RESEARCH PROGRAM ON
Water, Land and Ecosystems

CGIAR

Led by: IWMI International Water Management Institute

Use of remote sensing and GIS tools

in the irrigation commands to assist planning and management

Summary

Remote sensing (RS) and geographic information systems (GIS) have huge potential to improve the performance of canal irrigation. Increased uptake of these modern techniques by irrigation agencies should be encouraged.

Introduction

For centuries, irrigated agriculture has been the backbone of global food security. How efficiently it can continue to deliver crop growth using diminishing quantities of water is, therefore, of critical concern for the future of humanity. Currently, major surface irrigation systems in many countries appear to be stuck in a cycle of poor performance, deferred maintenance and constant rehabilitation. Benchmarking of irrigation systems, a systematic process for securing continual improvement through comparison with relevant and achievable internal or external performance indicators, remains wistful thinking. Attempts to assess performance or benchmark irrigation systems have often failed. One crucial reason for this is the difficulty of identifying cost-effective performance monitoring indicators that can be assessed rapidly, consistently and continuously.

Occasional assessment of irrigation system performance over vast areas has been greatly facilitated by high-resolution images acquired from satellites. They offer inexpensive, rapid and consistent methodologies to monitor spatial and temporal variation of large-scale processes. Over the past three decades, various combinations of images and algorithms had been used to estimate:

- irrigated areas;
- cropping patterns;
- cropping intensity;
- soil moisture availability;
- evapotranspiration;
- crop water stress;
- land and water productivity;
- prospective yields; and
- extent of land degradation due to salinization, waterlogging, flooding and soil erosion.

The International Water Management Institute (IWMI) has been at the forefront of moves to apply these techniques in Asia and Africa. The Institute's recent work in this field include:

- updating irrigated area maps;
- salinization mapping in Iraq;
- modeling and mapping flood-prone zones in the Nile and Ganges;
- mapping water productivity at the river basin scale;
- developing a near real-time methodology to assess adequacy, equity and reliability of water from crop evapotranspiration at canal command levels; and
- development of 'water information kits' for Sri Lanka.

Remote sensing-based irrigation and flood advice tools for smallholders in Africa

Weekly and bi-weekly, plot-specific information from high-resolution satellite measurements were used as inputs to an improved Surface Energy Balance Algorithm for Land (SEBAL). This improved version of the algorithm was able to estimate changes in vegetation index and evapotranspiration rates, which were communicated to irrigation managers on demand through web platforms and mobile phone short messaging service (SMS). The service has now been rolled out in three pilot areas: Ethiopia (Arata Chufa), Egypt (Nubaria) and Sudan (Gash Delta).

In Sudan, where spate irrigation is practiced, detailed flood and hydrological modeling is also incorporated. Flood information is disseminated in addition to crop growth and water use data.

More information is available at the project website (www.smartict-africa.com) and via the country-specific web platforms:

- Egypt: www.fieldlook.com.eg
- Sudan: www.fieldlook.com.sd
- Ethiopia: www.fieldlook.com.et

Irrigated area mapping

One irrigation management performance indicator is the area irrigated from a given reservoir. Traditionally, assessments had been made using crop surveys, which are tedious and often prone to error. An effective alternative is to map the area using RS images. In 2005, IWMI quantified the irrigated area, globally, using satellite images obtained between 1999 and 2000. It was the first effort of its kind to provide a global estimate of irrigated areas. Recently, these maps created for Asia and Africa have been updated using higher resolution satellite data and improved analytical techniques.

Evaluating adequacy, reliability and equity in water available for evapotranspiration

Remote sensing-derived raster maps (such as actual evapotranspiration and evaporative fraction) can be merged with vector maps of irrigation water delivery systems to better understand real-time performance under actual field conditions. Traditional indicators of canal irrigation are equity, adequacy and reliability, and are estimated from the supply side. Equity assessment, however, reveals whether spatial and temporal water use across a canal command is consistent. Adequacy is the quantitative component, and is defined as the sufficiency of water use in an irrigation system. In contrast, reliability is the time component and defined as the correspondence of water supply upon request. These indicators of water supply to cropped area have been assessed using the evaporative fraction maps, which directly reveal the crop supply conditions. However, in a canal command, where conjunctive water use is predominant, it is judicious to estimate them based on water consumed by crops. IWMI has recently completed an analysis of these indicators for an eleven-year period.

Mapping flood ‘hot spots’ for climatic change

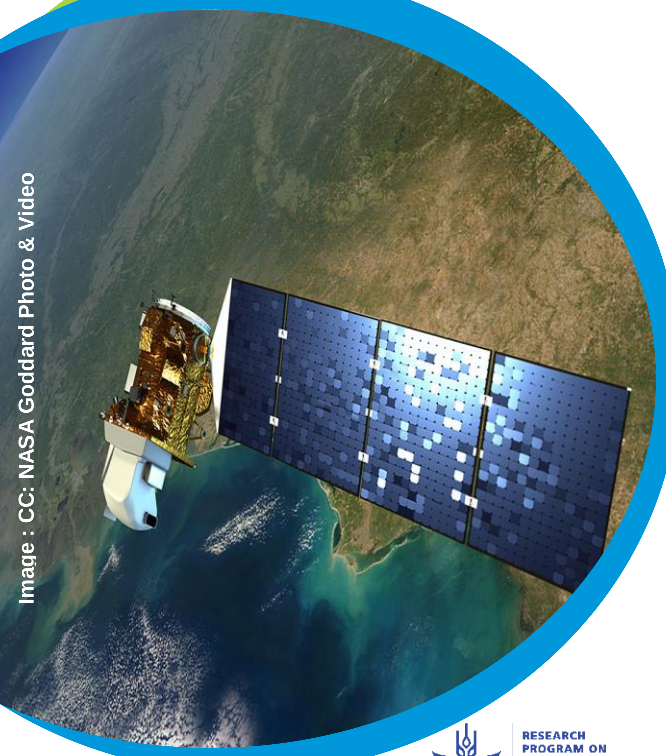
At a global-scale, georeferenced flood occurrence data between 1900 and 2011 were gathered from multiple sources to identify places where floods were frequent. Information on population density, agricultural land and gross domestic product (GDP) was overlaid to identify ‘hot spot’ areas. Hot spot analysis suggests that more investments are needed to minimize risk, and such investments are likely to have a substantial payoff in terms of reduced loss during floods.

Flood-risk mapping and assessment in South Asia

Time-series Moderate Resolution Imaging Spectroradiometer (MODIS) satellite datasets were used to understand seasonal and annual changes in flood extent. IWMI has developed a generic flood-mapping algorithm that has included, from 2000 to 2011, spectral indices such as Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) and Land Surface Water Index (LSWI) every 8 days with a spatial resolution of 500 m. Several flood products were generated from the inundated area database which included flood seasonality, flood duration and flood recurrent interval. These factors are of prime importance for the mitigation of floods. If insurers could identify the recurring patterns of floods in a particular area, they could insure farmers against extreme weather events. So, they would know what to payout in the case of an unexpected drought or a larger-than-usual flood that affected a farmer's harvest. This information assists communities in managing land development and businesses, and home owners in making better informed financial decisions regarding the protection of their property.

Flood mapping and modeling in a spate irrigation system in Sudan

Remote sensing and the Smart-ICT system (outlined above) were integrated to demonstrate how effective water and agricultural management can help farmers manage land and water resources. IWMI and its partners commissioned operational services for the Gash irrigation scheme, which includes daily and weekly flood inundation extent, flood hydrographs and agricultural products. In particular, a flood forecasting model using the hydrologic modeling system, HEC-HMS, was developed for the Gash Basin through a distributed modeling approach using space inputs. The approach includes rainfall-runoff modeling, hydrodynamic flow routing, and calibration and validation using field discharge data. The model is calibrated using field hydrometeorological data from 2011 and validated using data from 2012. The model was tested during the 2013 floods with real-time, three-hour interval Tropical Rainfall Measuring Mission (TRMM) 3B42RT data. This information can help field officers optimize water resources and maximize irrigation efficiency.



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