WORLD BANK GROUP

KNOWLEDGENOTES

GLOBAL INDEX INSURANCE FACILITY

Data for Index Insurance

AUTHORS: BRISTOL MANN, TUFA DINKU, HELEN GREATREX
INTERNATIONAL RESEARCH INSTITUTE ON CLIMATE AND SOCIETY

October 2014

Photo Credit: Syngenta Foundation

1) SATELLITE TECHNOLOGY FIELD RESEARCH AND INDEX INSURANCE

Satellite Technology and its continued advancement is critical to the relevance and accuracy of index insurance products as a counter against weather-related risks. The World Bank Group's Global Index Insurance Facility (GIIF) in partnership with its regional partners has been working with researchers and scientists to refine satellite technology for index insurance product design. The International Research Institute on Climate and Society (IRI)'s Financial Instruments Sector Team—a GIIF partner—for instance, has worked in over a dozen countries on index contracts with tens of thousands of policies purchased by farmers vulnerable to climate change. The team partners with farmers and international institutions such as the World Bank Group (WBG) to explore the potential for using index insurance in developing countries to assist emerging markets, increase productivity of small farmers, and reduce threats to crops and livelihoods from climate risk.

2) RECENT ADVANCES IN SATELLITE TECHNOLOGY: IMPLICATIONS FOR INDEX INSURANCE

Despite many advances in sustainable scaling of index insurance projects, the absence of comprehensive rainfall and crop data remains a key constraint since data is needed for index design and determining payouts. Index insurance cannot reliably scale up if it only works in areas covered by existing rain gauges, which lack extensive historical weather data records at least two decades long.

Satellites have many advantages for index insurance, such as reducing moral hazard and tampering, and providing an independent data source and excellent spatial coverage. The sensors are principally measuring rainfall and vegetation but satellite technology advances are being made with temperature, soil moisture, and evapo-transpiration (ET).

3) DIFFERENT TYPES OF SATELLITE SENSORS

Remote sensing of rainfall

There have been notable advances in remote sensing of vegetation and rainfall. In terms of satellite rainfall estimation, there are now several time-series of rainfall (including ARC2, TAMSAT, CHIRP(S)) capturing over 30 year weather data in tropical countries at a resolution of 4 to 10 kms. Similar strides have been made in the availability of long time series for vegetation indices that indicate the health and rigor of vegetation, with expanded spatial coverage and a more sophisticated understanding of connecting vegetation measures with crop conditions.

Satellite rainfall estimates work by taking images of clouds and inferring rainfall amounts from them. One way to do this is to use infra-red images, which work effectively as a 'heat camera', inferring information about cloud top temperatures (and hence their height). In recent years, new sensors have been launched, including passive-microwave cameras and space radars. However, these advances have only occurred in the last two decades, leading to shorter datasets.

Different estimates link the amount of time a cloud is above the threshold (Cold Cloud Duration or CCD) to rainfall in different ways. The African Rainfall Climatology Version 2 (ARC2) product uses a global relationship, and then merges with a small number of gauges; the Tropical Application of Meteorology using the Satellite and other data (TAMSAT) product uses a locally calibrated relationship; and the Climate Hazards Group IR Precipitation Stations (CHIRPS) product uses a relationship calibrated against the Tropical Rainfall Measuring Mission (TRMM) satellite, and then merges with a large number of gauges. It is critical to conduct a thorough validation before using a particular product.

There is also a new product, which combines satellite data (mainly TAMSAT) with quality-controlled data from all available stations at the national level. This product, which is part of IRI's ENACTS (Enhancing National Climate Services) initiative, is now available in Ethiopia, Tanzania, Madagascar, Rwanda and Gambia at the national level, and CILSS countries in West Africa at the regional level. These datasets are of good quality, but are only available through National Met Services.

NATIONAL GEOSPATIAL AGENCY (NGA) AND NASA

This new partnership will provide access to an abundance of high spatial resolution imagery acquired by commercial satellites such as IKONOS-2, GeoEye-1, Quickbird-2, and WorldView-1 and 2. This imagery will be used to identify field boundaries between irrigated versus non-irrigated agriculture and cultivated versus natural vegetation, which can ultimately improve the ability of index insurance programs to understand the relationship between what occurs on the ground and what satellites can measure.

Remote sensing of vegetation

Remote sensing of vegetation occurs with many sensors, but most commonly through the use of vegetation indices such as the normalized difference vegetation index (NDVI) or the enhanced vegetation index (EVI), which measure the proportional difference between infrared and visible red reflectance, indicating a measure of chlorophyll density. MODIS, a sensor on the Terra and Aqua NASA satellites, provides global coverage of these and other vegetation indices at spatial resolutions as fine as 250 meters for the past 14 years, and the National Oceanographic and Atmospheric Administration (NOAA) provides the record of NDVI for over 30 years using the Advanced Very High Resolution Radiometer (AVHRR) instrument globally at a resolution of 8 kilometers.

Exploratory analysis of other environmental variables, such as soil moisture, ET

Evaporative Stress Index (ESI): Organizations such as the USDA Agricultural Research Service provide evaporative stress index (ESI) estimates from the Atmosphere-Land Exchange Inverse (ALEXI) model, which are in the process of becoming operational and available in real time. ESI is able to robustly measure vegetative stress before vegetation turns brown and can identify the point of time in the crop cycle when this occurs. Agricultural extension agents will then have the opportunity to collect information from the field that can improve the model's performance in the region of interest.

.

NASA AND SOIL MOISTURE

NASA will provide a variety of products from sensors that measure moisture in the soil, penetrating cloud cover that often obscures imagery in the visual spectrum. All of these products are designed with agricultural monitoring in mind, and the soil moisture information is specifically relevant to cultivated areas. Ranging across different spatial resolutions, the combination of these products will provide a time series spanning over 30 years.

4) FIELD APPLICATIONS: LESSONS LEARNED AND FUTURE ROADMAP

Satellite sensors are useful tools in index insurance design and validation but they are not always accurate. Sensors provide new information on local impact of weather and climate. For satellite estimates of rainfall, we have found that estimates are significant indicators of the big picture, eg. it is possible to tell whether June was the driest June in the last five years in a specific location. However, they may not provide exact rainfall estimates for a specific pixel on a specific day, inhibiting many satellite rainfall estimate products from complimenting more complex index insurance products that require extensive datasets and complicated models. One approach to alleviate this problem would be working with the national meteorological services to blend their station observations with the satellite products. This approach has been shown to improve the quality of the satellite products significantly.

Spatial resolution challenges

There are challenges to overcome with spatial resolution. If one makes an index using rain gauges, it is crucial to understand the importance of the physical distance between the farm and the rain gauge. For satellites, it is imperative to understand the relationship between the farm and the pixel[1] in order to avoid a situation where two adjacent pixels would result in two very different payouts. Consequently, there has been an effort to analyze how satellite rainfall can be used at a larger scale, or data smoothing techniques that minimize the effect of spatial resolution on spatial distribution of payouts.

Different satellite data used for validation

Satellite information has been useful to validate and monitor climate impacts. Satellite vegetation products, for example, are based on completely different information than satellite rainfall products, and they have different strengths and weaknesses; therefore the datasets are used in comparison in order to see if both types of data capture similar years in which crops failed.

Multiple data sets from different sources for best data reliability

Ultimately using multiple datasets in conjunction with ground observations can bolster certainty that a weather event was significant enough to cause a payout. For instance, if there is a location where three different satellite rainfall estimates identify 2002 as a drought year, and if vegetation estimates, farmer interviews and a rain gauge also identify 2002 as a drought year, then there can be increased confidence that the index design is working correctly. But if all the sources of information disagree, then there needs to be a much closer examination of the site to understand the situation.

As index insurance projects scale up around the world, it will be increasingly critical to improve our geospatial capabilities. Misinterpretation of any environmental variable being used for a large-scale index insurance project could severely affect the livelihoods of many farmers. For the future success of index insurance, the need is for data solutions that not only link rain gauge and satellite datasets, but also ones that allow the poorest farmers in the world to interact with the community of global researchers and leverage in-country expertise to go beyond today's most advanced remote sensing products.

1. A pixel ("picture element") is the smallest defined element of an image.

Farmers in Korme village in Tigray, Ethiopia participating in interactive exercises that inform project partners of the most significant drought years that affected insured crops. Photo by Bristol Mann (2014)

CASE STUDY: ETHIOPIA

In Ethiopia, the R4 Rural Resilience Initiative successfully distributed $322,722 in payouts to 12,200 insured farmers in 2012, a drought year. The payout averaged only $27 per farmer but that small sum allowed farmers to contribute to savings programs.

The index for the R4 Rural Resilience Initiative (HARITA) project was based on the ARC2 rainfall product that estimates daily rainfall over the African continent. By using satellite remote sensing, index insurance can expand to cover farmers in diverse agro-ecological regions without having to rely solely on the limited historical record and number of ground-based rain gauges. However, it is only through continuous monitoring of both remotely sensed climate data and local conditions that index insurance projects can successfully manage to limit basis risk and reduce climate risk.

Challenges

Scaling Up: Scaling-up puts an increased burden on the ground network. Large-scale index insurance projects like the R4 depend heavily on a ground network of clients, experts, site visits and partners for continuous verification and improvement of products to cross check the satellite data. Verification technology may be able to reduce the information burden on these networks by focusing on the places that have the most technical challenges, and by strengthening the ability of on the ground networks to anticipate, understand, and resolve issues.

Multiple Data Sets Can Pinpoint Basis Risk: In locations where satellite rainfall and satellite vegetation data disagreed, farmers in Ethiopia were more likely to complain about not receiving payouts despite losses.

FUNDED BY

Produced By: Christina Files and Nitin Nambiar, Global Index Insurance Facility/World Bank Group