Water, drought and desertification in Africa

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Abstract One of the most pernicious plagues that the human kind has always suffered is drought; that is, prolonged freshwater deficit. A combination of drought, or a sequence of droughts, and human activities may lead to desertification of vulnerable areas whereby soil and bio-productive resources are degraded. Droughts and desertification have always been present in Africa. Recently, a long lasting sub-Saharan drought, combined with demographic pressure, has dramatically accelerated the desertification process. The specific aim of this contribution is to review the tasks for the hydrological community, both scientific and operational, and the management of water resources to mitigate the impacts of drought and desertification, in the context of the United Nations Convention to Combat Desertification (UN/CCD) and Agenda 21. Strengthening the knowledge-base of water resources is essential for an assessment of characteristics of water resources and their availability. For this purpose, revitalization of declining networks of hydrological observing stations in Africa is necessary. The necessary knowledge base should extend beyond the classical water sciences, embracing also economic, political and social systems that are intimately interlined.

INTRODUCTION

A drought, an eternal plague endured repeatedly by mankind, can be defined as the naturally occurring phenomenon of prolonged and severe water deficit: that is, a period during which the natural water availability is significantly below the normally recorded level. This notion should not be confused with aridity where water is always in short supply: that is, a "permanent drought" is a normal feature. Droughts may hit large areas (up to subcontinental scale) and, by their nature, extend in time, lasting months through years to decades. A drought manifests itself by low values of such hydrological variables as precipitation, river flow, river and lake level, soil moisture and groundwater level.

Droughts have been considered and treated from different angles. Time intervals of no rain or persistently low precipitation are typically referred to as the meteorological drought. A hydrological drought implies low flows and levels of surface waters (rivers, lakes) and of groundwater. An agricultural drought refers to low soil moisture and its effect on cultivated vegetation. The term "environmental drought" is used to emphasize adverse consequences of water deficits on ecosystems. To an economist a drought would mean losses in the product value, while to a social scientist: impacts on society.

A combination of adverse climatic conditions and human activities may lead to desertification of vulnerable arid, semiarid and dry sub-humid areas. In this process the soil structure and soil fertility are degraded and bio-productive resources decrease or disappear. Desertification affects about one sixth of the world’s population and one
quarter of the total land area of the world (UNCED, 1992). The extent of the problem of drought and desertification in general, and in Africa in particular, has raised global concern. It has forced the international community to adapt the United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UN/CCD, 1995) which has been signed by more than a hundred countries. The Convention refers to "arid", "semi-arid" and "dry sub-humid" areas where "the ratio of annual precipitation to potential evapotranspiration falls within the range from 0.05 to 0.65".

Drought may trigger desertification but human factors play a significant role (Glantz, 1994). Over cultivation, over grazing, deforestation and poorly drained irrigation can destroy the soil at a very fast pace. It takes a long time for the soil to form but little time to be destroyed; the present annual rate of global soil loss reaches 24 billion tonnes.

African people have interacted with these features with varying degree of success since history began. It was often a failure, as the disappearance of various civilizations is attributed to the phenomenon of desertification. Is the long lasting drought combined with demographic pressure in sub-Sahara leading to a similar end?

**STATE OF WATER AVAILABILITY**

What are the characteristics of water resources and hydrological variables in the arid and semiarid lands (ASAL) of Africa? Rainfall is low, in general, and highly variable in time and space. Temporal distribution of precipitation is characterized by long dry periods and short rainy seasons during which rainfall events are short but intensive, causing direct runoff, erosion and destructive flood flows. High air temperatures and intense solar radiation create a very high potential evaporative demand, that is, evaporation losses from a free water surface are very high.

River flows are determined by rain and, in the case of long rivers, by water "imports" from remote wetter areas. There is a large variability of flow. In a number of rivers a decreasing flow tendency has been observed in the last decades. For example, since 1970 the mean discharge of the River Niger at Koulikoro has nearly halved from its levels in the 1960s. The river nearly dried up at Niamey in 1984 and 1985. The Senegal at Bakel nearly stopped flowing in 1974 and 1982, and again in 1984 and 1985 (Fig. 1). The Nile and the Niger recovered somewhat in 1990, but have never reached their former flows. The mean annual discharge of the Nile has fallen from 84 km$^3$ (1900-1954) to 72 km$^3$ in the decade 1977-1987, whereas the mean flow between 1984 and 1987 was as low as 52 km$^3$ with the absolute minimum of 42 km$^3$ observed in 1984 (Howell & Allan, 1994). The Blue Nile, supplied by the scanty rainfall over the Ethiopia catchment has also shown a marked decrease in the last years. Like Lake Chad, many other lakes have also contracted.

Water resources management in Africa has been traditionally based on the assumption of stationarity, that is, one of unchanged climate. However, the drought anomalies observed in the last decades, as exemplified above, make many a specialist question the stationarity assumption. This may add another dimension to the problems of drought and desertification.
Groundwater is replenished by infiltration of rainfall through the soil to the underlying aquifers. Infiltration being scanty and soil water shallow and only temporary, replenishing of aquifers occurs only in favourable places. Often the response of aquifers lags by several years. Water in deep aquifers may date back to 10,000 years or more BC when the climate was wetter. They are virtually fossil water reserves and tapping (mining) these aquifers cannot be sustainable. Most of the shallow aquifers are near river valleys and their yields react fairly rapidly to the variations in river flows. In coastal areas, groundwater level has been falling as withdrawals have increased and infiltration has decreased, and this has allowed salt water intrusion.

![Graph showing the Senegal river flow at Bakel](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAABeAAAABCAQAAABJUHJQAAAABlBMVEXRwAAAAQ4A0AAABq5AAAAwCA20c5AAAABR0UWVeXG0AAAB1JREFUeNrs3bQlFjwAAAAASUVORK5CYII=)

**Fig. 1** Time series of monthly mean flow (in m$^3$s$^{-1}$) – the Senegal at Bakel (data from Cherel-Geffard & Albergel, 1996).

There is a strong concern about the water quality of waters in ASAL. Even when perennial surface water is available, its consumption in an untreated state presents a serious risk to human health because it is frequently contaminated by pathogens or waste. The subject of groundwater quality is not addressed adequately, largely because of the insufficiency of facilities to collect and analyse samples.

The most common sources of water (water points) are rivers and springs. "Streamflow drought" which can be defined as low flow below a specified level of concern, or an arbitrary threshold level, is a major practical indicator of droughts, yet there is a dearth of literature on streamflow or spring flow droughts in Africa. Although closely related to low rainfall, the timing and other measures of the severity of these events do not necessarily coincide with rainfall droughts because of the complexity of the processes which transform precipitation into streamflow and also because of man made measures such as flow control, diversion and storage. Knowledge concerning the duration and severity of streamflow drought is therefore essential in planning for activities which rely directly on streamflow, or for transferring water in known quantities to a drought area, especially where the process of desertification can be stopped. These real life issues involving communities and financial implications make the analysis of streamflow drought all the more distinctive when compared with rainfall droughts. A selected number of threshold levels applied to flow records can be used to...
study characteristics of streamflow droughts, such as their severity (maximum depth and cumulated deficit below a threshold), duration and frequency, and starting date. Woo & Tarhule (1994) have used this technique in their studies of low flows at some rivers in northern Nigeria (Fig. 2). Long droughts, which are related to different physical processes and which last throughout the dry season or longer, are recurrent phenomena and the inhabitants of the desert fringe have made long term adaptations to such events.

A recent study (Kulshreshtha, 1993) has shown that food insecurity is a major water-resource related issue in the ASAL of Africa, noting that about a third of the population lives in that region. The study shows that over a dozen countries in Africa are already under water stress, or water scarcity, if they were to attain the goal of food self-sufficiency alone. There is an obvious relation between precipitation and agricultural yield and livestock, as demonstrated in Fig. 3 for the case of the Sahel.

**WATER DATA BASE**

Strengthening the knowledge base of water resources in areas subject to desertification is essential for integrated management of land and water resources that could mitigate the adverse processes. However, recent studies in Africa have demonstrated that networks of hydrological observing stations are in decline and the data base to assess the drought and desertification risks and to plan for their abatement is not adequate. Even stations with long historical series of records are being neglected.
The strengthening of knowledge should extend beyond the classical water sciences, embracing also economic and social sciences. Such socioeconomic targets as eradication of poverty and alternative livelihood systems, which may contribute largely to combating desertification, require a substantial knowledge base. In addition, there is the need to develop contingency plans for drought preparedness and relief schemes.

Without at least the basic scientific studies and technical evaluations of various issues pertaining to population supporting areas which suffer from desertification and drought, it will be difficult to implement any mitigating measures. A few of the burning needs are:

(a) to identify "water points" used by communities in the areas of concern;
(b) to delineate populated areas subject to damage by desertification and severe drought;
(c) to carry out of statistical studies of drought duration, intensity and frequency, starting dates of drought and cumulated water deficit, and prepare maps;
(d) to undertake detailed water vulnerability studies of each water point/community taking into account population growth, economic development level, climate change, climate variability, current and projected water use for various human activities; and
(e) to draw up a plan of action for the water sector as a basis for combating desertification and to mitigate the effects of severe droughts.

One cooperative initiative to improve the water data base is the World Hydrological Cycle Observing System (WHYCOS) launched jointly by the World Meteorological Organization and the World Bank. WHYCOS would consist initially of about 1000 reference stations (hydrological observatories) worldwide sited on major rivers. Each station would monitor about 15 variables such as flow, water chemistry and on-bank meteorological variables, and then transmit the data through satellites to national, regional and global centres. Actual rehabilitation and expansion of operational monitoring and assessment programmes are being developed as regional components of WHYCOS, mainly in Africa (the Mediterranean, southern Africa, western and central Africa and eastern Africa).
TECHNICAL MEASURES AND ACTION STRATEGIES

In a systematic resolution of the problem, one needs to address the target for action, the controls (or factors influencing the process), the objective function to be optimized, and a set of constraints to be met.

The target of the action can be broadly seen as sustainable development, understood as meeting the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). This aim should be achieved while minimizing the losses (or maximizing the gains) to economic, social and environmental systems.

The controls which can be considered are anthropogenic factors influencing drought and desertification, though not always completely controllable: manipulation with soil and vegetation, agriculture, afforestation or reforestation, soil conservation policy, and control of grazing. There are also other human factors reducing anthropogenic pressure on the environment such as population dynamics (birth control), legislation, organization and education.

The primary element of desertification is non-availability or near-absence of water resources. There is no doubt, therefore, that all action plans to combat drought and desertification must be geared around the possibilities of extending the availability of water. All means which could serve this aim have to be considered. Some of the technical measures of water conservation and augmentation are: improved land use practices; conjunctive use of surface and groundwater; watershed management; rainwater/runoff harvesting; recycling water; water transfer studies; erosion control and sand dune fixation; development of water allocation strategies among competing demands. Not least, improvement of water conservation via reduction of the non-accounted-for water (which soars to more than 60% in some places in Africa) deserves attention. Using groundwater reservoirs (aquifers) to store water when available would be more advantageous than surface water storage which is subject to very high evapotranspiration loss.

Dynamic increase in population at the rate of 3.5% in sub-Saharan Africa, as compared to the global rate of 1.7%, leads to increased pressure on land. There is an urgent need to feed the ever-increasing number of humans, and irrigation, although inefficient, seems indispensable. Unless properly managed, irrigation may lead to soil salinization thus further reducing the bioproductivity potential. All means should be used to improve its efficiency.

In short, strategies related to development: irrigation, improved land use, urban and rural water supply, range and livestock management, agricultural extension, salinization prevention, energy (fuel wood and hydropower), and community development are inherently and intrinsically related to water. Resolve the water problem, and many of the other issues can be more easily determined and action plans successfully implemented.

RESPONSES TO COMBAT DROUGHT AND DESERTIFICATION

One of the earliest responses to combat drought and desertification in a systematic manner was that in the Nile Valley. With the help of the precious water of the river, people created the world’s longest oasis. A similar pragmatic approach is strongly
advocated. This obviously implies that the starting point of all plans and action programmes has to be those locations where reduction of the supply of water has large implications on human activities, in particular on the search for food and fodder.

There are commonly known responses for combating desertification and promoting development (cf. UNCED, 1992) which are much talked about but seldom implemented, such as:

(a) improving national capabilities, including training and human resources development, for assessing water resources and determining water use on a continuing basis and for the planning and management of these resources;

(b) conserving water resources and optimizing their use through the employment of measures mentioned earlier;

(c) augmenting the supply of water locally by exploiting surface water and groundwater which might be available in the area, taking into account long terms trends, the future demands of the local communities and other needs;

(d) augmenting the supply of water by transfers from more permanent surface water sources (lakes and rivers) and from groundwater resources within ASAL and/or long distance transfers from humid areas, if practically and economically possible.

These responses require a major input of financial and human resources to undertake feasibility studies. If such an input is not available, there is little hope of halting the process of desertification nor of mitigating the ravages caused by long droughts. It is worth applauding the desire of several developing countries who wish to break the dependency syndrome, i.e. not to count entirely on the uncertain external aid (WMO, 1995). In any case, countries themselves deploy about 90% of the resources for developing and maintaining water supply systems.

THE CONVENTION

The objective of the United Nations Convention to Combat Desertification is "to combat desertification and mitigate the effects of drought" (Article 2) particularly in Africa. To achieve this, long term integrated strategies are necessary "that focus simultaneously, in affected areas, on improved productivity of land and the rehabilitation, conservation and sustainable management of land and water resources" (UN/CCD, 1995). The Convention commits parties in developing countries affected by drought and desertification, as well as in developed countries, through a legally binding document, to join forces in combating the plague at the global level.

Drought and desertification normally evoke a picture of dryness and a scarcity, or lack of water resources in a given area. However, the Convention addresses this issue mainly as a problem of biodiversity. Water is assumed to be not a productive resource in the same way as soil and plants, although lack of water is the primary causative factor for the deterioration of soil and the biota it supports.

The Convention recognizes that deserts expand and retreat according to the amount of rainfall and that land is degrading at an alarming pace, creating desert-like conditions. Drought is part of the cause of desertification; but essentially it is a manmade problem resulting from placing too much pressure on the land.

A large majority of measures proposed in the Convention to combat drought and
desertification are related to the water supply and management of water resources. However, in the national action programmes (Article 8), the Convention lists water resources as one of the natural resources to be conserved and managed on a par with agricultural land and pastoral land, vegetation cover and wildlife, forests, and biological diversity. In fact, all the latter resources are a function of availability of water. In order to evaluate the role of water resources management in implementing the Convention, a number of case studies were recently published jointly by WMO and UN/CCD (WMO, 1996).

FINAL REMARKS

In the developed world, droughts hit but do not kill. There are success stories about implementation of measures limiting water use in the time of drought: sharp water price rises, bans on watering lawns or car washes. In a case study for a river basin in the USA, Glantz (1982) mentioned a whole spectrum of specific measures taken or prepared in response to a drought forecast. Is it possible that these measures can be used in the case of Africa? Unfortunately not at the present time, due to lack of adequate structures, institutions, legislation, market, awareness and education. That is why, in his earlier work, Glantz (1977) gave a gloomy yet a sober, realistic statement on the situation in the West African Sahel: "Even if a six-month forecast of weather were available few of the areas could have responded in any different way to that which actually happened".

Other than in the Nile basin, a large amount of external assistance has been directed to the local community, being usually of a humanitarian type. Long term solutions, like those in Arizona and California, USA have been thought about, but have not been put on the drawing board, mainly because these are costly ones and economic returns are still considered meagre. Mere humanitarian considerations do not attract investment. Moreover, the extremely feeble state of the economies of the countries in ASAL does not permit planners to accord priority to problems of water supply and development in rural areas.

This does not mean that nothing could be done to help the communities in the ASAL. The time has come to take local initiatives. They might be slow and small but they can be expected to last. The strategy to develop these solutions should be based on the policies promulgated by the African Conference on Water Resources: Policy and Assessment (WMO, 1995) and on results of available studies, national and regional. With respect to water resources, particular emphasis has been placed on the considerable available capabilities of national and basin-wide authorities to undertake the assessment of their water resources and on the quantity and quality of the data and information on water resources they have compiled (World Bank, 1989-1992). One should not wait to look for complete solutions to resolve water deficiency.

The approach should be based (cf. UNCED, 1992) on the principles of: decentralization and devolution of responsibility in water and environmental matters to the parties involved at the lowest appropriate level in society; local and private sector participation; a demand-driven cost recovery approach and equitable charging to enhance sustainability; and enforceable legislation at all levels.
REFERENCES


