Drought Early Warning Systems for disaster and risk reduction

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A B S T R A C T

Droughts have been more common in recent years, and their effects have been increased by rising water need and fluctuation in hydro-meteorological factors caused by global warming. As a consequence, drought hydrology has received a significant amount of interest. Drought early warning system (DEWS) has used many concepts, ranging from simple techniques to more complicated models. It is critical to comprehend various modeling methodologies, as well as their benefits and drawbacks. This paper, which supplements the important role in the previous papers reviews different methods used for droughts early warning systems, such as decision support system (DSS) drought predicting, probability-based modeling, Spatio-temporal analysis, use of Global Climate Models (GCMs) for drought scenarios, land data assimilation systems for drought modeling, and drought planning. Drought modeling has improved significantly over the last three decades, according to the findings. Hybrid models that incorporate large-scale climatic variables appear potential for long-term drought predictions. More study is needed to understand the spatiotemporal complexity of droughts under climate change due to changes in precipitation variability. Copula-based models for multivariate drought characterization appear to be promising for improved drought characterization. Research on decision support systems for delivering warnings, assessing risk, and taking preventive actions should be advanced, and effective methods for the flow of information from decision-makers to users should be established. Finally, some observations are provided about the prospects for drought research.

Key words: *drought early warning system (DEWS); drought modeling; developing countries*

1. Introduction

The Oxford Dictionary defines drought as "a lengthy period of exceptionally low rainfall; a lack of water as a result." Due to its long-term development and length, the gradual nature of its effects, and dispersed spatial breadth, drought is more difficult to identify, monitor, and manage than other natural disasters figure 1 illustrates the Drought early warning systems (DEWS) have been designed by NIDIS across the United States, where local networks of scientists, funding agencies, governments, and corporate sector, academics, and other stakeholders share information and activities to assist their communities to cope with drought. A DEWS manages this network of key regional partners so that decision-makers and communities may plan and prepare for drought using a systematic approach to drought monitoring and forecasting integration. By incorporating new, locally relevant drought information and supporting the introduction and testing of devices that detect and transmit drought risks and alerts, regional DEWS leads to development.

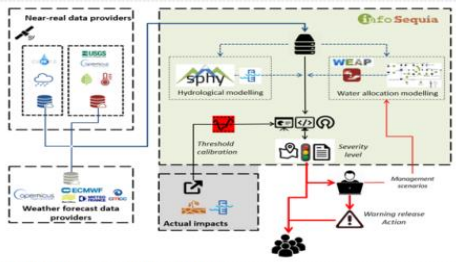


Figure 1. Drought Early Warning System (DEWS)
Source: www.futurewater.eu

1.2. Drought Classification

Figure 2 illustrates the drought classification in different contexts. Meteorological drought can be defined as “a reduction in rainfall supply compared with a specified average condition over some specified period”. Agricultural drought is defined as “a reduction in moisture availability below the optimum level required by a crop during different stages of its growth cycle, leading to reduced yields”. Hydrological drought “refers to the impact of a reduction in precipitation on a natural and artificial surface and subsurface water storage systems, and possibly lagging behind periods of agricultural or meteorological drought”. Finally, social drought “relates to the impact of drought on human activities, both indirect and direct impacts” [1].

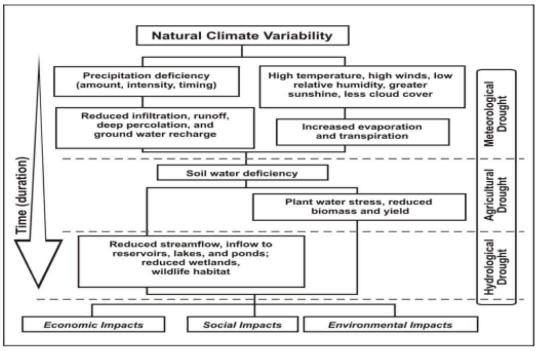


Figure 2: Different types of droughts
Source: National Drought Mitigation Center (NDMC)

2. Methodology

Once the variables are specified, it's important to talk about alternative drought forecasting approaches and their benefits and drawbacks. Different approaches and their uses in drought forecasting are shown in figure 3.

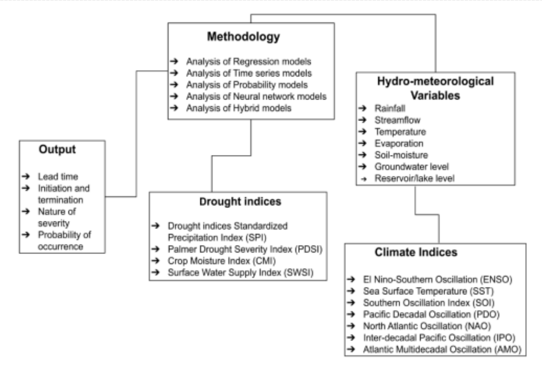
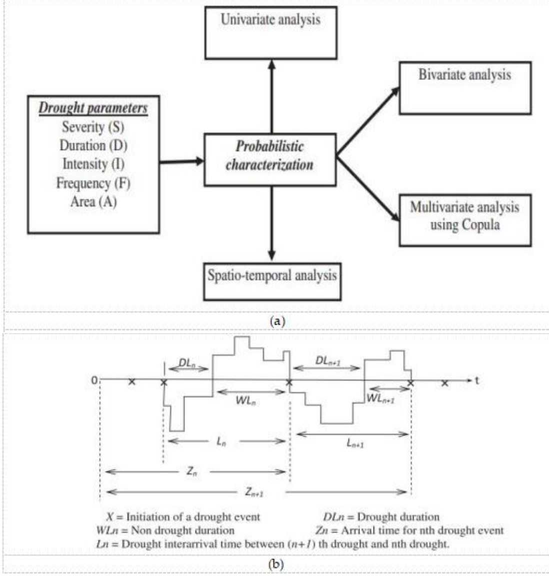


Figure 3. Drought Methodology

3. Probability of Drought characterization

Droughts have a well-known probability feature [2–4]. Drought probability characterization is critical, especially in areas where correct water resource strategy and control required a thorough understanding of water scarcity. Since Yevjevich (1967) presented ideas on the theory of runs, there has been a lot of research on the probability-based classification of dry spells e.g., [5,6] the severity, length, intensity, and interarrival time are all important factors for describing a drought, and they are all estimated using the theory of runs. Various probabilistic methods may be used to define different features of droughts (Fig. 4) includes: (1) “estimation of return periods for drought parameters and univariate drought analysis” and (2) “bivariate drought analysis which deals with two drought parameters” (3) “multivariate drought analysis using copulas which include more than two drought parameters” and (4) “Spatio-temporal drought analysis”.



4. Global warming situations and drought modelling for (EWS)

Global surface temperatures have risen dramatically over the last century and will continue to do so unless greenhouse gas emissions are severely limited (IPCC, 2007). Climate change has a wide range of consequences that differ in strength, duration, and geographic scope from location to region, even locally. Global Climate Models (GCMs) outputs are downscaled to predict drought characteristics at a local scale to better understand the impact of climate change. Figure 5 illustrates the overall methodology for the structure of SAF curves consisting of two portions: (1) “downscaling of precipitation at grid levels which included identification of GCMs, selecting predictors, downscaling using suitable techniques, bias correction, and interpolating precipitation at fine grids” and (2) “development of SAF curves based on downscaled precipitation by deriving drought properties, identifying a suitable probability distribution, and performing

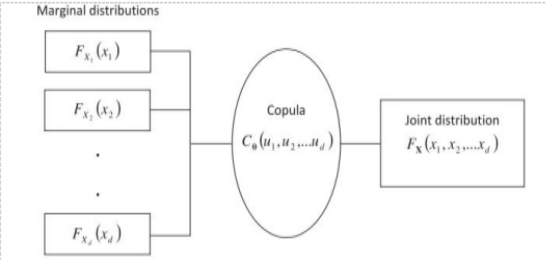


Figure 4. (a) Shows the Probability of Drought characterization, (b) shows the general concept of drought duration and severity, and (c) illustrates the general concept of the copula.

frequency analysis at different return periods. Results showed that there were likely to be more severe droughts in 2001–2050 with more spatial extent than those that have occurred historically".

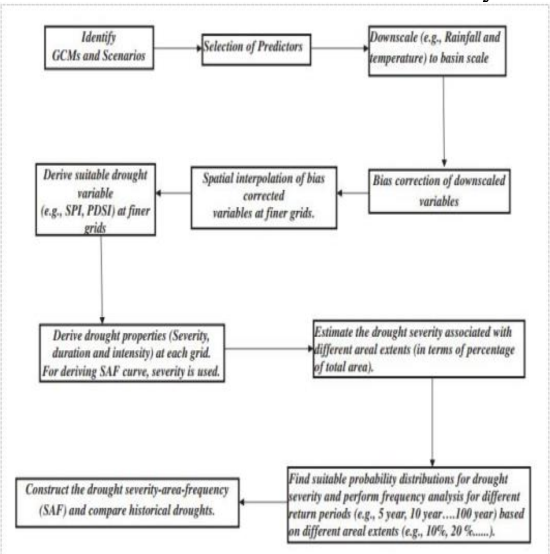


Figure 5. Methodology for developing drought SAF curves using GCM results.

5. Drought monitoring and early warning systems for South Asia

The SADM was created for seven nations in South Asia (Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka), and it covers the four largest river basins in the region, including the Indus (1120000 km2), Ganges (1087300 km2), Brahmaputra (543400 km2), and Meghna (82000 km2) (figure 6). The German Drought Monitor www.ufz.de/index.php?en=37937 developed the SADM [7]. Using the mesoscale hydrologic model (mHM) www.ufz.de/mhm the SADM forecasts daily and monthly agricultural drought situations [8]. The system's main architecture is made up of three key phases (figure 7). First, utilizing historical meteorological forcing (near real-time), morphological factors, and land cover data, the mHM is used to recreate daily and monthly soil moisture. Second, based on the mHM's history of soil moisture reconstruction, the SMI is calculated using a non-parametric kernel-based cumulative distribution function[9]. According to on the intensity of the drought, the SMI maps are divided into five categories: unusually dry, moderate drought, severe drought, extreme drought, and exceptional drought. The US Drought Monitor was used to create the drought categorization [10]. Third, the SADM http://ufzchs.pythonanywhere.com is created, which is an interactive web platform for the distribution of simulated near-real-time drought conditions. The daily and monthly SMI fields are uploaded and published on the SADM webpage every day to ensure maximum distribution.

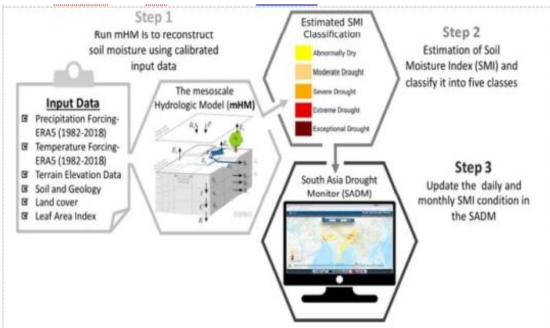


Figure 7. The South Asia Drought Monitor's framework

6. Drought early warning systems in the China, Europe, and United States

6.3 Europe

The Drought Management Centre for South-Eastern Europe (DMCSEE) and the European Drought Observatory (EDO) of the European Commission Joint Research Centre employs a combined drought

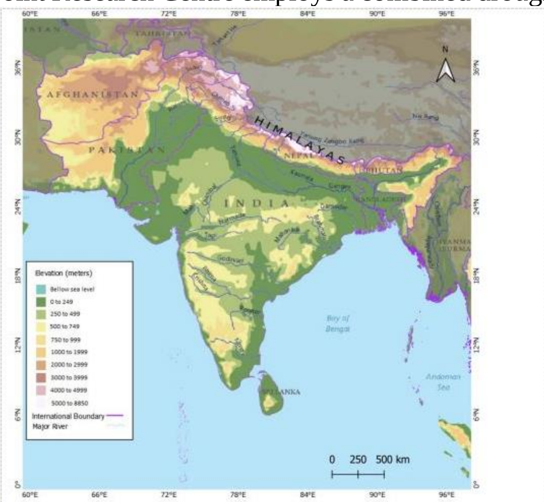


Figure 6. South Asia's physiography, rivers, and nations (source: Esri, Garmin, CIA World Factbook 2015, Esri 2016, NOAA, maps.com 2016).

indicator based on SPI, soil moisture, and fAPAR in their drought monitors. Figure 8 shows a map of droughts across Europe from the 22 March to 20 May 2022.

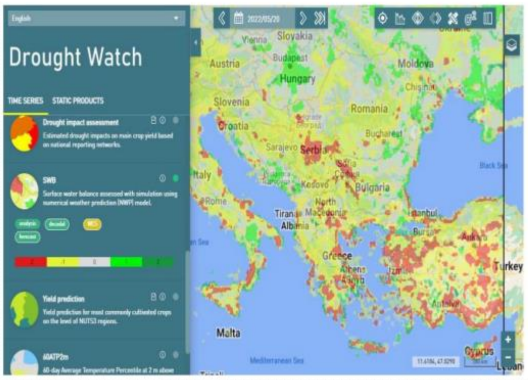


Figure 8. The European drought monitor map (https://www.droughtwatch.eu/)

6.4 United States

The National Oceanic and Atmospheric Administration (NOAA), the United States Department of Agriculture (USDA), and the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln formed a working relationship in 1999 to better teamwork and develop new drought observing techniques. On August 18, 1999, the United States Drought Monitor (USDM) began operating. The USDM is kept up to date on the NDMC's website (http://droughtmonitor.unl.edu/), which has grown into a web-based gateway for drought and water supply monitoring. Figure 9 depicts a drought monitoring map for the United States, which was issued on May 24, 2022.

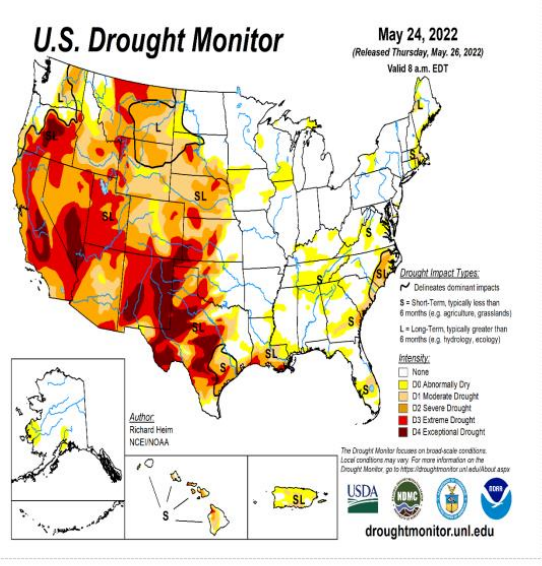


Figure 9. The U.S. Drought Monitor map

6. Discussions

There are still several issues to clear before developing a workable drought monitoring and early warning system in the West Asia and North Africa area, even with some existing structures to employ or established approaches to improve further. The essential concerns involve but are not limited to, which indicator(s) are optimal for drought monitoring and what the action threshold seems to be. To get answers to these questions, some research should be carried out in the following manner:

1. Collect the data needed to calculate the various indicators.

2.Calculate the indicators and compare them to prior drought situations to check if the calculated indicators can accurately indicate the severity or coverage of the current drought.

3.Compare the various indications, select one or more based on their ability to accurately represent the true state of past occurrences, and determine the threshold for taking action (relief measures).

7. Recommendations

4.Understanding stakeholder and institutional arrangements, roles, responsibilities, and capacity requirements are essential for involving these stakeholders and institutions in drought initiatives, developing appropriate products, underpinning capacity development as needed, and embedding the products and knowledge developed within drought mitigation plans.

5.It's also critical to focus more resources on fostering cross-national cooperation in terms of data and technology exchange. The nations of South Asia, Europe, and the U.S, are now suffering drought threats and may be facing more severe drought events shortly.

Author Contributions: Conceptualization, M.A.; E.J.L.; methodology, S.A.K; formal analysis, Z.W.; references, T.K.; writing—original draft, M.N.A.

Conflicts of Interest: The authors declare no conflict of interest

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