding is needed to complete this critical stage of work.

Other insurance work within the CGIAR

ILRI has undertaken research on livestock insurance since 2010, focusing initially on the arid and semi-arid lands (ASALs) of Kenya. They developed an Index-Based Livestock Insurance product (IBLI) through a research-into-development agenda to help pastoralists avoid significant livestock losses in drought years from which it was difficult to recover (Chantarat et al. 2019). IBLIis a micro-insurance scheme in which the insurance is sold directly to pastoralists by private insurance companies. Payments are triggered at local levels by the NDVI (Normalized Difference Vegetation Index), which is highly correlated with livestock losses in drought years (Jensen et al. 2015). The insurance was piloted in Marsabit county in Kenya and is now offered on a voluntary basis throughout most of the ASAL areas in Kenya. It is also now offered in some of the pastoral areas of Ethiopia. The pilot program in Kenya and Ethiopia was carefully monitored over several years by an ILRI led research project that included a panel survey of about 1400 households. Studies based on the panel data show that purchase of IBLI leads to strategic livestock accumulation, better livestock husbandry practices, and overall better marketing decicions, resulting in higher animal productivity (Jensen et al.2017). The project involved partnerships with private insurers, leading universities and research organizations, and government departments that extended over several years, from initial product design, pilot testing, and final implementation. It is arguably one of the most successful research to development projects on agricultural insurance undertaken within the CGIAR, a success that is attributable in part to a long funding timeline that enabled the research team to complete rigorous and longer-term impact assessments and feed results back into the program's design as needed.

Several other CGIAR centers have also worked on agricultural insurance in recent years. Like IFPRI, most of this work has focused on demand-side issues, and on bundling insurance with agricultural inputs like improved seeds and climate-smart farming practices. CYMMIT[17], ICRISAT and IRRI[18], for example, have all experimented with bundling index insurance with drought or stress-tolerant seed varieties, but unlike IFPRI they have worked with standard forms of IBI and have not investigated PBI or more flexible weather index contracts. IWMI has developed flood insurance for irrigated farming areas (Amarnath et al., 2021).

[17] https://basis.ucdavis.edu/project/bundling-innovative-risk-management-technologies-improve-nutritional-outcomes-africa

[18] (https://www.irri.org/news-and-events/news/accelerating-adoption-climate-risk-management-strategies-odisha-farmers

The CG's Research Program on Climate Change and Food Security (CCAFS) has provided funding to some centers to support their work on agricultural insurance, especially that related to climate events (including some of the studies mentioned in the previous paragraph and at IFPRI). The CCAFS website also provides a platform for presenting study results, syntheses, and good practice guidelines. Nearly all the supported work relates to demand-side issues for farmers, especially smallholders, and technological innovations for reducing basis risk in product design (e.g., improvements in the use of remote sensing data and crop modelling). Many of the studies also bundle insurance with climate smart farming technologies and practices.

### *6.2. Recommendations for Future Research by OneCGIAR*

**Picture Based Insurance (PBI):** IFPRI's research program on agricultural insurance has become very centered on PBI and on bundling it with improved seeds, climate-smart farming practices, extension advice, etc., and using ML and AI as ways to speed up and reduce the costs of interpreting picture-based evidence of crop damage. How far PBI can transform agricultural insurance and enable it to scale up commercially remains to be seen, and the ongoing work with implementing partners in Kenya, India, and Ethiopia will be critical for determining the value of PBI. IFPRI needs to decide how much further it wishes to take PBI, and what its exit strategy will be as PIM funding is ending, especially for some of its longer-term engagements with partners in India, Ethiopia and Kenya. There would also seem to be potential for other centers to adopt PBI within their own work.

**Risk Contingent Credit (RCC):** IFPRI's work on RCC is billed as a new product, yet credit linked insurance has been around for decades and with mixed results. What appears to be new is really the expertise of the specific IFPRI researchers involved with remote sensing and spatial analysis and their potential to design index products with low basis risk. Some cross-divisional thought should be given to the synergies that might be captured if the RCC work were better integrated with IFPRI's work on flexible insurance and PBI, perhaps through a joint project in Kenya.

Despite the progress made to date in developing insurance products within the CGIAR and elsewhere, there are a number of related topics that remain inadequately researched and which seem likely to become increasingly important in the future.

**Inclusive insurance:** On its own, the development of sustainable commercial insurance markets does not enable many poor and women-headed households to access insurance. Additional interventions are required, often through an intermediary like a non-government organization (NGO) or a safety net program (SNP) that can address the complex targeting problems in designing and delivering insurance for these groups. Permanent subsidies may also be necessary, which might be justified on equity grounds. However, a limitation of most past research by IFPRI and other CG centers is that their design of insurance products is targeted at typical smallholders, and there is a need for randomized trials to estimate costs and benefits of insurance programs that are designed specifically to reach and benefit excluded groups. Such research should also have a strong gender dimension as women farmers are often among the most excluded from agricultural insurance.

**Insurers and intermediaries**: Most past CG research has focused on making insurance more attractive to farmers, and little interest has been shown by researchers in also making sure insurance is attractive to private insurers and the intermediaries needed for bundling insurance with credit and other agricultural services. Yet there are only a few examples of commercial firms intiating bundling schemes at any scale, and more research is needed to better understand why they do not see insurance as a more attractive business proposition, and what changes are needed to encourage them to be more venturesome. This might also involve research on meso insurance that can be sold directly to intermediary organizations.

**Catastrophic risks:** Many tail-end risks are too expensive for farmers to insure, and their frequency and severity is increasing with climate change. The public sector needs to help finance the removal of these risks from the agricultural sector. Subsidies are inevitable, and the real question is whether heavily subsidized insurance for farmers would improve on other forms of disaster assistance or safety net transfers in terms of encouraging better *ex ante* risk management, improving the speed at which disaster assistance is delivered, reducing future dependence on disaster assistance, and crowding-in insurance for remaining risks. Very limited evidence exists in this area, highlighting insurance-based financing of disaster assistance as a key priority for future research.

**Public policy:** The public sector plays key roles in scaling up agricultural insurance, and significant amounts of public money are spent on insurance subsidies in many developing countries – in excess of $11 billion/year in total according to one recent study (GIZ, 2021). Yet there have been few comprehensive cost-benefit analyses of subsidized insurance programs to guide public spending decisions. IFPRI is collecting the data for such analyses in some of its ongoing pilot programs, but there is urgent need for more research studies on the net value of subsidies, including the design of smarter targeting methods, especially for otherwise excluded groups. In some cases there is need for comparisons between the benefit-cost ratio of using insurance subsidies to assist these groups verses alternatives like safety net programs and disaster assistance.

**More comprehensive risk management**: Most of the CGIAR research studies on agricultural insurance abstract from the larger risk management problem that farmers face. Many important risks cannot be insured, and farmers use a broader portfolio of tools to manage and cope with risk - insurance is at best just part of the solution. In this context, it is easy to overestimate individual farmer demand for insurance and additional research is needed on holistic risk management strategies that include coverage against other agricultural and even some non-agricultural risks; and on quantifying the added value of insurance compared to other financial instruments that more commercially oriented farmers can use to partially manage their risks. Technological progress is creating new opportunities to strengthen the quality of not only insurance but also credit products and forward contracts.

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Ward, Patrick, David L. Ortega, David J. Spielman, Neha Kumar, Sumedha Minocha. 2020. Demand for complementary financial and technological tools for managing drought risk. Economic Development and Cultural Change, 68(2): 607-653

## ANNEX I: LIST OF IFPRI INSURANCE PUBLICATIONS AND THEIR CITATIONS, 2011-2020

| Year | Authors | Title | Where Published | Downloads* | Google Scholar citations | ISI Web of Science Citations | Alt-metric Score |
|---|---|---|---|---|---|---|---|
| 2011 | Ruth Vargas Hill, Miguel Robles | Flexible Insurance for Heterogeneous Farmers Results from a Small-Scale Pilot in Ethiopia | IFPRI Discussion Paper 01092 June 2011 | 175 | 70 | N/A | 3 |
| 2012 | Ruth Vargas Hill, Angelino Viceiza | A field experiment on the impact of weather shocks and insurance on risky investment | Experimental Economics 15, 341–371 | | 142 | 40 | 6 |
| 2013 | Ruth Vargas Hill, John Hoddinott, Neha Kumar | Adoption of Weather-index Insurance: Learning from Willingness to Pay among a Panel of Households in Rural Ethiopia | Agricultural Economics 44 (2013) 385–398 | | 222 | 56 | 0 |
| 2015 | Daniel Clarke, Francesca de Nicola, Ruth Vargas Hill, Neha Kumar, and Parendi Mehta | A Chat about Insurance: Experimental Results; from Rural Bangladesh | Applied Economic Perspectives and Policy (2015) volume 37, number 3, pp. 477–501. | | 11 | 6 | 4 |
| 2015 | Patrick Ward, David J. Spielman, David L. Ortega, Neha Kumar, Sumedha Minocha | Demand for complementary financial and technological tools for managing drought risk | IFPRI DP 01430 | 275 | 8 | N/A | 6 |
| 2016 | Ruth Vargas Hill, Miguel Robles, Francisco Ceballos | Demand for a Simple Weather Insurance | Amer. J. Agr. Econ. 98(4): 1250–1270 | | 51 | 20 | 2 |

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|---|---|---|---|---|---|---|---|
| | | Product in India: Theory and Evidence | | | | | |
| 2016 | Francisco Ceballos | Estimating Spatial Basis Risk in Rainfall Index Insurance ; Methodology and Application to Excess Rainfall Insurance in Uruguay | IFPRI Discussion Paper 01595 ; December 2016 | 300 | 3 | N/A | 6 |
| 2016 | Daniel J. Clarke, Neha Kumar | Microinsurance Decisions: Gendered Evidence from Rural Bangladesh | Gender, Technology and Development 20(2) | | 13 | 2 | 2 |
| 2017 | Berber Kramer, Francisco Ceballos, Koen Hufkens, Eli Melaas, Azad Mishra, Michael Mann, Mann S. Toor, Miguel Robles | Picture-based crop insurance: Is it feasible? Using farmers' smartphone pictures to minimize the costs of loss verification | Project Note. Washington, DC: International Food Policy Research Institute (IFPRI). | 651 | 1 | N/A | 6 |
| 2017 | Berber Kramer, Francisco Ceballos, Matthew Krupoff, Mann S. Toor, Azad Mishra, Siddesh Karekar, Miguel Robles | Picture-Based Insurance, is it Sustainable? Effects on Willingness to Pay, Adverse Selection, and Moral Hazard Insurance opportunities against weather risks for smallholder farmers in Africa | IFPRI ; Project Note 02 August 22 2017 Chapter 6 in RESAKSS Annual Trends and Outlook Report 2017. | 851 | 1 | N/A | N/A |
| 2018 | Berber Kramer, Francesco Ceballos | Enhancing adaptive capacity through climate-smart insurance: Theory and evidence from India | Prize winning Contributed Paper at IAAE Vancouver. | | 7 | N/A | 11 |

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|---|---|---|---|---|---|---|---|
| 2018 | Markus Enenkel, Carlos Farah, Christopher Hain, Andrew White, Martha Anderson, Liangzhi You, Wolfgang Wagner, Daniel Osgood | What Rainfall Does Not Tell Us—Enhancing Financial Instruments with Satellite-Derived Soil Moisture and Evaporative Stress | Remote Sens. 2018, 10(11): 1819; doi:10.3390/rs10111819 | | 8 | 5 | 4 |
| 2018 | Francisco Ceballos, Tim Foster, Koen Hufkens, Arun Jadhav, Samyuktha Kannan, Berber Kramer | Seeing Is Believing: Using Crop Pictures in Personalized Advisory Services | IFPRI Project Note September 2018 CABI Blogs | 476 | 1 | 0 | 0 |
| 2018 | Berber Kramer, F. Ceballos | Enhancing adaptive capacity through climate-smart insurance: Theory and evidence from India | 30th international Conference for agricultural economists. July 28-August2 2018 | | 7 | N/A | 11 |
| 2019 | Ruth Vargas Hill, Neha Kumar, Nicholas Magnan, Simrin Makhija; Francesca de Nicola, David J. Spielman, Patrick S. Ward | Ex ante and ex post effects of hybrid index insurance in Bangladesh | Journal of Development Economics 136 (2019) 1–17 | | 34 | 20 | 34 |
| 2019 | Francisco Ceballos, Samyuktha Kannan, Vartika Singh, Berber Kramer | Digital Technologies for Financial Inclusion of Smallholder Farmers ; Needs Assessment in Three States of India | MTID Project Note, IFPRI | 351 | 0 | N/A | 8 |
| 2019 | B Parkes, T P Higginbottom, K. Hufkens, F. Ceballos, B Kramer, T Foster | Weather dataset choice introduces uncertainty to estimates of crop yield responses to climate variability and change | Environ. Res. Lett. 14 (2019) 124089 | | 25 | 16 | 26 |

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|---|---|---|---|---|---|---|---|
| 2019 | Koen Hufkens, Eli K. Melaas, Michael L. Mann, Timothy Foster, Francisco Ceballos, Miguel Robles, Berber Kramer | Monitoring crop phenology using a smartphone based near-surface remote sensing approach | Agricultural and Forest Meteorology 265 (2019) 327–337 | | 41 | 23 | 32 |
| 2019 | Apurba Shee, Calum G. Turvey, Liangzhi You | Design and rating of risk-contingent credit for balancing business and financial risks for Kenyan farmers | Applied Economics 51(50) | | 7 | 3 | 5 |
| 2019 | Francisco Ceballos, Berber Kramer, Miguel Robles | The feasibility of picture-based insurance (PBI): Smartphone pictures for affordable crop insurance | Development Engineering 4 (2019) 100042 | | 35 | N/A | 20 |
| 2019 | Francesco Cecchi, Samson Dejene Aredo, Benjamin Kivuva, Simon Omondi, Joseph Chegeh, Amos Tabalia, Berber Kramer | Promoting seed systems for stress-tolerant varieties at scale Potential For bundling with insurance-advisory services | Project Note. Washington, DC: International Food Policy Research Institute (IFPRI). | 125 | 0 | N/A | 9 |
| 2019 | Francisco Ceballos, Berber Kramer | From index to indemnity insurance using digital technology: Demand for picture-based crop insurance | Discussion paper. Washington, DC: International Food Policy Research Institute (IFPRI). | 275 | 1 | N/A | 1 |
| 2020 | Rewa Misra, Francisco Ceballos, Samyuktha Kannan, Berber Kramer | Potential Impacts and Demand for Picture-Based Crop Insurance. Qualitative research findings from Haryana State, India | Washington, DC: International Food Policy Research Institute (IFPRI). | 300 | 0 | N/A | 0 |
| 2020 | Francisco Ceballos, Samyuktha | Impacts of a national lockdown on | World Development 136 (2020) 105069 | | 52 | 22 | 58 |

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|---|---|---|---|---|---|---|---|
| | Kannan, Berber Kramer | smallholder farmers' income and food security: Empirical evidence from two states in India | | | | | |
| 2020 | Michael K. Ndegwa, Apurba Shee, Calum G. Turvey, Liangzhi You | Uptake of insurance-embedded credit in presence of credit rationing: evidence from a randomized controlled trial in Kenya | Agricultural Finance Review 80(5) | | 6 | 5 | 8 |
| 2020 | Francisco Ceballos, Miguel Robles | Demand heterogeneity for index-based insurance: The case for flexible products | Journal of Development Economics 146 (2020) 102515 | | 6 | 1 | 6 |
| 2020 | Yanyan Liu, Kevin Chen, Ruth V. Hill | Delayed Premium Payment, Insurance Adoption, And Household Investment In Rural China | Amer. J. Agr. Econ. 102(4): 1177–1197 | | 8 | 0 | 3 |
| 2020 | Dejene A. Samson, Berber Kramer | Using digital repeat photography to strengthen seasonal monitoring in Ethiopia's R4 Rural Resilience Initiative | Working paper | | 0 | N/A | 6 |
| 2020 | Patrick Ward, David L. Ortega, David J. Spielman, Neha Kumar, Sumedha Minocha | Demand for complementary financial and technological tools for managing drought risk | Economic Development and Cultural Change | | 7 | 2 | 16 |
| 2020 | Mehdi H. Afshar, Timothy Foster, Thomas P. Higginbottom, Ben Parkes, Koen Hufkens, Sanjay | Improving performance of index insurance using crop models and | CCAFS Working Paper no. 337. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, | | 1 | N/A | 6 |

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|---|---|---|---|---|---|---|---|
| | Mansabdar, Francisco Ceballos, Berber Kramer | phenological monitoring | Agriculture and Food Security (CCAFS). Subsequently published in Remote Sens, 2021(13):924 | | | | |
| 2020 | Francisco Ceballos, Samyuktha Kannan, Berber Kramer | Disruptions to smallholders' incomes and food security during a national lockdown: Evidence from two crop insurance trials in India | INSURESILIENCE BLOG POSTS | | 0 | N/A | 6 |
| 2020 | Francisco Ceballos, Berber Kramer, Azad Mishra, Miguel Robles, Mann S. Toor | Picture-based crop insurance (PBI): Using farmers' smartphone pictures to reduce basis risk and costs of loss verification | International Initiative for Impact Evaluation (3ie) | | 0 | N/A | 0 |

## ANNEX II: LIST OF PEOPLE INTERVIEWED FOR THIS STUDY

Frank Place, Director PIM
Berber Kramer, IFPRI
Francesco Ceballos, IFPRI
Liangzhi You, IFPRI
Joseph Chegeh, PBI partner at ACRE Africa, Kenya
Apurba Shee, RCC Partner, University of Greenwich, London
Michael Ndengwa, University of Greenwich, PhD Student under RCC

## ALL IFPRI DISCUSSION PAPERS

All discussion papers are available **here**

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