Automated Drought Severity Monitoring Framework

Comparative Drought Analysis (TOR, Report) – Component 2

Methodology Note

Background

Considering Afghanistan as a context where drought is one of the most common natural Hazards, available data since 1999 indicates that droughts have occurred in Afghanistan every 3 to 10 years, with varying severity and geographical extent. REACH and WFP conducted a comparative drought analysis[1] during first and second quarter of 2024, to study the impact of drought on communities' access to livelihoods, food, water, and drought-driven displacement. This study was based on available datasets, including both collected data and remote sensing-driven climate data.

Comparative Drought Analysis

In comparative drought analysis, The analysis of different datasets from various sources, including remote sensing climate data and field-collected data by different organizations from communities, reflects the interrelationship of different types of drought and how they evolve from one type to another. Furthermore, how the impact of these drought types varies based on community livelihoods, topography, and socio-economic conditions.

Based on the findings from comparative drought analysis, REACH aims to develop an automated drought severity monitoring framework. The results will enhance timely monitoring of drought conditions and support early warning systems. The purpose of this activity is to identify areas experiencing (or at risk of experiencing) severe drought events. In conjunction with other real-time monitoring activities developed by REACH related to exposure to shocks and humanitarian needs, this framework will help inform districts at risk of severe and extreme food insecurity.

Key Objectives

Automated drought severity analytical framework: Enhance timely drought severity monitoring to support early warning systems and response planning by leveraging freely available remote sensing-driven climate datasets and the Google Earth Engine platform

Google Earth Engine Code:

https://code.earthengine.google.com/ce086a09ba7bb2eb8579e44cad130980?noload=true

Note: To open the link and use the code, you need to have a google earth engine account.

[1] REACH, Comparative Drought Analysis Report : https://repository.impact-initiatives.org/document/impact/fbb84f88/REACH_AFG_Report_ComparativeDroughtAnalysis_Sept_2024.pdf

Methodology Overview

The automated drought severity analytical framework consists a set of indicators for each type of drought (Meteorological, Hydrological, and Agricultural). Data for these indicators will be derived from regular (daily or monthly) remote sensing sources. For each indicator, severity thresholds will range from 1 (Normal/Near Normal) to 4 (Severe/Possible Extreme). The remote sensing data includes MODIS (Vegetation), CHIRPS (Precipitation), and FLDAS (Snow Conditions). The severity score for each indicator will be calculated in District (admin2) level.

For the automated drought severity analytical framework The analysis of remote sensing climate data will be conducted in the Google Earth Engine environment. The entire process will be set up to ensure that the model functions fully automatically. Overall, the model will perform the following processes:

1. **Raster Image Analysis:** Filter data by the time range of interest. For indicators requiring historical data, a similar process will be applied to extract those historical values.
2. **Apply Zonal Statistics:** Calculate zonal statistics for the raster files based on the analysis unit.
3. **Convert Zonal Statistics Results:** Transform the zonal statistics results into conventional formats (Excel, feature collection).
4. **Score Conversion:** Convert the values into scores based on predefined thresholds.
5. **Join Data:** Merge the Excel and feature collection data.
6. **Final Score Calculation:** Calculate the final score based on the scores of each indicator.
7. **Produce Outputs:** Generate the Severity Drought Map and the corresponding tables.

Analysis time for the automated drought severity monitoring

Analysis time in the model is dynamic, and it based on the user preference. For example, by default, the script is set up to run from 2023/12/01 to 2024/10/01. The results will provide the following calculations of the indicators:

Accumulated precipitation: Total precipitation from 2023-12-01 to 2024-10-01, compared to the average of total precipitation of same period in last 4 years.

SPI-3: from 2024-07-01 to 2024-10-01, 3 months precipitation variation from longterm average precipitation.

Snow water equivalent: Total snow water equivalent from 2023 –12-01 to 2024-10-01, compared to the average of total precipitation of same period in last 4 years.

Standard Vegetation Index (SVI): measures vegetation conditions over the recent 20 days. This indicator assesses the greenness of vegetation during the 20 days preceding the selected end date for analysis and compares it to the long-term mean for the same time period since 2000.

The indicators used in the drought severity monitoring selected to reflect the conditions and severity of each type of drought, except socio-economic drought, which requires field data collection. However, the results from this framework can be integrated with available assessment data to further inform the socio-economic impacts of drought.

The indicators in this model include the condition of essential climate variables such as precipitation, snow water equivalent (SWE), and vegetation. While drought can be assessed using various indicators, the analysis output from this model can serve as a trigger for further localized, in-depth assessments of drought. Additionally, in Afghanistan, drought triggers vary from region to region; therefore, for a general drought analysis across the country, a few important indicators may provide better results than complex models.

Indicator List

Drought Type	Indicator	Source	Description
Meteorological	**Accumulated Precipitation**	CHIRPS	Accumulated precipitation, or total precipitation, will be calculated for the analysis date range and compared with the average accumulated precipitation over the same date range from the past four years
	SPI-3	CHIRPS	SPI-3 will be used to assess the variation in precipitation over the three months preceding the end of the analysis date range, compared to the average precipitation for the same period across multiple years (since 1981)
Hydrological Drought	**SNOW Water Equivalent**	ERA5	Snowpacks are the primary source of water for river flows. Early depletion of these snowpacks can lead to reduced river flow, negatively impacting agriculture and access to water.
	SPI-24	CHIRPS	SPI-24 will be used to assess the variation in precipitation over the 2 years preceding the end of the analysis date range, compared to the average precipitation for the same period across multiple years (since 1981)
Agriculture Drought	**SVI**	MODIS	The Standard Vegetation Index (SVI) shows the variation of green and healthy vegetation

Analysis Unit

All the indicators calculation results will be aggregated in district (adm 2) level.

Data Analysis Plan

#	Drought type	Indicator	Granularity	1.Normal/ Mear normal	2.Mild/Moderate	3.Moderate/Severe	4.Severe/Extreme
1	Meteorological	Accumulated Precipitation	Adm2	x >= 90% ltm	90% ltm>x>= 75% ltm	75% ltm>x>= 50 ltm	x<-50% ltm
2	Meteorological	SPI-3	Adm2	x >= 0	0>x>= -0.3	-0.3> x>=-0.7	x<= -0.8
3	Hydrologic	Snow water equivalent	Adm2	x>=90% ltm	90% ltm>x >= 75% ltm	75% ltm >x >=50% ltm	x< 50% ltm
4	Hydrologic	SPI-24	Adm2	x >= 0	0>x>= -0.3	-0.3> x>=-0.7	x<= -0.8
5	Agricultural	SVI	Adm2	X>=0	0>x>= -0.2	-0.2>x>= -0.8	x<-0.8

Note:

X = indicator value

ltm = Long term mean

Thresholds

The thresholds for the indicators are chosen based on a review of values from various dry and wet years. Since 1999, Afghanistan has experienced several droughts, with particularly severe events occurring in 2001, 2008, 2018, and the triple-year drought of 2021, 2022, and 2023.

Although some thresholds for indicators are already defined by various organizations and research centers, the findings from the comparative drought analysis on previous drought events in Afghanistan suggest that these thresholds need to be contextualized. Due to Afghanistan's annual precipitation regime, diverse livelihood types highly relied on water, and the low adaptive capacity of communities, the country is particularly vulnerable to drought. Therefore, in this model, the thresholds are adjusted to account for these specific aspects.

Aggregation Method

For each indicator, the severity score will be calculated according to the thresholds outlined in the Data Analysis Plan. Drought severity for each type of drought will be assessed based on the relevant indicators. The calculation will use simple statistical processes (mean). The final drought severity score will be derived from the total of the individual drought severity scores.

The final severity score will be categorized into four levels: 1 (Normal/Near Normal) to 4 (Severe/Extreme).

Severity	Normal/Near Normal	Mild/Possibility of Moderate condition	Moderate/Possibility of Severe condition	Severe/Possibility of extreme condition
Score	1	2	3	4

Data Aggregation Diagram

Note: The values used as an example is not a real value, and is included solely for better explanation.