RS technology for crop insurance

Despite advances in the use of remote sensing technology in the field of agriculture, data analysis & developing applications for agricultural risk management have proved to be more complex and expensive than anticipated

Agriculture is set to play an important role in achieving the goals set by developing economies in the next few decades. Providing food, raw materials and energy in sufficient quantity for a burgeoning population will be a major challenge. Food security will be an increasingly important element of agricultural policy for every country.

According to the projections, climate change may increase the variability of weather patterns in many regions, with consequences such as rising frequency and severity of extreme climate events.

Against this backdrop, managing agricultural risks is a key challenge. Crop insurance systems will play an increasing role in this task. This was clearly demonstrated by the US drought in 2012, which affected the most important agricultural region in the USA, the Midwest, with the corn and soybean crops getting affected. Total crop losses in the USA in 2012 amounted to around $20 billion, of which $16.99 billion was indemnified to farmers by the National Crop Insurance System. Historically, this is the highest amount ever indemnified by a crop insurance system worldwide.

In recent decades, crop insurance systems have been designed and implemented in several countries (Figure 1). The most promising and sustainable approach is that of insurance systems within the framework of a public-private partnership between the state, the agricultural sector and the (re) insurance industry (depicted as green and blue). It can be assumed that crop insurance systems will be developed and implemented as public-private partnerships more and more in developing economies. Advances in remote sensing technology will certainly fuel this trend.

Current applications

Most agriculture-related applications of remote sensing technology are focused on monitoring the vegetation status by using signals collected in the visible and near infrared regions by special space-based sensors and by mathematically combining these signals to vegetation indices. One of the most prominent vegetation indices is the NDVI (Normalised Difference Vegetation Index). The advantage of this index is that data are recorded daily by different sensors, and time-series of up to 30 years are available. These are the reasons that the NDVI is widely used, also for crop insurance purposes. However, according to Joint Research Centre (Meroni et.al, 2013) due to inaccuracies as a consequence of factors such as background reflectance and the three dimensional structure of the canopy, alternative indices are currently being developed.

The disadvantage of optical sensors is that they provide useful data only when there is no cloud cover. This is a major constraint because the cropping season is relatively short, and for many applications, data in specific growing stages are needed with a good spatial resolution. By contrast, radar sensors can be used even in case cloud cover. Their area of application in agriculture is currently restricted, but with the availability of new bands and more research, advances can be expected in future. At present, radar sensors are used for information on cultivated area, soil moisture analysis and flood monitoring, often in combination with optical sensors.

Potential applications

Remote sensing technology can bring innovations to the process of developing and operating crop insurance systems. Innovations will be seen especially in the following areas:

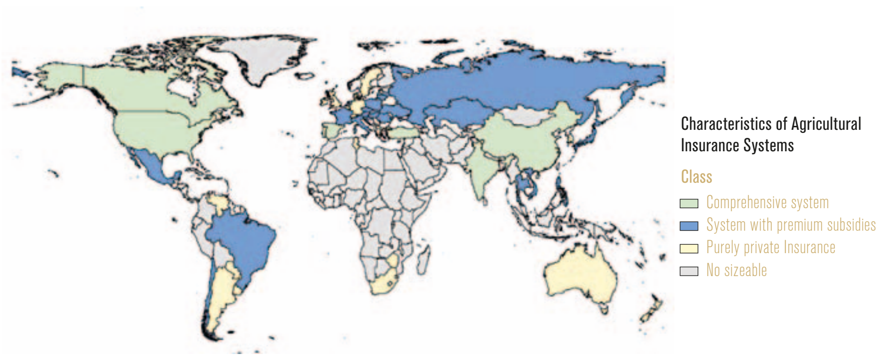
»Plot identification: Identifying productive agricultural plots and distinguishing them from other land use is an essential element in any agricultural information system. Determining the boundaries and the size of individual plots is another requirement for operating any crop insurance scheme. In Germany, a field reference system has been established to identify individual plots for administration and control of European agricultural subsidies; according to GAF AG remote sensing data combined with GIS and aerial photographs have been used.

»Crop identification: Another important piece of information is which crop or crop type is being cultivated where during a specific cropping season. This is not an easy task as the appearances of the wide variety of crops being cultivated are often difficult to distinguish on satellite images. However, significant advances have been made using multi-temporal datasets during the vegetation period.

»Crop monitoring: Monitoring the crop cycle from planting to harvesting is important for identifying potential problems at an early stage. For crop insurance purposes, it is important to know if crops have really emerged since the insurance cover often starts only with the emergence of a viable crop stand. Reliable remote sensing data can reduce time-consuming and costly field inspections.

»Yield estimations: Estimations based on crop monitoring are still in the early stages of development, and considerable work is required to arrive at reliable estimates. The work is costly, as it requires not only analytical work but also reliable ground truth data, i.e. yield data collected in the field, for calibration and testing the results. With the fast spreading of automatic yield recording and harvesters producing yield maps of individual plots, however, more reliable ground truth yield data will be available in future.

Worldmap of Agricultural Insurance



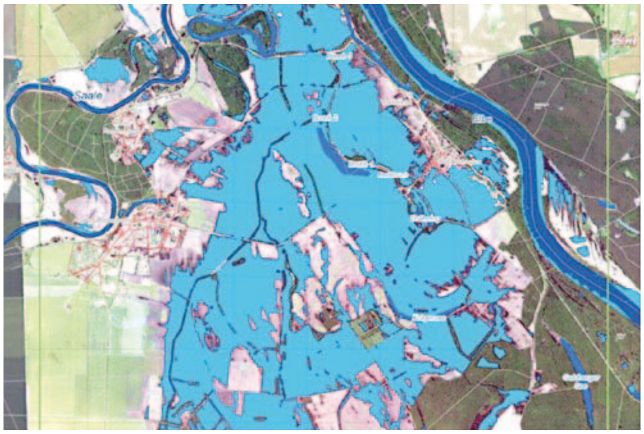
Different approaches to forecast yields are used at present:

- Satellite information as the primary source: The NDVI is the classical example. What is measured is the reflection of the plant canopy using different wave lengths. Depending on the crop type, biomass is more or less correlated with yield. There is a relatively good correlation in grassland but a low correlation can result for arable crops under particular circumstances.
- Using crop growth models as the primary tool, based on satellite information on the biomass as the input factor besides others like soil type, weather conditions (e.g. precipitation, temperature) and management factors: This approach is more promising when dealing with arable crops, as more accurate yield estimations can be obtained.

Regional yield estimates for cereals, oilseeds and tuber crops can be expected in the near future. However, it will be much more difficult to assess yields on individual plots. The currently available spatial and temporal resolution (both being required simultaneously in high definition) is not sufficient, especially when we are dealing with average sized plots.

Crop insurance systems will be developed and implemented as public-private partnerships more and more in developing economies as advances in remote sensing technology fuels this trend

Courtesy: European Commission/Copernicus, 2013



Flood on the River Elbe in the agricultural area around Breitenhagen in Germany in June 2013. The flooded area is shown in light blue, and the reference water level in dark blue

Courtesy: European Commission/Copernicus, 2013

Pre-flood situation in the agricultural area around Breitenhagen, Germany

»Loss event monitoring: This is a very important application not only for crop insurance but also for state authorities in managing crop disasters in an efficient and timely manner. Early loss estimations and catagorising the regions according to the degree affected are required. In the case of floods, according to GAF AG radar sensors are very efficient in addition to optical sensors, as they also provide information if there is a cloud cover (Relin, 2013). The extent of crop losses can be assessed with the information about the duration and height of the flood, together with the information about the planted crop types which react differently to water submergence and water logging.

»Risk assessment and underwriting: The two essential elements of any crop insurance operation can be supported by digital elevation models elaborated with remote sensing technology. These models can be used to assess flood and frost risk and derive underwriting criteria.

»Insurance products: Insurance products based on the NDVI have been offered to cover grasslands. However, these products, introduced in the US and Spain have only limited market penetration. One of the obstacles is the lack of acceptance and trust among clients with regard to a satellite index which is neither transparent nor easy to understand. With the development of reliable regional yield estimates by remote sensing technology, corresponding area yield insurance products will come. Yield insurance at farm level, however, is still a distant prospect.

Outlook

Though still in its infancy, satellite technology has considerable potential to develop and enhance crop insurance and the disaster response of state authorities after major losses. The heterogeneous structure in crop production poses a major challenge for the technology, which works best with big plots and homogenous crops. Furthermore, the temporally limited availability of optical methods because of cloud cover is a major constraint; especially after loss events, images are needed at defined points of time, and it is not possible to wait for weeks for a cloud-free period. Advances in the area of radar data might supplement optical data, thus easing these constraints. Additionally or alternatively to remote sensing information, aerial photographs taken from unmanned airplanes will play an increasingly important role, especially when dealing with specific issues of loss adjustment in the field, like determining areas of damaged crops in big fields.

Dr Joachim Herbold
Senior Underwriter, Agricultural business unit, Munich Reinsurance Company, *jherbold@munichre.com*