A new monitoring system will help prepare South Asia for increased drought frequency caused by a changing climate. Amarnath Giriraj and James Clarke at the International Water Management Institute (IWMI) in Sri Lanka explain how the system can be used to predict drought trends in time for communities to put climate-smart water management solutions into place.

Drought monitoring system helps strengthen resiliency to climate change

The great temples of Khajuraho in the central Indian region of Bundelkhand are a tourist magnet. Famed for their intricate – and occasionally erotic – sculptures, they are situated next to refreshing pools of water, which are remnants of a sophisticated water management system that has kept the region food secure for generations.

However, this same region is in crisis today, enduring one of the worst droughts in living memory. Many of the historic ponds and tanks have fallen into disrepair, compounding the lack of rainfall. Once an ancient kingdom, but now straddling the states of Uttar Pradesh and Madhya Pradesh, the area remains relatively underdeveloped compared to other parts of India. Consequently, many local people still rely on agriculture for their livelihoods. Faced with drought conditions and with limited capacity for water storage, thousands of smallholder farmers now face hardship – and even destitution.

The current water scarcity, the most severe of this century, has parched an area the size of Israel, but experts believe that the extreme conditions could have been foreseen. A new monitoring system, developed by the Sri Lanka-based International Water Management Institute (IWMI), has been used to review satellite imagery from earlier in the year. Adopting an innovative approach to assessing drought conditions, the system could help South Asia address the more extreme weather events predicted by a changing climate.

Current methods of monitoring drought in South Asia, and India in particular, are dependent on state-based monthly rainfall maps, calculated by national meteorological agencies. However, these maps do not provide the spatial resolution needed to show differences in drought severity across such vast areas.

In order to better understand and monitor drought events, the new IWMI project created a geodatabase of historical climate information as well as a decision-support tool to calculate average Standardized Precipitation Index values for specific areas. The tool and geodatabase combine rainfall data from three different sources: APHRODITE, the Asian Precipitation Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources; the Tropical Rainfall Monitoring Mission; and the Global Precipitation Measurement.

The data from these multiple sources is used to create an Integrated Drought Severity Index.

By combining the rainfall information with data on vegetation, temperature, and soil moisture, drought-affected areas can be more accurately determined. This approach includes developing far more reliable indicators of impending drought than has hitherto been possible using conventional methods.

This development has all been made possible by new advances in recording and processing remotely sensed satellite data, which radically changes what can be seen from space. For instance, it has been possible for some time to make rough estimates of how each area of agricultural land is being used, but the huge variety of crops and the patterns in which they are farmed create a complex challenge for mappers. In the past, this analysis was performed by measuring variations in the spectral light that different crops reflect. However, these variations are not always significant enough to be registered. The latest techniques look at the changes in the growing cycles of plants – called phenology – and this approach has greatly increased scientists' ability to differentiate among crops over time.

The methodology takes a series of images from the MODIS satellite and, through advanced image processing techniques, essentially looks at a plant's "greenness." This information is then combined with annual and semi-annual cycles of vegetation change, including its dependence on seasonal rainfall. With this level of detail, it is possible to determine which agricultural areas are being irrigated and which depend solely on rain. The relative health of crops can also be established, and this information can then be used to help establish when drought conditions are emerging.

Resolutions from space have also increased dramatically – by as much as forty fold in some instances. This capability for increased resolution has allowed remote sensing specialists to analyze previously unseen detail such as individual farm wells.

Reviewing data from the whole of 2015, the IWMI team established that the likelihood of drought in Bundelkhand was emerging as early as June 2015, when abnormally low rainfall patterns became evident. Space-based remote sensing should be more widely used in drought prediction, say the IWMI experts, as they can identify potential problems well before the extent of the conditions on the ground are evident.

Analysis of aerial images offers a greater sense of the enormity of agricultural spaces as well as greater insight into their functionality. For example, it's possible to see when paddy fields are bone dry or when farmland is left fallow due to lack of water. One future hope for the technology includes using remote sensing to pick up drought trends before there are serious water shortages on the ground so that relief efforts can occur more quickly.

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The satellite images were generated as part of IWMI's ongoing South Asia Drought Monitoring System (SADMS) project, developed in partnership with the World Meteorological Organization, the Global Water Partnership, and with support from the Consortium of International Agricultural Research Centers (CGIAR) Research Program on Climate Change and Food Security. Converted into easy-to-read maps, the images have been sent to Bundelkhand.in, a website that brings together social activists, community groups, and local policy makers in the region. This is the first time that the SADMS has been used.

"The maps have been invaluable," says Ashish Sagar, a leading social activist in the Bundelkhand region. "We have been sharing them with farmers and the local authorities so that we can better plan a response."

The world is currently in the midst of an El Niño event, leading to abnormal weather conditions across much of Asia, and this region's drought provides but one example of a larger issue. Some areas of Bundelkhand, for instance, received no monsoon rain at all this year. El Niño is a regular climatic event that occurs when a band of warm ocean water develops in the middle of the Pacific Ocean. This occurrence leads to high air pressure in the western Pacific and low air pressure in the eastern Pacific. As a result, drier conditions in parts of Asia can be expected.

Coupled with El Niño, global climate change is also affecting long-term weather patterns. This shift in the climate will likely make extreme events such as droughts more frequent, and the IWMI team believes that this pattern is already emerging in Bundelkhand. Using these new mapping technologies, they hope they can assist in responding to and planning for droughts in addition to improving the overall capacity of communities to be more resilient in addressing these events.

This concept of creating climate smart villages is being tested by IWMI and its partners in CGIAR. Vulnerable communities are approached by a team of experts who work closely with local institutions to identify a variety of appropriate climate-smart options for the area. These might include climate-smart technologies, climate information services, local development and adaptation plans, and supportive institutions and policies, all tailored to that community's needs. The community chooses its preferred options in a process that aims to be as participatory and inclusive as possible, encouraging women and more vulnerable groups to get involved. The project partners believe that by taking this holistic approach, communities will have a far better chance of successfully coping with climate shocks.

For water management, climate-smart approaches might include better storage, access to solar pumps, and new techniques such as laser land leveling to ensure efficient use of irrigation water.

The study highlights the need to consider further investments in water management and infrastructure in the Bundelkhand region. These advancements could include developing more centralized storage, such as dams and reservoirs, and improving institutional arrangements in addition to local initiatives such as village ponds and farm wells. Groundwater recharge also needs to be improved in the region, and a method for assuring that aquifers are used sustainably needs to be established.

This work is supported by The CGIAR Research Programs on Water, Land and Ecosystems and Climate Change and Food Security. The South Asia Drought Monitoring System is being developed as a collaboration between the World Meteorological Organization, Global Water Partnership, and the IWMI. A first Assessment Report has been released and the website is expected to go live in 2016.

Authors' Note

Giriraj Amarnath is a senior researcher in remote sensing and water management, who leads International Water Management Institute's drought mapping project. James Clarke is the director of communications at IWMI, located in Sri Lanka.

Opposite: Farmer in Gujarat, India looks on as irrigation pumps and pipes pull water from the canal for agricultural use. Photo by Hamish John Appelby/IWMI

Left: A farmer in Faisal Town, Taxila in the Rawalpindi district of Punjab looks into the dry tanker, constructed for irrigation due to an electricity crisis. Photo by Sajjad Ali Qureshi/IWMI