Technical Brief

CGIAR INITIATIVE ON Climate Resilience

# Zambia Drought Management System

Among measures that Zambia is taking to increase resilience to climate change is ZADMS which is an end-to-end drought management approach that can help ensure the resilience of agricultural production and food security.

## Equipping Zambia to effectively manage drought

The Zambia Drought Management System (ZADMS) is a satellite-based online resource that provides farmers, extension workers, and agriculture and water resources authorities the information needed to forecast, monitor, and manage drought. Specifically, it provides (sub)seasonal and seven-day weather forecasts; monitoring tools to indicate when drought is present and, if so, the level of severity; and district-level agricultural contingency plans that can be put into action if the system indicates particular triggers have been reached.

The ZADMS incorporates national- to district-level datasets drawn from multi-satellite observed data and other sources. Data are primarily presented as easy-to-interpret on-screen maps but can be presented as user-friendly drought bulletins if required.

In the past, difficulties in locating, accessing, and having the computing power to analyze weather and agricultural data made drought monitoring a slow and costly process. The ZADMS overcomes this challenge by presenting all the data required for monitoring and managing drought through a single portal, which is freely accessible to anyone with a desktop computer and internet access.

## Responding to the need for better drought management

Drought frequently affects more than two billion people living in the world's drylands, which extend across 41 percent of Earth's land surface. Droughts are cyclical, natural hazards that have occurred for millennia, but their severity and ability to cause extensive loss and damage are increasing due to climate change. According to the United Nations Office for Disaster Risk Reduction, there were 338 disasters caused by drought between 2000 and 2019 globally, compared to 263 between 1980 and 1999.

In Zambia, drought is a recurring problem. Over the past three decades, an increasingly variable climate has brought higher temperatures, lower rainfall, and more frequent droughts and floods. The periods 1991–1992, 2015–2016, 2019–2020 and 2021–22 brought particularly damaging dry spells that affected millions of people with crop failures, food and water shortages, livestock deaths, and reduced GDP. Presently, although Zambia is defined as a middle-income nation, 60 percent of its people live on less than US$1.90 per day, and malnutrition rates are among the highest in the world. As climate change impacts grow, unleashing more climate shocks, the situation is forecast to worsen.

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> ZADMS is a multi-level governance tool for timely anticipatory drought mitigation

## How the ZADMS works

### The system incorporates the following modules:

**Weather forecast:** Users can access seasonal (three to four months in advance), sub-seasonal (up to a month in advance) or near-time (up to ten days in advance) forecasts, at province and district level, with data updated every hour. Individual meteorological parameters – such as rainfall, temperature, cloud, wind speed, and air pressure – can be selected to provide more detailed insights. Data can be downloaded in a variety of formats (csv, jpeg, etc.) for use in reporting.

**Drought management:** Users can monitor past drought frequency and severity, as well as assess current drought conditions, to support the development of drought management measures.

**Drought decision support:** Based on signals identified in satellite indices – including precipitation, surface water extent, soil moisture, and vegetation health – the system can accurately identify how a drought is progressing for a particular region, down to district level. 'Mandatory' indicators are used to identify the existence of drought while 'Impact' indicators show how the drought is developing. The system has triggers set for predefined conditions, to indicate the level of severity reached (Moderate, Severe, or Extreme). These can be used to support drought declaration and contingency planning.

Users first select the region of interest and then choose from 'Drought prediction,' 'Drought monitor,' 'Drought decision support,' or 'Other indices.'

- The 'Drought prediction' tool is currently under development, but once operational, it will enable users to map results from precipitation and runoff indicators (NPSMI, SPI, SRI), with the results indicating if there has been less rain than usual.
- Selecting 'Drought monitor' enables users to examine a wide range of indices for drought (Dry spell, SPI), water resources (NDWI), and impacts on agriculture and water resources (NDVI, MAI, VCI, IDSI, Risk Score).
- 'Drought decision support' is currently being developed, but once complete, it will provide options for users to select the province/district of interest, season, and drought phase (active, alert), as well as 'Dry spell' or precipitation indices for specified time periods, showing drought patterns and trends related to cropping seasons.
- Selecting 'Other indices' allows further exploration of conditions through any of the data incorporated in the system, which includes information on extent of flooding using NASA MODIS and ESA Sentinel-1 satellite data, as well as crop production.

The results can be formatted into a bulletin for external dissemination by the Ministry of Agriculture, with the capacity to add additional information or guidance if required.

**Contingency plan:** This tool is still under development through consultation with stakeholders. Once operational, it will provide users with options for actions based on the different levels of drought severity. For example, users can explore the types of crops usually grown by farmers in a particular area, along with the water requirement of those crops and the proportion of agricultural land generally rainfed versus irrigated. This will facilitate the selection of drought-tolerant crops if dry conditions prevail.

**News feed:** Users can access the latest news related to drought and food security published by the International Water Management Institute (IWMI); relevant news from external feeds (such as the BBC, CGIAR, ScienceDaily, and the World Meteorological Organization); relevant events such as World Water Week; and the latest publications from CGIAR.

**User guide:** This explains in detail how to use the ZADMS. It includes information on the data sources being used, resolution, etc. Technical support is available if required.

**Public Application Programming Interface (API):** This enables the incorporation of the ZADMS API into existing drought and agricultural data systems, enabling users to query selected datasets through their own interfaces. A simple sign-up process facilitates this access.

**Online bulletin:** This publishes current drought alerts from around the world.

## Evolution of satellite-based drought monitoring tools

As satellite technologies evolved early in the new millennium, the International Water Management Institute (IWMI) collaborated with the Office of U.S. Foreign Disaster Assistance to establish the first drought monitoring system for Southwest Asia. Covering Iran, Pakistan, and the western states of India, it aimed to make available knowledge products related to drought and to promote regional capabilities with regard to managing agricultural risk from dry conditions. Following the success of this initiative, IWMI was supported by the Integrated Drought Management Program of the World Meteorological Organization/Global Water Partnership to promote three pillars of drought risk management – monitoring and early warning, vulnerability and impact assessment, and mitigation and preparedness – at regional to subnational levels, including in South Asia.

This work led to the development of the South Asia Drought Monitoring System in 2017, aimed at enhancing resilience to drought through monitoring and early warning efforts, vulnerability assessments, agricultural contingency planning, climate adaptation measures, and capacity building in both rainfed and irrigated farming systems. This work was supported by the Indian Council of Agricultural Research, Japan's Ministry of Agriculture, Forestry and Fisheries, and the CGIAR Research Program on Water, Land and Ecosystems.

IWMI is now extending its drought-monitoring system to Zambia, as part of the CGIAR Research Initiative on Climate Resilience (ClimBeR) and the Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) program. Involving collaboration between multiple organizations, the program is applying new technologies and approaches to addressing the social, environmental, and economic consequences of climate change, aiming to support nations in building resilient farming systems. Zambia was selected as a focus country of the project because of its high vulnerability to climate change but low levels of resilience.

## Indices incorporated in the ZADMS

### Weather forecasting indices

- Up to 10-day: OpenWeather; Global Forecast System of the National Oceanic and Atmospheric Administration (GFS-NOAA)
- Sub-seasonal: European Centre for Medium-Range Weather Forecasts
- Seasonal: Climate Prediction Center (CPC–static); International Research Institute for Climate and Society (IRI) at Columbia University

### Drought monitoring indices

- Standardized Precipitation Index (SPI)
- Dry spell (lack of days with rain)
- Vegetation Condition Index (VCI)
- Normalized Difference Vegetation Index (NDVI)
- Moisture Anomaly Index (MAI)
- Normalized Difference Water Index (NDWI)
- Integrated Drought Severity Index (IDSI)

### Other

- Rainfall Anomaly Index (RAI)
- Crop Harvest Area (National Aeronautics and Space Administration [NASA] Moderate Resolution Imaging Spectroradiometer [MODIS], European Space Agency [ESA] Sentinel-1)
- Crop Stress (ESA Sentinel-1)
- Crop Cover (NASA MODIS, ESA Sentinel-1)
- Soil Water Anomaly Drought Index (SWADI)
- Extreme rainfall
- Flood (NASA MODIS, ESA Sentinel-1)

# The ZADMS in operation

The ZADMS can be used to assess weather conditions and understand when a drought is emerging and how it develops, to explore contingency measures and take appropriate action to avoid the worst impacts. For example, the Ministry of Agriculture might:

- Identify that, for the past five years, the start of the rainy season has been characterized by dry spells lasting two to three weeks. This might lead the Ministry to pay close attention to near-time weather forecasts ahead of the anticipated onset of the season, with a view to advising farmers to delay planting crops if the trend appears to be continuing. Use the system to identify when to initiate their strategy for mitigating water scarcity.
- If the seasonal forecast indicates a moderate drought is anticipated, for example, then the Ministry might support farmers in spreading out their risk by bundling various climate-smart approaches, for example, supplying seeds of more drought-tolerant crop varieties, subsidizing weather insurance, providing supplemental irrigation, and ensuring farmers can access agro-meteorological information.
- Provide information to finance and insurance suppliers, who might use the data on climate risk and farming system performance to develop new climate adaptation finance products aimed at transferring risk from smallholder farmers.

Ministry of Agriculture

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IWMI
International Water Management Institute

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