EARTH OBSERVATION AND CLIMATE SERVICES FOR FOOD SECURITY AND AGRICULTURAL DECISION MAKING IN SOUTH AND SOUTHEAST ASIA

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The majority of Asia's rural population livelihoods depend on rain-fed agriculture. However, exacerbated by climate change, agricultural production faces increasing pressure from more frequent and extreme climatic events such as droughts and floods. In response to the growing stress on food security, there has been a dramatic increase in the demand for user-oriented, easily accessible, timely, comprehensive, and actionable scientific information using Earth observation and for improved agricultural decision-making (Kansakar and Hossain 2016).

Currently, several research groups across South and Southeast Asia (SSA) are working with Earth observations within agroclimatic monitoring, prediction, and integrated modeling systems designed to identify and mitigate drought impacts on local to regional scales. Research output from such efforts and cross-learning from existing national and regional drought monitoring and forecasting practices, crop monitoring systems, and agriculture advisory services can provide actionable information to farmers and other agricultural decision-makers. In addition, the urgency and importance of food security requires a major collaborative effort to transcend existing norms of information generation and dissemination. Thus, an internationally supported, transdisciplinary regional knowledge forum on drought was facilitated for continued deliberations on the issue and its societal implications.

REGIONAL KNOWLEDGE FORUM ON DROUGHT

What: Deliberations on new developments in the use of Earth observation for agriculture and food security in South and Southeast Asia gathered 120 participants to discuss i) agricultural and hydrological drought monitoring and early warning systems, ii) crop mapping and yield estimation, and iii) risk financing and agrometeorological advisory services.
When: 8–10 October 2018
Where: Kathmandu, Nepal

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FORUM OBJECTIVES AND METHODS. In October 2018, the International Centre for Integrated Mountain Development (ICIMOD) and the Asian Disaster Preparedness Center (ADPC), under the framework of the National Aeronautics and Space Administration (NASA) SERVIR program and the Climate Services for Resilient Development (CSRD) initiative, convened the "Regional Knowledge Forum on Drought: Earth Observation and Climate Services for Food Security and Agricultural Decision Making in South and Southeast Asia" at ICIMOD's headquarters in Kathmandu, Nepal.

More than 100 professionals participated, including regional experts from key institutions in SSA and international experts working on the application of Earth observation to drought monitoring and prediction, agriculture, and food security. There was broad participation from operational data providers, decision-makers, and scientific professionals as well as researchers from 52 international, regional, and local institutions that study, provide, and use agricultural and meteorological services.

The key objectives of this forum were to i) review current status and needs for sustained information services at regional and national levels for drought monitoring, crop monitoring, and climate services and ii) establish a regular forum and related expert groups to foster regional cooperation on agriculture and food security related services. To meet these objectives, the forum engaged participants from countries in the Hindu Kush–Himalaya (HKH) and the lower Mekong regions via panel discussions and breakout groups that focused on three main topics, summarized in the following sections.

DROUGHT MONITORING AND EARLY WARNING SYSTEMS. Drought in SSA has severe and long-term impacts on several development sectors, such as water, agriculture, livestock, food, energy and health, at local, national, and regional scales. At the local scale, these impacts can be severe, particularly for agrarian communities, resulting in livelihood insecurity, demographic changes, and conflicts over resources. Thus, improving drought monitoring and early warning systems (DM-EWS) provides significant benefits for drought risk management, including efficient and timely response, adaptation, mitigation, and reduced vulnerability in the region.

Remote sensing–based estimation of key environmental variables such as rainfall, temperature, soil moisture, and evapotranspiration have been increasingly used to develop drought-monitoring tools. However, further improvement (including evaluation and bias correction) is needed using ground observations to generate more accurate datasets. In the SSA region, several efforts have been made to evaluate satellite-derived rainfall datasets, with encouraging results. For example, the evaluation of satellite-derived rainfall data [i.e., Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) data] in South Asia presented at the forum showed encouraging results for rainfall estimates in the region. The forum participants suggested building up regional and local cooperative mechanisms that could help in operationalizing DM-EWS in the region.

Progress has been made in improving hydrometeorological modeling for drought monitoring. For example, NASA's HKH Sub-seasonal to Seasonal Forecast System (HKH-S2S) has been designed for optimal monitoring and probabilistic seasonal forecast of hydrological conditions distributed across the HKH and South Asia. HKH-S2S merges models and satellite observations to get spatially complete monitoring and forecasts in data-limited regions. However, challenges remain, such as uncertainty in seasonal forecasts of the South Asian monsoon and evaluation of land data assimilation system (LDAS) simulations. Using Earth observation and merging different ground observations with model output through an innovative approach (including data mining/artificial intelligence) were recommended to help reduce uncertainties and improve DM-EWS.

In addition, there is a strong interest in developing regionally and locally calibrated drought indices as well as integrating/combining several types of data and information on climate and water supply, including satellite-derived products and seasonal forecasts, to provide decision-makers with a comprehensive representation of current conditions and outlooks. The participants emphasized that effective and reliable modeling of drought monitoring/prediction tools will need to be directly connected to end users, with stakeholders engaged at all stages of model development and application. The engagement and access to actionable information for DM-EWS should also include the most vulnerable, such as the elderly, and those in poor communities. This could help experts and decision-makers to better monitor, predict, plan for, and cope with the impacts of drought, including food security.

DROUGHT IMPACT, CLIMATE SERVICES, AND RISK FINANCING. Understanding the impacts of drought events and their associated vulnerabilities is critical for efforts to mitigate drought impacts and understand how to build resilience in

the future. Risk financing (e.g., credit and insurance) is an effective tool to minimize losses from hazards such as drought; it can enable early intervention within communities at risk and ultimately help build their capacity to respond and recover faster and more efficiently. Even though there is general progress in climate services in the region, the panel noted that disaster risk management (including drought preparedness and mitigation) suffers from three main weaknesses that have led to preventable damage to lives and livelihoods and greatly increased the cost of responding to disasters: i) decision-making processes are too slow; ii) preparedness planning is inadequate and often done too late; and iii) the current response models are outdated, costly, and underfunded.

The participants of the forum suggested that there should be long-term policy interventions, together with capacity building activities for farmers on efficient water use technologies and climate resilient farming. In addition, operationalizing vulnerability assessments by utilizing remote sensing-based analysis in combination with socio-economic, demographic and infrastructural data are critical for identifying the most vulnerable communities. Remote sensing and modeling offer a means to understand changing drought conditions caused by climate variability, their impacts, and approaches to plan effective risk management strategies. Organizations should also work on social protection, so that the most vulnerable can get assistance. Coping strategies work well if they are connected with generating money through microfinancing and building local institutional partnerships.

The participants noted a strong need for improvement on three levels of science-based climate risk financing and how it is used to mitigate drought impacts: i) local (e.g., resource pooling and parametric insurance), ii) national (e.g., risk financing policy), and iii) regional (e.g., country consortium and cross learning). One forum participant noted that "risk management through risk financing by means of index-based insurance is very important as finance should be ready before the hazard impacts people."

CROP ASSESSMENTS, AGRICULTURAL LAND USE, AND WATER RESOURCES. Studies and best practices in the SSA region (including Pakistan, India, Nepal, Bangladesh, Mongolia, Vietnam, Afghanistan, and China) presented at the forum show progress with assimilating remote sensing data into crop models to recalibrate model parameters based on remotely sensed crop status on the ground, and reducing uncertainties in seasonal weather conditions by incorporating ground observations in the models. These presentations discussed in-season crop assessment and yield forecasts using satellite-derived data and field observations to determine key crop production indicators such as crop area, yield, crop condition, cropping intensity, and crop-planting proportion. In addition, experts shared their research output and experience from other parts of the world including the United States.

The forum's panels discussed innovative approaches for regional crop mapping using cloud-based remote sensing and machine learning in the region. The presentations included lessons learned from new and advanced techniques in remote sensing applications for crop area assessments and an advanced deep learning algorithm (e.g., convolutional neural network) to predict vegetation levels across large and heterogeneous geographic regions. In addition, open-access cloud-based solutions for crop area mapping for food security planning and policies were discussed.

The panels deliberated on how remote sensing technologies are being integrated with conventional systems for improving efficiency and accuracy of crop models and the challenges of adoption of new technologies. The participants found that the major technical challenges to crop assessments include i) lack of ground observation (e.g., crop calendar/types), differentiating inter-cropping patterns, soil profile, quality, and resolution of remote sensing data and ii) understanding of methods and uncertainties of the crop models, tools, and products. The panel suggested that institutional collaboration is needed to integrate satellite, climate, and crop data and models by engaging users and decision-makers and tailoring communication to local levels as well as defining a process to make information available, thus reducing barriers.

ESTABLISHING EXPERT WORKING GROUPS TO FOSTER REGIONAL COOPERATION. The multifaceted nature and interconnectedness of drought, food security, and socioeconomic issues related to race, class, and gender demand a strategic partnership to develop engaged and drought-resilient communities. In breakout groups, the participants at the forum discussed ways to establish a regional partnership (innovation platforms) through the participation of national and regional institutions, private sectors, and local and international organizations to improve climate services using Earth observation and facilitate agricultural decision-making to help with food security in the region. Thus, three working groups (WGs) were proposed at the forum: i) drought monitoring and early warning, ii) crop area and yield estimation,

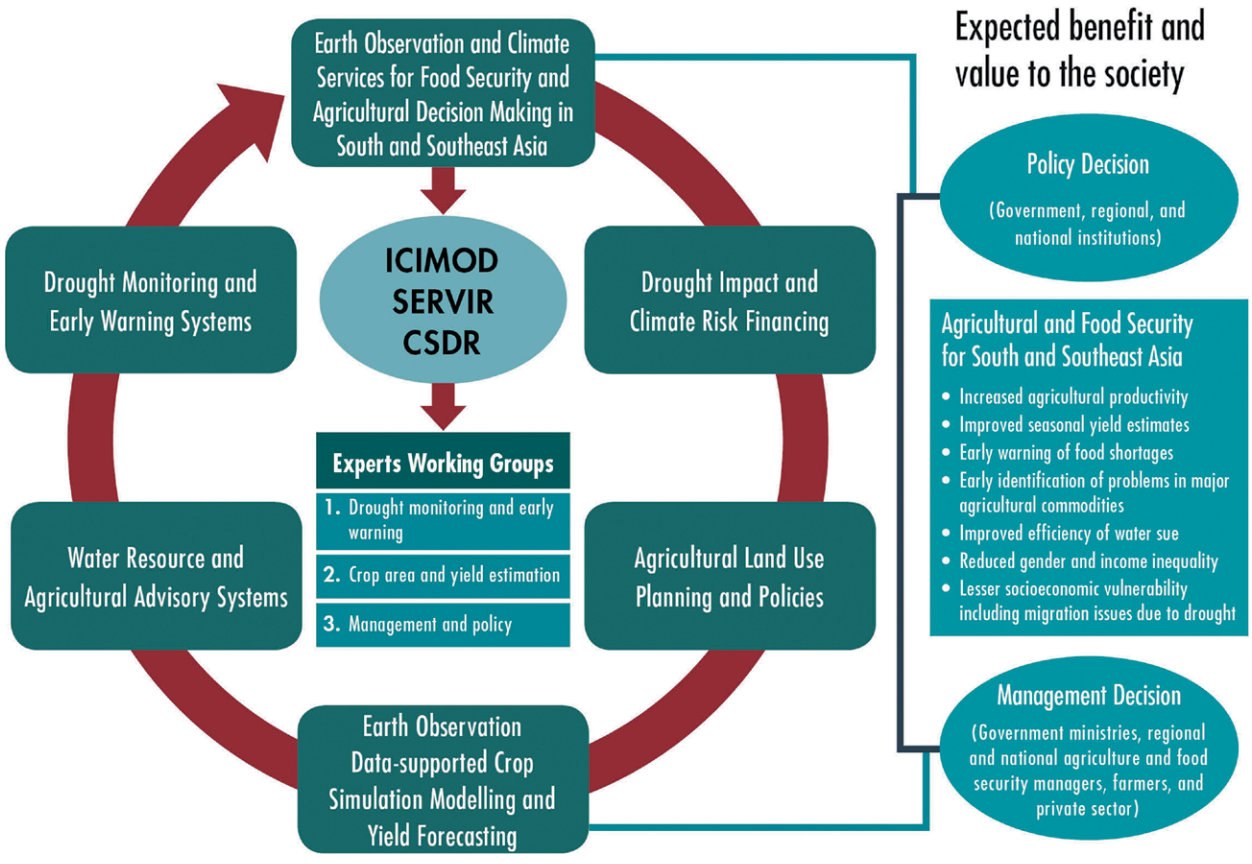

Fig. 1. The framework of the main thematic areas and expected benefits of the proposed expert working groups at the Regional Knowledge Forum on Drought.

and iii) management and policy (Fig. 1). The value and benefit of Earth observation for drought risk management and food security, which were discussed at the forum, are also highlighted in Fig. 1. These WGs will have regional coordinators (e.g., experts from ICIMOD, CSRD, and SERVIR) and representatives from each country's key institutes in the region. The WGs are expected to help in knowledge sharing and the exchange of data resources as well as building institutional capacity needed to address drought monitoring and food security issues. Volunteering members of these WGs will meet periodically to share their experiences and lessons learned. In addition to fostering collaboration at the regional scale, the forum participants strongly recommended including training local experts in capacity building.

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REFERENCE

Kansakar, P., and F. Hossain, 2016: A review of applications of satellite Earth observation data for global societal benefit and stewardship of planet Earth. *Space Policy*, **36**, 46–54, https://doi.org/10.1016/j.spacepol.2016.05.005.