

South Asian drought monitoring and outlook system to support agricultural advisory processes

Executive Summary

The livelihoods of over 50% of rural population in the countries of Hindu Kush Himalaya (HKH) depend on rain-fed agriculture, livestock, and forestry. The increase in frequency and severity of droughts that affects agriculture, food security, and the livelihoods of millions of marginal and vulnerable people is becoming a major concern in the countries of the HKH region. During past decades, large amounts of climate information have been made available by scientific communities but the use of these information by decision makers at local and management levels remain low. Provisioning of user oriented, easily accessible, timely, and decision-relevant scientific information, in the form of a Climate Service, can help society to cope with current climate variability and limit the economic and social damage caused by climate-related disasters.

The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning, knowledge and enabling centre devoted to sustainable mountain development and serves the eight regional member countries (RMCs) of the HKH region. Through its Mountain Environment Regional Information System (MENRIS) program, ICIMOD has been promoting the use of Earth observation and geospatial technologies in the HKH region for more than two decades and is well known as a pioneer institution in the region in this field. It has a long experience in data production, analysis and development of web-based information systems related to various thematic topics (e.g. disaster, ecosystem, cryosphere, etc.) which are accessible online at ICIMOD's Mountain GeoPortal (<http://geoportal.icimod.org>). Further, ICIMOD supports the open data initiative and makes its data public and downloadable through its Regional Database System portal (<http://rds.icimod.org>).

ICIMOD has an ongoing SERVIR-Hindu Kush Himalaya (HKH) initiative which is part of the global SERVIR program, a joint development initiative of National Aeronautics and Space Administration (NASA) and United States Agency for International Development (USAID). ICIMOD is also a GEO Participating Organization and has been instrumental in promoting GEO vision in the Himalaya region through the community initiative Himalayan GEOSS.

ICIMOD under SERVIR-HKH initiative and through collaboration with NASA Applied Science Team (AST) at John Hopkins University has been developing South Asian Drought Monitoring and Outlook system (SADMO). The SADMO, currently in its beta version, provides information on five key drought related parameters, i.e. soil moisture, precipitation, temperature, evapotranspiration and standard precipitation index, on dekad (10 days), monthly and quarterly basis. As an extension to SADMO, ICIMOD is developing an agro-met advisory information dashboard (AAID) for national and local level planning in Nepal and Bangladesh. The

dashboard allows visualization of drought indicators aligning with local crop calendar/cropping practices and aggregated at district level. Currently, both the SADM and AAID are running on servers at ICIMOD. In order to operationalize the system with national agencies like Ministry of Agriculture and Livestock Development (MoALD) and National Agricultural Research Council (NARC) in Nepal and Bangladesh Agricultural Research Council (BARC), it is required to provide partner agencies efficient access and full control over computational platform along with decision support tools that allow running analytical tools on-the-fly to help them in generating agro-advisory information and disseminating them to local government bodies and farmers.

It is proposed that the AAID application which is currently being developed will be enhanced and deployed at Amazon Cloud. ICIMOD has established the South Asia Land Data Assimilation System (SALDAS) that consists of a powerful server with 88 core CPUs, 40TB storage and 256GB of RAM and produces daily datasets on 30 parameters for use in different modeling platforms. It is envisaged that the overall system will be hybrid in nature such that the AAID will be deployed on Amazon Cloud that accesses necessary drought related data products from SALDAS server at ICIMOD and other data products such as MODIS NDVI and MODIS NDVI Anomaly from NASA's server automatically. The AAID will provide information on drought indicators including Standard Precipitation Index on dekad (10 days), monthly and quarterly basis for a given district or user defined area; tools to provide seasonal forecast meteorological parameters for districts or user defined area; provide early warning information in the form of emails to relevant users and providing the information in both English and local national language.

The AAID will be developed using open source python platform in Windows machine. The monthly cost of the required server is estimated to be USD 2788.96 with the total cost for 3 years coming to around USD 100,000. In order to develop and operationalize the system, ICIMOD will put together necessary human resources such as GIS applications developer, system administrator, thematic experts on drought and so on, and the total contribution from ICIMOD over 3 year period will be over USD 50,000.

With access to Amazon cloud services, ICIMOD will be in position to actively engage national partner agencies in Afghanistan, Bangladesh, Nepal and Pakistan through collaborative work on climate modelling and data analysis. Holistically, the work aims to contribute to the Sustainable Development Goal (SDG) 13 which emphasizes on action to combat climate change and its impacts. Access to modelling tools for drought monitoring and forecasting will strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in the ICIMOD member countries. The effort will also contribute in promoting mechanisms for raising capacity for effective climate change-related planning and management in least developed countries.

1. Problem Statement

The livelihoods of over 50% of rural population in the countries of Hindu Kush Himalaya (HKH) depend on rain-fed agriculture, livestock, and forestry. The Intergovernmental Panel on Climate Change (IPCC) [Fifth Assessment Report](#) (AR5) identifies heat-related mortality and malnutrition due to increased drought-related water and food shortage among the top five climate-related risks. The assessment suggests that climate change will have adverse impacts on human health, food and water security, livelihoods, and create new vulnerabilities.

The increase in frequency and severity of droughts that affect agriculture, food security, and the livelihoods of millions of marginal and vulnerable people is becoming a major concern in the countries of the HKH region. As the climate continues to change, agricultural productivity across nations are likely to suffer, with changes in rainfall patterns and intensity affecting agricultural production, especially in marginal rain-fed areas. In this context, there is an increasing need for timely and accurate information on climate and crop conditions.

During past decades, large amounts of climate information have been made available by scientific communities but the use of these information by decision makers at local and management levels remain low. Provisioning of user oriented, easily accessible, timely, and decision-relevant scientific information, in the form of a Climate Service, can help society to cope with current climate variability and limit the economic and social damage caused by climate-related disasters.

2. Institutional Context

The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning, knowledge and enabling centre devoted to sustainable mountain development and serves the eight regional member countries (RMCs) of the HKH region. It has been working for sustainable development of HKH region for more than three decades in close collaboration with government departments, universities and research institutes in its regional member countries. Through its Mountain Environment Regional Information System (MENRIS) program, ICIMOD has been promoting the use of Earth observation and geospatial technologies in the HKH region since its early years and is well known as a pioneer institution in the region in this field. Keeping abreast with the latest development in the geospatial and information technology domains, developing innovative solutions, capacity building and transferring them to the RMCs have been the modus operandi of ICIMOD. It has a long experience in data production, analysis and presentation in both efficient and effective manner. It has developed a number of dynamic web-mapping applications and information systems related to various thematic topics (e.g. disaster, ecosystem, cryosphere, etc.) which are accessible online at ICIMOD's Mountain GeoPortal (<http://geoportal.icimod.org>). Further, ICIMOD supports the open data initiative and makes its data public and downloadable through its Regional Database System portal (<http://rds.icimod.org>).

ICIMOD has an ongoing SERVIR-Hindu Kush Himalaya (HKH) initiative which is part of the global SERVIR program, a joint development initiative of National Aeronautics and Space Administration (NASA) and United States Agency for International Development (USAID). Through SERVIR-HKH, ICIMOD has been helping the RMCs in addressing different aspects of environmental degradation and climate-change impacts, promoting access to geospatial and climate information, and developing user-tailored data and tools for decision-making.

ICIMOD is also a GEO Participating Organization and has been instrumental in promoting GEO vision in the Himalaya region through the community initiative Himalayan GEOSS.

3. Ongoing effort: South Asian Drought Monitoring and Outlook System

ICIMOD under SERVIR-HKH initiative and through collaboration with NASA Applied Science Team (AST) at John Hopkins University has implemented South Asia Land Data Assimilation System (SALDAS), a first of its kind in the HKH region which provides 20 years of historical data on various climate and drought related parameters along with seasonal forecasts. SALDAS is a collaborative modeling platform consisting of a suite of advanced Land Surface Models (LSM) implemented at a 5-km horizontal resolution for fully distributed hydrological simulations across all of South Asia. The system, which is built on the NASA Land Information System (LIS) software platform, merges models with satellite data, as remotely sensed observations are applied as meteorological forcing data (e.g. satellite-derived precipitation estimates), land surface parameters (e.g. land cover and vegetation fraction), and, in some instances, update observations in hydrological data assimilation (e.g. satellite-derived snow cover observations).

A South Asian Drought Monitoring and Outlook system (SADMO) is being developed using drought related parameters from SALDAS which produces daily datasets on 30 parameters for use in different modeling platforms. The key objective of the system is to improve the capacity of national agro-meteorological and agricultural agencies in developing data products related to drought monitoring and interpretation and dissemination of climate services in country-specific contexts.

The SADMO, currently in its beta version, provides information on five key drought related parameters, i.e. soil moisture, precipitation, temperature, evapotranspiration and standard precipitation index, on dekad (10 days), monthly and quarterly basis. It allows viewing of historical time-series data on these parameters and generating charts of selected drought indices for a user defined area on map (see figure 1). The front end component of SADMO is based on the Tethys platform, an open-source web-GIS suite developed by Brigham Young University (BYU).

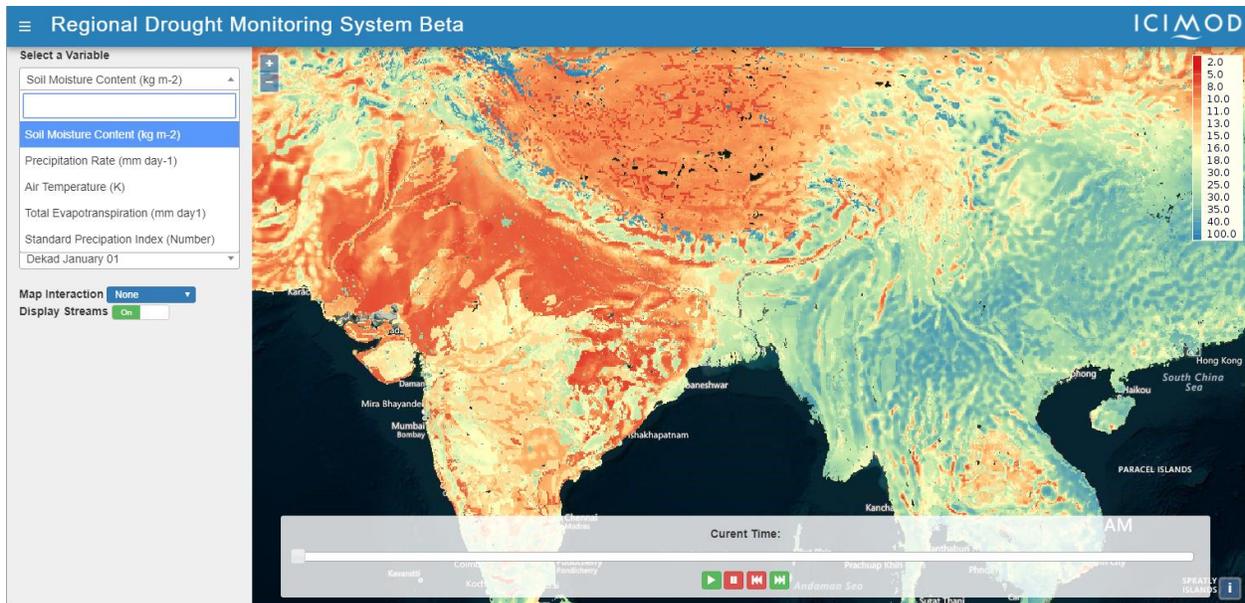


Figure 1. South Asian Drought Monitoring and Outlook system (SADMO)

4. The proposal: Agro-met Advisory Information Dashboard on Amazon Cloud

As an extension to SADMO, ICIMOD is developing an agro-met advisory information dashboard (AAID) for national and local level planning in Nepal and Bangladesh. The dashboard allows visualization of drought indicators aligning with local crop calendar/cropping practices and aggregated at district level (see Figure 2). In particular, the seasonal forecasts provide early means to make relevant policy decisions and act at farm levels which might not be practical with daily or weekly forecasts in agriculture sector. The AAID assimilates data from SALDAS and other sources (e.g. NASA - MODIS NDVI, MODIS NDVI Anomalies, etc.) and offers one stop access to information on various agriculture related parameters for a given district. The AAID allows viewing of statistics of multiple user selected parameters in the form of charts or maps in a single interface in the form of dashboard. This enables agencies like MoALD or BARC to create agro-advisory bulletin and disseminate the much needed information to the farmers through their agriculture extension staffs on the ground.

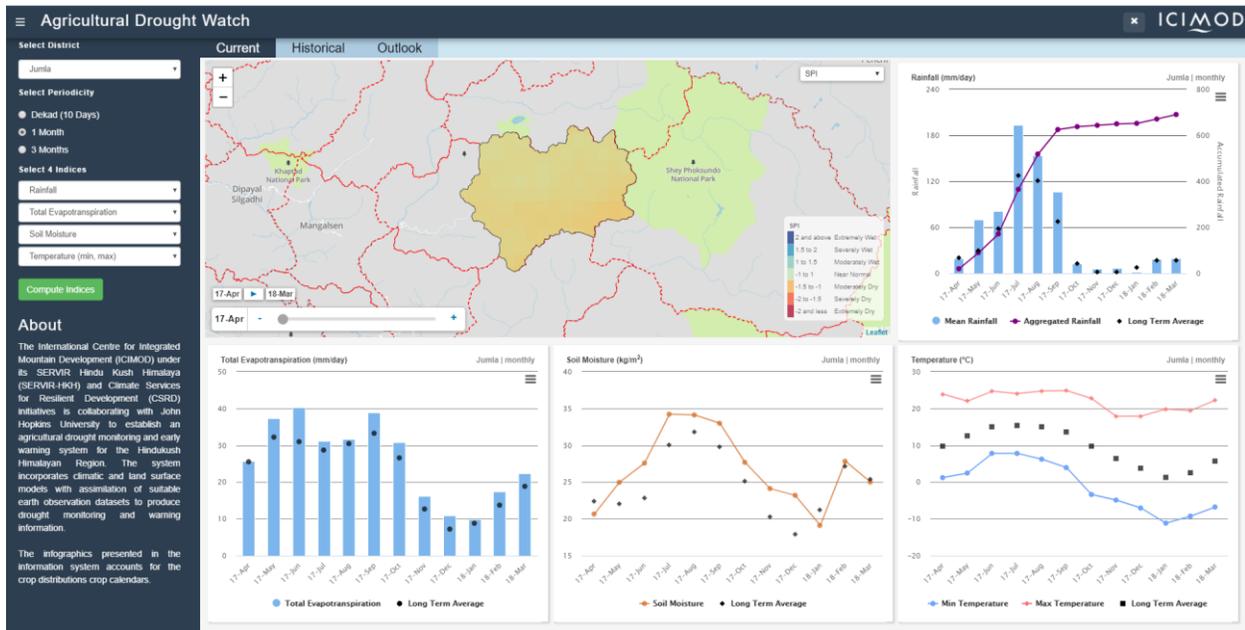


Figure 2. Prototype of Agro-met advisory dashboard for Nepal

In this way, AAID is envisaged as an innovative approach to translate the SALDAS outputs to actionable information products providing a state of the art solutions to national agencies. The AAID will consists of following key features:

- Provide information on drought indicators including Standard Precipitation Index on dekad (10 days), monthly and quarterly basis for a given district or user defined area.
- Tools to provide seasonal forecast meteorological parameters for districts or user defined area.
- Provide early warning information in the form of emails to the relevant users (e.g. MoALD, BARC, etc.)
- Providing information in English as well as local national language (e.g. Nepali, Bangla, etc.)

5. Implementation Plan

The SALDAS that ICIMOD established at its premise consists of a server with 88 core CPUs, 40TB storage and 256GB of RAM. It is proposed that the AAID application which is currently being developed as a prototype will be enhanced and deployed at Amazon Cloud. In this regard, it is envisaged that the overall system will be hybrid in nature such that the AAID will be deployed on Amazon Cloud that accesses necessary drought related data products from SALDAS server at ICIMOD and other data products such as MODIS NDVI and MODIS NDVI Anomaly from NASA's server automatically.

The AAID will be developed using open source python platform in Windows machine. The key specifications of the server that will be used in the AAID are as follows:

- 32 Core CPUs
- 64 GB RAM
- 250 GB SSD HDD
- 1 TB disk space on Amazon Glacier

The total monthly estimated cost of the server based on the calculator comes to USD 2788.96 (see Figure 3). The total cost for running the server for 3 years comes to around USD 100,000 (~USD 100402.6).

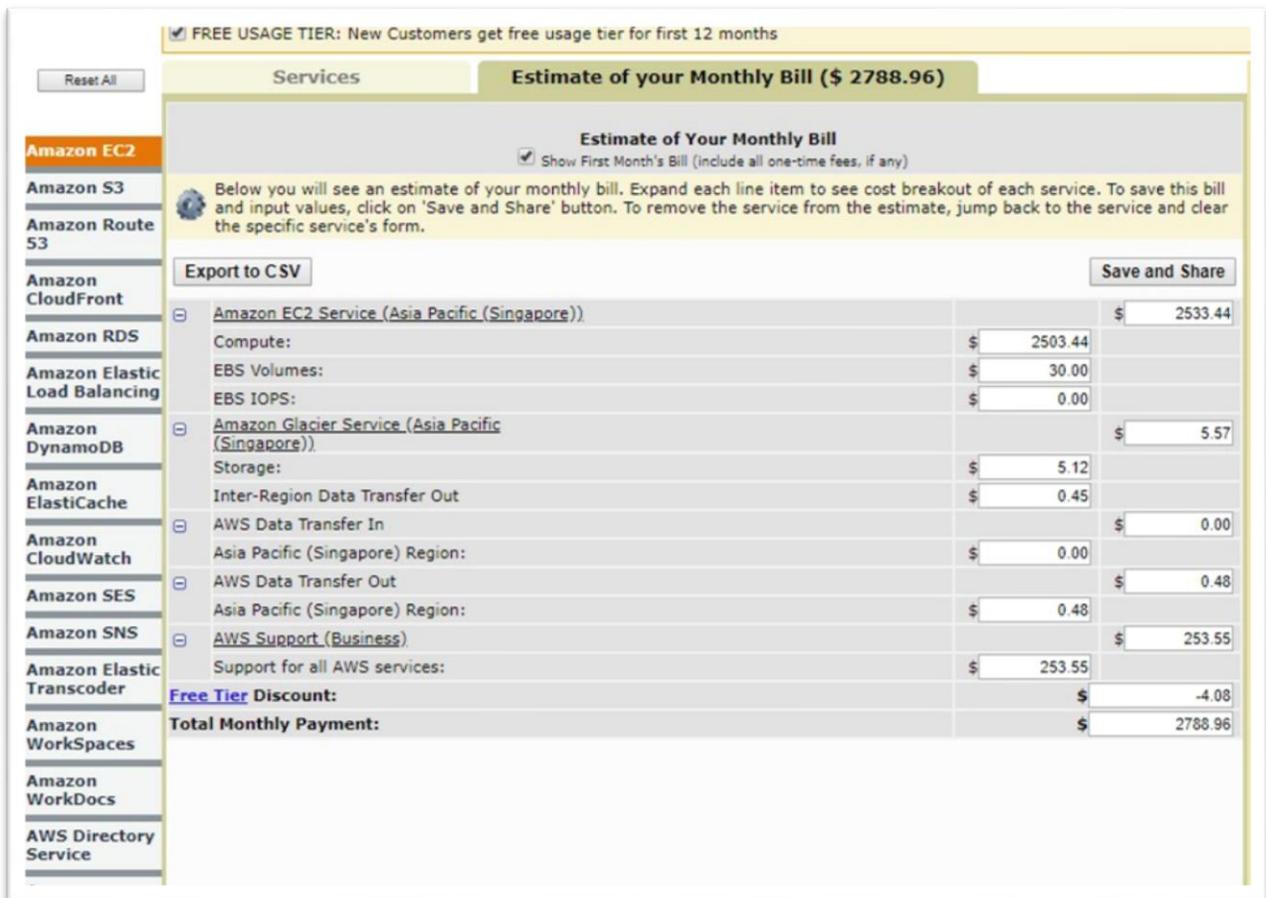


Figure 2. Monthly estimated bill of Amazon cloud

In order to develop and operationalize the system, ICIMOD will put together necessary human resources such as GIS applications developer, system administrator, thematic experts on drought. It is estimated that over the three year period, the total contribution from ICIMOD in operationalizing the system will be over USD 50,000.

In order to operationalize the system with national agencies like MoALD, NARC, and BARC, it is required to provide partner agencies efficient access and full control over computational platform along with decision support tools that allow running analytical tools on-the-fly to help them in generating agro-advisory information and disseminating them to local government bodies and farmers.

Partnerships and user engagement have been key components in designing and developing any application services at ICIMOD under SERVIR-HKH. John Hopkins University is the key Science partner in the implementation of SALDAS/ SADMO at ICIMOD. The Department of Hydrology and Meteorology (DHM) Nepal and Bangladesh Meteorology Department (BMD), NARC, and BARC are collaborating in model calibration and validation. Other user engagement activities include requirement analysis, obtaining feedbacks and capacity development trainings which are carried out on a regular basis.

Table 1. The key activities envisaged in establishing AAID for Nepal and Bangladesh in the Amazon cloud along with the milestones:

S. No.	Activity	Deadline
1.	Setting up the AWS server with required operating system and software including Tethys platform	End of month 1
2.	Setting up the datasets in the AWS server with necessary SALDAS output data	End of month 3
3.	Migration of AAID for Nepal that is currently being developed and deployed at ICIMOD to AWS and its operationalization	End of month 6
4.	Development of AAID for Bangladesh and its operationalization	End of month 12
5.	Operation and maintenance	Year 2 and 3

With access to Amazon cloud services ICIMOD will be in position to actively engage partner national agencies, belonging to Nepal and Bangladesh through collaborative work on climate modelling and data analysis. This will help ICIMOD on resources optimization, build its own capacity on Amazon cloud services and provide opportunities of scalability and replication to other thematic applications.

Holistically, the work aims to contribute in the Sustainable Development Goal (SDG) 13 which emphasize on action to combat climate change and its impacts. Access to modelling tools for drought monitoring and forecasting will strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in the ICIMOD member countries. The effort is also contributing in promoting mechanisms for raising capacity for effective climate change-related planning and management in least developed countries.