Paper B12

GENERAL PERSPECTIVE ON DROUGHT QUANTIFICATION AND MITIGATION IN SUB-SAHARAN AFRICA

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Abstract
Since precipitation is the primary input to the watershed system, the unavailability of precipitation in a good measure could lead to all forms of drought. Sub-Saharan nations of Africa have been the victim of droughts, hence there is a need to quantify and mitigate drought challenges with appropriate strategies to reduce vulnerability. Since there is no single universal technique to quantify drought severity, appropriate drought indices based on empirical methods and mathematical models can be deployed to characterise and zone drought field. Specialized indices such as the Standardised precipitation index (SPI), having relevant evaluation criteria such as robustness, tractability, transparency, sophistication, extendability and dimensionality are usually deployed for quantification of drought. More so, modern modelling techniques that use extreme learning machines (ELM) and artificial neural networks (ANN) as well as fuzzy inference system to predict Effective Drought Index (EDI) have also been employed. In addition to considering the dynamics of climate change and its apportionment impacts, it has become increasingly necessary that analysis of drought should take into cognizance the need for a cultic variable index model, unlike the most common use of only rainfall-based indices. Besides, for effective drought quantification, finding available across the sub-Saharan, calls for drought monitoring and early warning systems which are good tools that will help in designing drought mitigation strategies. This paper highlighted different ways of monitoring and mitigating the occurrence of droughts that can be useful in Africa.

Key words: Drought, indices, Mitigation, Precipitation, Quantification, sub-Saharan AfricaAfrica

1. Introduction

Drought is the consequence of a natural reduction in the amount of precipitation or flow received over an extended period, which could be months, a season or more in length. The concept of drought as a phenomenon is inevitable and occur in all climate mostly dry regions [1]. The concept of drought is in existence since the history of antiquity however, its management is still not optimal because of the way it is generally perceived and misunderstood by policymakers and technicians. According to [2] drought is the world's costliest natural disaster attracting global damages of about 6 - 8 billion US Dollars annually and affects more people than any other form of natural disaster. During recent years, a lot of progress has been made, with a major shift from the perception of considering drought as an emergency phenomenon, to long-term actionable planning for efficient management. Drought will increase in the 21st century. Hence, drought warnings, preparedness and assessments should be considered as strategic policy objectives for actionable plans [3]. But a lot of efforts are still needed to elaborate and implement drought mitigation plans, for which most countries are still in need of great help to reduce their vulnerability and build their capacity to combat drought effects in an efficient manner [4].

2. Drought in sub- Saharan Africa

2.1 Drought Quantification in sub- Saharan Africa

Generally, there is no single unifying technique to quantify drought severity. However, there are conventional indices used based on desirable properties that an index should possess. Also, drought indices are obtained by empirical methods and mathematical models [5]. In this context, a great deal of modern modelling techniques is used such as extreme learning machines (ELM) and artificial neural network (ANN) to predict Effective Drought Index (EDI). Drought in sub-Saharan Africa (SSA) contributes to undernourishment and hunger which reduces agricultural production leading to food insecurity situation.

Drought monitoring system employed in sub-Saharan Africa usually adopted are as shown in Figure 1.

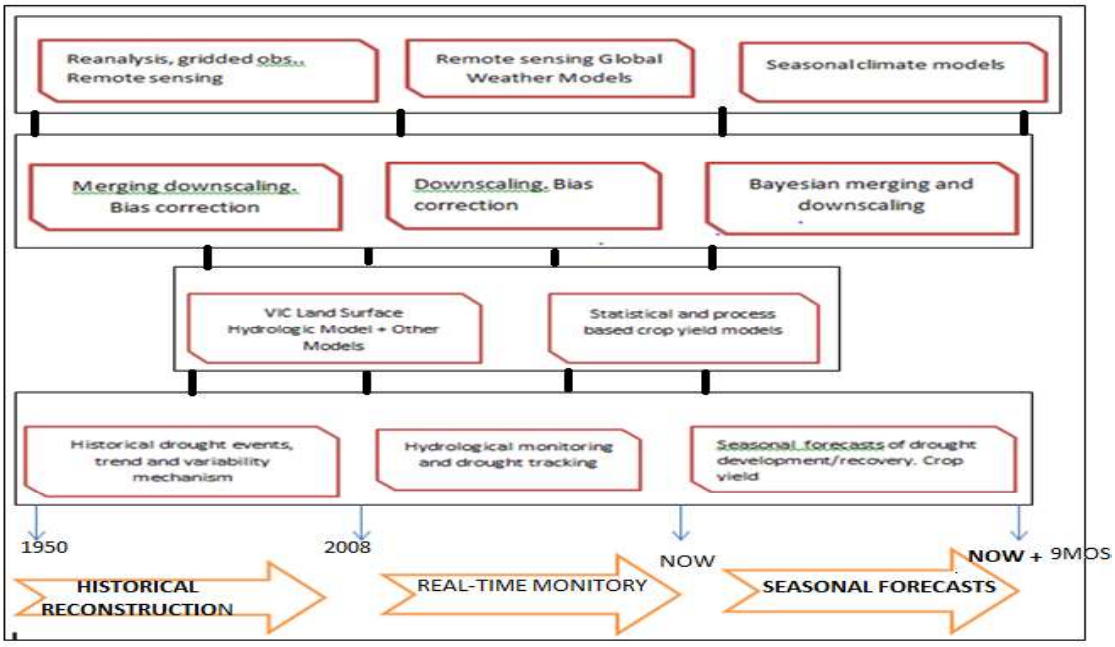

Figure 1. Flowchart of the African Drought Monitoring and Forecast System
Source: [6]

Some of the specialized indices that have been adopted for the different types of droughts (i.e., meteorological, hydrological, ecological and agricultural) include SPI, SPEI, VIC and SMOS soil moisture indices, NDVI, EVI, VOD index, dB index, Stream flow percentiles and Cumulative streamflow deficit. Depending on the aspect of drought to be reflected, data of different attributes from different sources have been used for their computation [6].

The above system was tested for operational usage by African collaborators at workshops held in January and June 2012 in Niger and Kenya respectively. The system estimates drought conditions through a combination of hydrological modelling, satellite remote sensing, and seasonal climate forecasts. It draws from the long legacy of operational and experimental systems in the United States, in particular, the Princeton drought monitoring and forecasting system. Given the tremendous impact of drought in sub-Saharan Africa, where the growing population is mostly dependent on rain-fed agriculture, the development and implementation of the African Drought Monitor (ADM) system has the potential to build capacity through technology and knowledge transfer.

2.2 Drought Types and Occurrences in sub-Saharan Africa

Conventionally, the four types of droughts recognized by scientific literature include;

i. **Meteorological:** This is a drought that occurs due to shortage of precipitation.
ii. **Hydrological:** Drought that describes deficiency in the volume of water supply such as streamflow, reservoir storage, and groundwater heights
iii. **Agricultural:** Drought that relates to shortage of available water for plant growth. That is, insufficient soil moisture to replace evapotranspiration losses.
iv. **Socioeconomic:** A socioeconomic drought will not occur without one or more of the other droughts. Furthermore, the index of socioeconomic drought is clearly monetary.

2.3 Causes and Impact of Drought in sub-Saharan Africa

The most important factor causing drought can be stated as global warming. Also, land use practices as well as resulting land–atmosphere interactions contribute to drought-inducing mechanisms. Drought has a vast effect on mass starvation, famine and cessation of economic activity especially in areas where rain-fed agriculture is the mainstay of the rural economy. Forced human migration and environmental refugees, deadly conflicts over the use of dwindling natural resources, food insecurity and starvation, destruction of critical habitats and loss of biological diversity, socio-economic instability, poverty and climatic variability

through reduced carbon sequestration potential are common knowledge of the causes of drought. Since the late 1960s, the Sahel, a semi-arid region in West Africa between the Sahara Desert and the Guinea coast rainforest, has experienced a drought of unprecedented severity in recorded history. The drought has had a devastating impact on this ecologically vulnerable region and was a major impetus for the establishment of the United Nations Convention on Combating Desertification and Drought [7]. Figure 2 showed the impact of drought across different sectors.

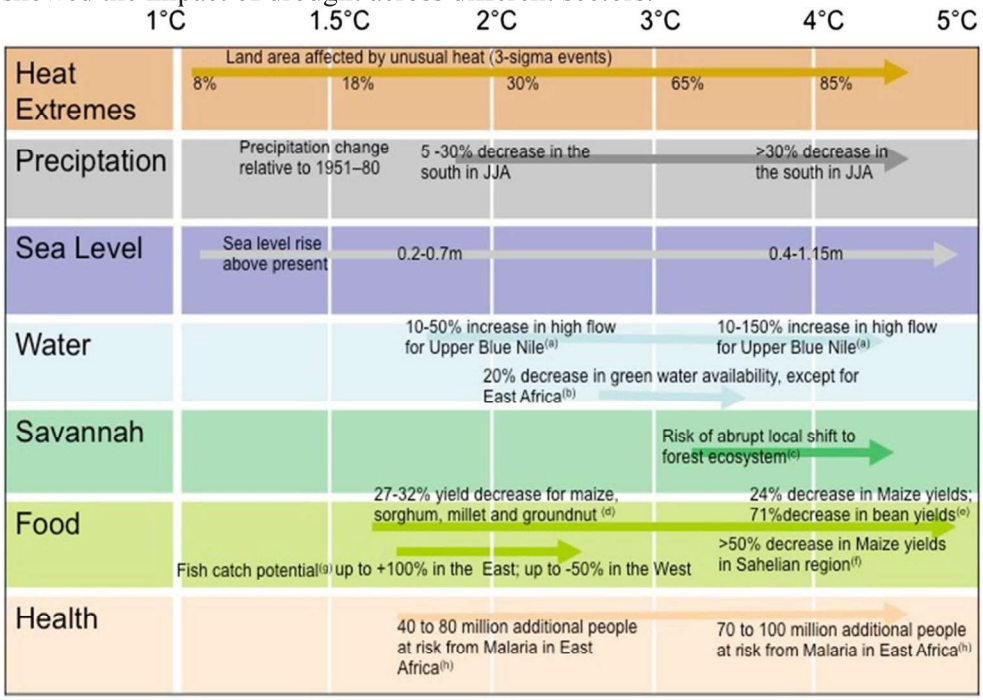

Figure 2.: Climatic changes and impacts across sectors at different levels of warming. Source: [8]

Table 2.: Reported drought fatalities from 1900 to 2015

Country	Year	Total deaths	Total affected
Niger	1910	85 000	32 000
Cape Verde	1946	30 000	n/a
Ethiopia	1965	2 000	1500 000
Somalia	1974	19 000	230 000
Chad	1981	3 000	1500 000
Mozambique	1981	100 000	4 750 000
Sudan	1983	150 000	8 400 000
Ethiopia	1983	300 000	7 750 000
Somalia	2010	20 000	4 000 000
Ethiopia	2015		10 200 000
Somalia	2015		4 700 000
Malawi	2015		2800 000
South Africa	2015		2700 000
Niger	2015		2588 128
Zimbabwe	2015		1490 024
Namibia	2015		11 500

[4] highlighted that the frequency, intensity and geospatial coverage of droughts have significantly increased across the entire African continent during the second half of the 1900–2013. Figure 3 illustrate this phenomenon.

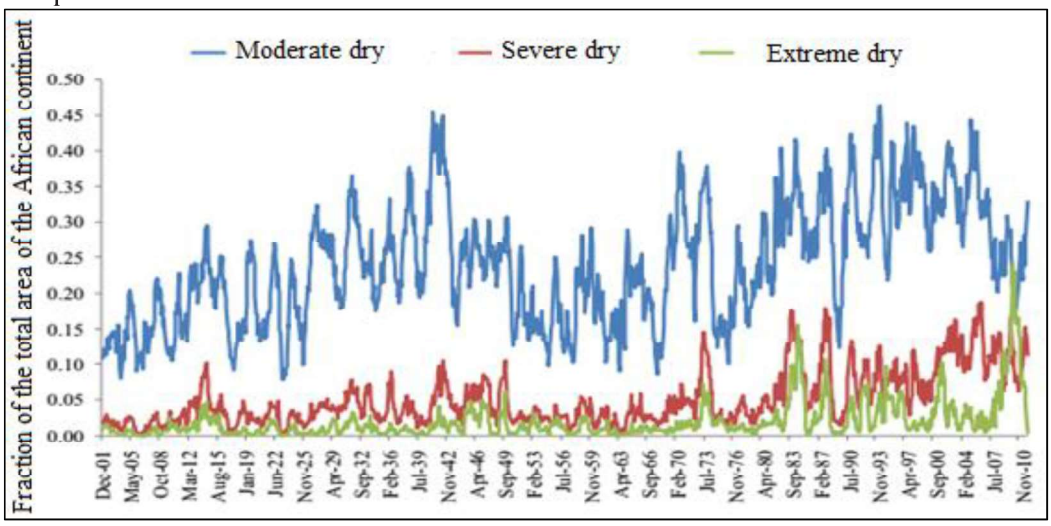

Figure 3.: Variation of drought in Africa
Source: [4]

3. Drought Mitigation

Mitigation simply refers to activities that eliminate or minimizes the chances of occurrence or effects of drought. This involves the application of any structure as well as physical measures (appropriate crops, dams, engineering projects) or non-structural measures (policies, awareness, knowledge development, public commitment and operating practices. Drought, unlike other natural disasters such as floods, does not occur abruptly, but it evolves over some time, thus such features make it possible to read timely viable mechanisms to mitigate and manage its impacts [9] [10]. The following measures can be adapted;

3.1 **Drought monitoring and early warning systems:** Drought monitoring systems must rely on multiple indicators to adequately identify areas of maximum severity and be able to evaluate how changes in the spatial dimension of drought alter current and future impacts and the activation and termination of mitigation actions and emergency programs. Also, new technologies based on geospatial information are available to determine the risk and vulnerability of a system to drought and to develop monitoring and early warning systems based on real-time information to support decision-making [11]. Some efforts to establish regional drought monitoring systems in Africa include the Regional Early Warning System of the Southern African Development Community (SADC), the Drought Monitoring Centre for the Great Horn of Africa (GHA) and the West African Permanent Interstate Committee on Drought Control in the Sahel (CILSS).

3.2 **Drought Mitigation Strategies in Sub-Sahara Africa:** A drought mitigation plan in Africa must contribute to enhancing drought risk management in Africa through the development of fundamental drought information tools [12]. The plan must make use of the available information sources on meteorological, climatic and remote sensing data to generate new information relevant to drought risk management. The available geospatial tools for drought mitigation in Africa must be framed in a series of scientific and technical topics that are state-of-the-art. They are based on geospatial information and modelling approaches that can be summarized in the following issues: Drought indicators

a. drought hazard assessment
b. drought vulnerability assessment
c. drought monitoring and early warning
d. drought forecasting

4. Perspectives on Emerging Issues of Drought Quantification

Drought predictions based on the global climate models' simulation show varying results and thus remain uncertain for most of the African continent. However, the results of simulation models suggested a high likelihood of increased droughts in central and southern Africa. Despite considerable improvements in these models, they are still not able to accurately represent a large number of complex factors responsible for causing the droughts across various regions of the continent (such as wind and pressure anomalies, and land–atmospheric feedback mechanisms). Their complex interactions induce uncertainty in drought predictions [4]

These systems focus on selected drought-prone areas, but they do not cover the entire African continent. More importantly, the systems are not operative in real time and in some cases are not updated regularly. The situation for drought impact assessment, monitoring and early warning in most drought-prone regions in Africa, remains far from satisfactory. Despite the international efforts for improving drought management in Africa, the implementation of drought management plans at the national level is in a very early stage. Only in some drought-prone regions such as the Sahel drought management protocols such as Projet de Gestion des Crises (PREGEC) have been developed [4]. The following emerging issues need to be taken into consideration to manage drought incidents.

1. Based on what has been done, implication of threshold has not been taken care of for operational drought analysis.
2. Most of the quantification studies do not give room for the most harmonious characteristics which would allow us to determine the on-set and recovery time of drought.
3. Most studies have not been able to come out with definite probability so as to determine threshold for operational drought analysis.

5. Conclusion

It is clear that there is not a single unifying technique to quantify drought severity. Even within an individual category, the supremacy of a specific index is not immediately clear Mitigation of drought hazard in Africa must be considered following a holistic perspective: from the collection of new information relevant for drought knowledge and management in Africa. Development, improvement and testing of new techniques for a better understanding and monitoring of droughts, to developing of real-time information and forecasting systems to assist the preparedness, management and mitigation of drought risk in the entire continent should be given quality attention.

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