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Improving Drought Management and Planning through Better Monitoring in Africa

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Introduction

Drought is part of the environment. It occurs in every part of the globe and adversely affects the lives of a large number of people, causing considerable damage to economies, the environment, and property. It also affects countries differently, having a greater impact on countries with poor economic conditions.

Recurrent drought in Africa in the last 30 years has had a disastrous effect on an economic and social situation that already had serious problems. Today, in the aftermath of these devastating droughts, planning and preparedness have become more important. Most disasters, including droughts, are no accident. They are made by misgovernment. However, competent governments, given foresight and funds, can build defenses against these natural disasters.

The enormous physical consequences of drought and the huge financial cost of relief efforts (compared to prevention) have led Africa to improve its drought management and preparedness scheme regularly.

Modern Techniques Used to Monitor Drought

In the current "information age," technological advances in communication, computers, and remote sensing have greatly improved our ability to measure the important characteristics and impacts of weather-related disasters. A well-integrated use of ground observations and earth-oriented satellite application improves drought monitoring.

Meteorological observations are the primary sources of information widely used for drought monitoring. Ground observations of rainfall so far have a tremendous potential to analyze past, present, and future weather conditions. One of the methods that is being developed involves numerical weather prediction models. These models strongly depend on meteorological elements observed from ground and space.

Meteorological observation of ocean surfaces is of tremendous importance in understanding and predicting ocean–atmosphere relations. Such observations are taken routinely in many parts of the world. This provides a good opportunity for drought prediction as well as ground verification of satellite measurements of the vast ocean surface.

The other method of accurate and timely weather data observation and collection from the ground is the Automated Weather Data Network (AWDN). The accuracy of measurements at ground level, especially in remote areas, is far from sufficient. For example, in Ethiopia, the National Meteorological Services Agency (NMSA) uses about 80 stations for the 10-day weather analysis and less than 50 stations for daily weather assessment and forecast. For real-time weather monitoring, NMSA uses less than 16 synoptic stations. Each station characterizes the weather for an area of more than 14,000 km^2, which is far from sufficient to monitor drought. This makes the integration of space-based meteorological observation essential.

Observations from meteorological satellites routinely provide more complete, more timely, and finer spatial coverage of terrestrial information. This information is normally produced by transformation of the observed radiance into environmental variables such as clouds, radiation, snow cover, sea ice, temperature, vegetation, and other meteorological and geophysical components. Recently developed techniques transform the satellite-observed radiance into more complex environmental phenomenon such as drought (Kogan, 1991).

Interest in satellite observation and subsequent evaluation of drought may be attributed to several characteristics of remote sensing. These include the fact that remote sensing provides a unique vantage point, a synoptic view, a permanent record or data archive, extra visual information, and cost effectiveness in many cases (Johnson et al., 1993).

Assessment of Drought Using Ground and Space Techniques

Drought indices

Various drought indices have been developed and used in many parts of the world (including Africa) to monitor the spatial extent and severity of drought conditions. Generally, drought indices are developed based on cumulative precipitation deficit. These provide guidance for the use of mitigation measures during a drought.

Some of the better-known drought indices are Percent of Normal, Deciles, Palmer Drought Severity Index (PDSI), Surface Water Supply Index (SWSI), Standardized Precipitation Index (SPI), Crop Moisture Index (CMI), National Rainfall Index (RI), and Dependable Rains (DR).

Among these, the SPI is a relatively new index. It is used to quantify the precipitation deficit for multiple time scales (averaging periods). These time scales reflect the impact of drought on the availability of different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale, while ground water, streamflow, and reservoir storage reflect longer-term precipitation anomalies (NDMC, 1998a). The SPI is being monitored at the climate division level for the contiguous United States by the National Drought Mitigation Center and the Western Regional Climate Center (WRCC).

Preliminary results of a case study of Ethiopian rainfall stations show that the potential exists for the SPI to provide near-real time drought monitoring in Africa based on quantifying the precipitation deficit for multiple time scales for a specific station or climatic divisions.

Satellite techniques

The effects of drought are evident on vegetation. Reduced biomass production, increased fire danger, and other long-term changes can often be linked to drought events (Peters et al., 1993). Satellite observations of vegetation can thus be used to monitor drought. One of the most popular methods is the Normalized Difference Vegetation Index (NDVI). This is an index derived from measurements of spectral reflectance acquired by the Advanced Very High Resolution Radiometer (AVHRR) on board NOAA's series of polar orbiting satellites. The NDVI was designed to measure density and vigor of green vegetation and to discriminate vegetated from nonvegetated surfaces (Kogan 1991). These data are being used in environmental monitoring and global climate change studies. This AVHRR-based monitoring tool for global drought watch is being used in many parts of the world, including North and South America, Europe, Africa, Australia, and Asia.

Despite the potential application of the NDVI, numerous shortcomings have also been revealed. For heterogeneous land cover, the NDVI is normally higher in areas with more favorable climate and soil and more productive ecosystems (forest) than in areas with less favorable environmental conditions (dry steppe). To reflect the ecosystem's features and to separate the weather signal from the ecological signal, the NDVI was modified into the Vegetation Condition Index (VCI) (Unganai, 1998). First, the maximum and minimum NDVI values, which correspond to favorable and unfavorable weather impacts on vegetation, are identified for each week of the growing season by calculating multiyear maximum and minimum composites. Then the amplitude for the identified extremes is calculated. The amplitude is also determined for each week of the growing season by calculating multiyear maximum and minimum composites. NDVI values are then normalized relative to this amplitude.

In cases of extended periods of cloud coverage, the NDVI values tend to be depressed, giving a false impression of water stress or drought conditions. To remove the effects of such cloud contamination in the satellite assessment of vegetation condition, the Temperature Condition Index (TCI) is used. The TCI is derived from Brightness Temperature (BT), and its algorithm is similar to the NDVI vegetation's response to temperature (high temperature is less favorable for vegetation). The combination of VCI/TCI is also used to estimate vegetation stress (Kogan, 1995).

Drought Prediction

Unlike most other natural disasters, droughts develop slowly and their existence is often unrecognized until human activity begins to be affected. It is not easy to forecast when a dry spell becomes a drought. In most cases, no single model or technique will serve in predicting drought. Therefore, several courses of action and integration of different techniques are usually required.

There are a number of concepts and techniques to predict drought. The following are some of the most important current concepts and technologies used in many parts of the world, including Africa.

Ocean–atmosphere interaction

The change in weather patterns during an El Niño/Southern Oscillation (ENSO) event alters regions of high and low pressures around the globe. Descending air of atmospheric circulation cells creates high pressure centers at the surface. The high surface pressures prevent areas of precipitation from moving into a region where these pressures exist. When these abnormal high pressure patterns persist, they lead to drought conditions, depriving the area and its ecosystem of rainfall. Droughts generally occur in the western Pacific, an area normally rich in rainfall, during ENSO events. Studies have indicated that there is a high correlation between ENSO and drought or rainfall deficiency in Africa. Thus, measurements and predictions of the sea surface temperature of the Pacific Ocean using improved numeric computer models can lead to better monitoring of drought.

The identification of ENSO as a drought precursor has raised the possibility of drought predictability. Teleconnections between North American precipitation patterns and ENSO events, and North Pacific sea-surface temperature anomalies, have been used as a precursor in many parts of the world. For example, in east Africa, studies have indicated that the correlation of ENSO with seasonal rainfall deficiency leading to drought is strong (Ogallo, 1994).

The ability that does exist is primarily the result of empirical and statistical relationships. In the tropics, empirical relationships have been demonstrated to exist between precipitation and ENSO events, but few such relationships have been confirmed above 30°N (NDMC, 1998b).

Therefore, the forecasting of seasonal precipitation anomalies, based on these precursors and models, appears to be an important step toward better drought monitoring in Africa. However, a considerable amount of research is still being conducted to develop models of the identified precursors and to find other precursors.

Synoptic weather systems

The immediate cause of drought is the predominant sinking motion of air (subsidence) over land surfaces that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months or seasons (or longer). On the other hand, the semipermanent high pressure cells over the oceans supply moisture. For example, the weakening of the Atlantic and South Indian ocean semipermanent highs in the monsoon seasons results in a reduction of moisture to the equatorial regions of Africa. This has been observed during drought years. The complex nature of atmospheric phenomenon from the ground to the upper atmosphere must be better understood. However, the prediction models are becoming more sophisticated and more effective in many respects.

Drought Impacts and Human Suffering in Africa

The overall impact of a drought on a given country, and its ability to recover from the resulting human and material damage, depends on several factors. For one set of people it will mean disaster and famine; for another it will only be a matter of inconvenience. One of the most widely accepted reasons for the aggravation of drought impacts in Africa is the continuous increase in its population growth rate. The demands of a rapidly expanding population are placing increasing burdens on the continent and its resources. This means that the potential for adverse effects of disasters on human life is also growing, since population pressures will lead more people to live and work where risks are highest. This implies that population growth is a serious intensifier and multiplier of other social and economic problems, especially as it retards the prospects for developing a better life in the poorer countries. This makes drought impacts more severe in developing countries.

In many African countries that have a subsistence lifestyle, the impact of drought usually extends to famine. Once a famine has reached the proportions of a major disaster, it is too late to mount a fast and efficient relief operation. Supplies rushed to a country are often held up at the country's ports, unable to be distributed by the existing infrastructure. Moreover, in a number of countries, governmental organizations that issue relief aid are not set up to respond quickly or effectively, and volunteer agencies are neither designed nor equipped to cope with starving masses. The drought in the 1980s and even in recent years caused millions of people to starve to death. The African continent in the mid-1980s suffered from famines on a scale never before experienced. As of April 1985, some 10 million people had abandoned their homes in search of food and water, 20 countries had been critically affected by drought, and 35 million lives were in danger (UIA, 1998). In east Africa and the Sahel, widespread starvation resulted from long-term drought in 1984.

Therefore, drought represents one of the most important natural triggers for malnutrition and famine, a significant and widespread problem in many parts of Africa and in other developing countries as well. However, deaths resulting from famine are sometimes mistakenly attributed to drought rather than to underlying causes of misgovernment. The occurrence of famine as a result of drought is believed to happen mostly because of inadequate planning, inadequate notification, slow response, government pride, misdirected aid, uncoordinated relief agency field work, politics, sluggish bureaucracy, ignorance, and incompetence. It is a grave problem that shakes the entire political, economic, and social foundations on which the stable and prosperous future for developing countries was to have been built (UIA, 1998). This shows that there should be appropriate planning and preparedness for drought, which can be a natural trigger for famine in Africa if the right circumstances exist.

Drought Management

Drought management is too often restricted to treating the symptoms, often when it is too late and only a relief function can be performed. A critical factor in the effectiveness of disaster management is the preparation of policy, management strategies, intervention criteria, and emergency action plans. A great deal of valuable time can be lost and confusion caused if planning for intervention only happens after the disaster has struck.

Major steps that should be taken include developing a national policy for drought preparedness, response, and mitigation measures; developing a drought contingency plan that includes early detection, monitoring, decision-making criteria, short- and long-range planning, and mitigation; and including programs that address public awareness of and education on drought and water conservation (Wilhite 1993).

Moving to a deliberate and purposeful policy of drought management and planning is urgently required of all African countries and other governments in the world. Although this may not be politically and economically palatable in the short term, efforts should be made to do so.

The Need for Data and Information Exchange and Coordination in Africa

In many African countries, data collection and analyses are carried out by a number of government departments and agencies, with little or no coordination. This strongly suggests the need for a suitable mechanism or independent agency that coordinates and facilitates the provision of information to all kinds of users. This can be done within the country and at the regional level. Subregional organizations such as the Arab Magreb Union (AMU), Permanent Inter-State Committee for Drought Control (CILSS), Economic Community of Central African States (ECCAS), Economic Community of West African States (ECOWAS), Inter-governmental Authority on Development (IGAD), and Southern African Development Community (SADC) could play an important role. Contributions of other international and governmental organizations like the UN Food and Agricultural Organization (FAO) and the U.S. Famine Early Warning System (FEWS) would also be improved by a smooth and well-coordinated information exchange.

The efforts that are being made to ensure timely warnings and provide guidance to decision makers and farmers through the Drought Monitoring Centres (DMC) in Nairobi (Kenya) and Harare (Zimbabwe) and the African Centre of Meteorological Applications for Development (ACMAD) in Niamey (Niger), which monitor the drought situation in Africa, would be much improved by a well-coordinated information and data exchange. It might also reduce the redundancy of work being done by different agencies for a specific area or country.

Conclusions

Technological advances in space studies allow improved drought monitoring using satellites with high resolution in a cost-effective manner. Ground techniques that are being developed to monitor drought should be integrated with space technology for better results. This technical know-how and its implementation should also consider the people and culture of the various countries.

Although African governments have taken some steps toward drought management and planning, the shift from relief to preparedness and mitigation will require an ongoing effort. Developing scientific understanding and techniques in each country and planning to shift from crisis management to risk management is a necessary condition for sustainable development. Hence, if better monitoring must be undertaken, the development of a management plan is essential. This will require considerable political courage and foresight.

The international community provided and still provides assistance in mitigating drought. The African people themselves should do the maximum possible to combat drought and become, at the least, self-sufficient. The coordination of drought monitoring data and information among government and international organizations is essential for better drought management in Africa. This strongly suggests the need for a suitable mechanism or independent agency that coordinates and facilitates the availability of information to all kinds of users. It may also help reduce duplication of efforts among the various groups involved in drought management.

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