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Impacts of floods and drought on the development of water resources of Kenya: case studies of Nyando and Tana catchments

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Abstract With the rapidly growing population in Kenya at an estimated rate of 3.63% per annum and the resultant high rate of urbanization coupled with the fact that 75% of the country is either arid or semiarid, the proper management and therefore planning for water resources development is vital in order to maintain the use of water on a sustainable basis. The proper management and planning for the use of water resources calls for the evaluation of the water resources available within the country and the degree to which they can be exploited. This paper examines the magnitude of the problems of drought (water deficit) and floods (water surplus) within two catchment areas in Kenya: the Nyando and Tana. It is shown that, apart from meteorological and/or climatological factors, man has greatly influenced the severity of the two events within the study catchments. The anthropogenic influences such as large-scale deforestation programmes, damming of the rivers, urbanization and other development programmes, have to a large extent affected the return periods of these two events within the catchments. Various programmes that could be adopted in reducing the magnitude and/or severity of the two events have been suggested. Drought has been identified particularly with eastern Kenya which is comprised mainly of semiarid low-lying land, and the pastoral areas of northern and southern Kenya. Recently attention has been paid to climatic variability in the dry areas near Lake Victoria, settlement schemes in the Rift Valley and the coast province where too much rainfall and poor soils compound the problems. Flooding is particularly characteristic of western Kenya in the Lake Victoria drainage basin, the Lower Tana and Athi River reaches and more recently the city of Nairobi is showing increased vulnerability to floods.

SOCIAL ECONOMIC BACKGROUND

Kenya has an area of about 580 000 km^2 located on the equator lying in between the Indian Ocean and Lake Victoria. The country has between 10 and 12% high potential agricultural areas mainly in the Central and Western highlands of where the crops grown include maize as the staple crop and coffee and tea as the main cash crops. Most of the remaining parts in the northern district, southern Rift Valley and the eastern highlands which is either arid or semiarid is used by nomadic or semi-nomadic pastoralists and about 5.5% of the land area is devoted to National parks.

The country's population is concentrated around the high potential agriculture areas, but the population of the country is growing so rapidly such that its expected to reach 37 million in the year 2008 as opposed to the present 24 million, and thus people have been forced to move into the marginal areas.

RAINFALL PATTERNS IN KENYA

The average rainfall in Kenya varies from less than 100 mm to over 2000 mm on Mt Kenya. Most of the country experiences two rainy seasons, the long rains between March and May and the short rains between October and December.

The weather in most of East Africa is related to the large-scale atmospheric circulation. Some of the synoptic features that influence the weather in this region include the inter-tropical convergence zone (ITCZ), easterly waves, tropical storms, low-level troughs, jet streams and extra-tropical weather systems (Downing *et al.*, 1989).

In sub-saharan Africa the drought years are accompanied by increased subsidence and decreased low-level convergence, decreased moisture flux and reduced upper-level easterlies flow into the region. In East Africa, anomalies in the wind field were related to the abnormally wet conditions of 1961 and abnormally dry 1984. Kenya seems to depend greatly on moisture advection encouraged by the circulation systems in the Indian ocean and central Africa as well as convective processes brought about by the ITCZ and unstable conditions from the west. The two rainfall seasons in Kenya are controlled mainly by the southward and northward movement of the sun. The sun is over the equator approximately in March. Due to high temperatures the equatorial region forms a low pressure belt, coinciding approximately with the intertropical convergence zone which is formed a month later; hence the high rainfall over most of Kenya in April. The spatial variation in rainfall is mostly a product of topography, distance from the Indian ocean and Lake Victoria at the heart of East Africa.

The formation of the tropical convergence zone results in the convergence of southeasterly and northwesterly winds alternatively tumultuous and poorly organized. The result is vertical movement of air leading to condensation and precipitation.

The seasonal rainfall patterns dependent on the ITCZ are usually modified by anomalies in the semi-permanent anticyclones. Development of tropical storms may introduce such anomalies. Tropical cyclones typically occur from November to April in the southern Indian Ocean.

AN OVERVIEW OF THE FLOOD AND DROUGHT SITUATION

Major floods in certain low-lying parts of the Lake Victoria catchment and Tana basin in particular occurred in March 1925, 1937, 1947, 1951, 1957, 1958, 1961, 1962 and 1978. In the Lake Victoria basin there has a major flood annually or twice annually since 1982, suggesting that the flood situation is worsening.

Among the floods mentioned above, the exceptionally heavy rainfall of 1961 resulted in unusually severe floods in many areas of Kenya. The floods covered large areas of the Kano Plains, Yala swamps and other low-lying areas of the lake basin. Lake Victoria rose by 1.25 m in 1962 over that of the previous year. The lake water level actually started rising in November 1961 and reached its peak in 1964.

The worst drought occurred in the period 1933-1934 in central Kenya while the second worst was in 1942-1944. In the last two decades severe droughts occurred in 1971-1975 and 1981-1985. Both climatological records and oral knowledge show that major droughts with serious results to man, livestock and game occurred in 1928, 1933, 1934, 1942, 1944, 1952, 1955-1960.

THE NYANDO CATCHMENT

The Nyando River runs a total length of 170 km and drains a total catchment area of 3618 km^2. The flood zone lies in the lowlands of the Lake Victoria drainage basin, and forms part of the lake shore lowlands and lies within the Nyanza rift valley in what is known as the Kano Plains. Most of these flood plains lie between 1120 and 1150 m. In terms of climate the Nyando catchment can be divided into two major regions by temperature and rainfall characteristics. The highland source regions receives an annual average of about 1835 mm; the mean annual maximum temperature is 27°C, the mean annual temperature about 9°C. The lowland region forming the flood plain receives a mean annual rainfall of about 1000 mm with great variability, the mean annual maximum temperature being about 30°C and a mean annual minimum of about 18°C.

Ojany & Ogendo (1986) state that rains in western Kenya are partly due to the unstable Congo airstream and partly from convection thunderstorms associated with breezes introduced by the pressure of Lake Victoria and augmented by the Congo airstream.

The differences in climatic conditions between the lowland surrounding Lake Victoria and highlands beyond are mainly a consequence of the topographic differences. The lowlands lie in the rain shadow of the highlands on the eastern shoulder of the rift valley. By the time the winds descend the rift valley scarp they are relatively dry. Most of the flood waters of the Nyando River originate in the highlands. The soils are generally medium to heavy clays which have a low infiltration capacity. The main activity here is arable agriculture with irrigation schemes for rice, maize, and sorghum as the main crops.

THE FLOOD OCCURRENCE

In March 1925 very heavy rains occurred and many homes were abandoned. The situation did not last long and after a few years life returned to normal along the shores of lake Victoria. The real trouble started with the rains of 1961. Since then the lake level has remained relatively high at approximately 1136 m which combined with the peak flood of 1963, 1968, 1977, 1979 and 1985 have had the cumulative effects of turning lands at the deltas of the river into permanent swamps. The amount of flood water in the river is related to the amount of rainfall received by the catchment area. The flood is, however, not so much due to the amount of discharge carried by the river but more to do with capacities of different sections of the river. Overtopping of the banks occurs at fairly low discharges at sections which have low capacity . In the case of Nyando, the channel capacity is frequently exceeded in the lower 30 km, but most seriously in the last 8-12 km from the lake.

ADJUSTMENT TO FLOODING IN THE NYANDO CATCHMENT

It is estimated that between 1963 and 1964, 8000 ha were flooded in the Kano Plains. Most of the plain suffers from impeded drainage. The mean lost production per year for the crops has been estimated at US $1.3 million because of flooding and impounded drainage (Lake Basin Development Authority, 1986). The total area of the Kano plains is about 70 000 ha out of which 28 500 ha are cropped. The total value of production is estimated at US $3.5 million. Flood control may release the remaining over 40 000 ha for annual cultivation and increase the agricultural income nearly three times. The floods normally occur annually. The cost of moving people from one area to another and of other relief efforts is quite high. During such events public institutions have to be closed down.

It can be stated therefore that flood control would result in direct economic savings and would greatly enhance the general welfare of the population living in the Nyando River basin region.

Studies by Denga(1990) showed that most of the response by the affected public is in terms of reinforcing the buildings to withstand the flood waters. This include raising the floor and building barrages outside the houses, and digging diversion canals round the houses. It is, however, accepted that moving away from the flood plain during such events is a must and the houses are mainly reinforced so that on their return of the occupants, they will still be there. Denga (1990) found that the people continued to occupy the flood plain as all or most of their economic activities were centred there – including fishing, irrigated rice cultivation and other cultivation. Other factors which affect individual adjustment include income levels, hazard exposure and levels of education.

The institutional response from the central Kenya government has been coordinated mainly by the Lake Basin Development Authority set up in 1978. Studies by Alexander Gibbs and Partners 1954-1956 and 1961-1962 led to the establishment of two rice irrigation schemes: Ahero and West Kano pilot schemes.

The National Irrigation Board, after experiencing some flooding of the Ahero Scheme, constructed some flood protection bounds on the Nyando side. The West Kano pilot scheme was built in the form of a polder right from the start for flood protection purposes.

The Ministry of Agriculture has implemented two projects with assistance from the EEC and the Dutch Government aimed at protecting land for irrigation.

There is also a flood control unit of the Ministry of Water Development which is constructing flood protection dykes along the Nyando River. A larger scale project is in plan and will involve the construction of flood protection works consisting of following:

(a) Construction of flood protection dykes over a total length of 24 km of the River Nyando on both banks increasing its height at a later stage.
(b) Earlier investigations proposed five storage sites within the Nyando sub-catchment with a total storage capacity 80 million cubic metres. However no systemic studies

of sedimentation rates have been taken. This is important because high rates of sedimentation would reduce the economic life of these reservoirs. It is to be observed here that an important element in flood studies is the quantification of land use changes in the highland catchments and the relationship of these to the increasing flood frequency on the Nyando catchment. It is in this connection that flood control should emphasize within channel measures. It is necessary to emphasize adjustments of non-structural approaches.

DROUGHT INCIDENCE, TRENDS AND PREDICTION

Table 1 shows the major drought occurrences and the areas in which they occurred. Table 2 shows seasonal drought probabilities in two towns within the Tana catchment.

Impacts of drought in the Tana catchment

The lower Tana catchment is essentially a grazing area with low rainfall totals as has already been discussed before. Drought affects the hydrology of the area. With decreasing rainfall, surface runoff becomes sparse, subsurface water is not recharged and the local aquifers become dry. The pastoralists concentrate their livestock near the reliable water sources such as boreholes. These areas are already under a high grazing pressure. During drought the water levels fall and crops under irrigation are affected. In some instances, the area cultivated is reduced. In other cases irrigation is halted and all the water available is used for domestic purposes. Essential food commodities such as maize, beans and flour become scarce and sell at exorbitant prices. Many of the livestock (cows and goats) die, while others have to be sold for cash for food or school fees (Downing *et al.*, 1989).

Table 1 Droughts in Kenya.

Year	Region
1883	Coast
1889-1890	Coast
1894-1895	Coast
1896-1900	Extended over most of East Africa
1907-1911	Lake Victoria area, Machakos, Kitui, coast
1913-1919	Ethiopia, Kamba Lands, coast
1921	Coast
1925	Kerio Valley, coast
1933-1934	Coast, Kikuyu Lands
1942-1944	Kenya, Uganda
1947-1950	Kikuyu Lands, coast
1952-1955	Kitui and other districts
1969-1961	Maasai Lands, Machakos Kitui, Rift Valley
1981	Eastern Province
1983	Coast, Kitui, Machakos, Meru, Kakamega, Nyanza.
1984	Kenya

Table 2 Seasonal drought probabilities.

	Machakos	Makindu
March-May (long) rains		
No. of years	91	81
Mild drought	0.25	0.43
Moderate drought	0.20	0.23
Severe drought	0.05	0.06
October-December (short) rains		
No. of years	90	80
Mild drought	0.49	0.56
Moderate drought	0.26	0.40
Severe drought	0.11	0.11

Source: Akanga *et al.* (1987).

Notes: Probabilities based on a normalized drought index:

No drought	$DI > -0.2$
Mild drought	$DI \leq -0.2$
Moderate drought	$DI \leq -0.5$
Severe drought	$DI \leq -0.8$

where $DI = (P - X)/S$; P = seasonal precipitation; X = long-term average from that season; S = seasonal standard deviation of P.

Drought mitigation

One important solution to this problem was envisaged as water storage. Ongwenyi (1987) suggests possibilities of underground storage. It is important that this be looked at with long-term goals to solve desertification problems. Procedures have been developed by the Department of Resource surveys and remote sensing to predict crop yields mainly using aerial photography and radiometry. This is important in warning about expected yields in order to set mechanisms to offset the food shortages that may occur during droughts. The Central Bureau of Statistics (CBS) also runs an independent crop forecast survey. This is dependent on data collection from the district levels based on questionnaires to farmers and historical data. The monitoring system includes an agroclimate crop yield model, processing of data collected in crop forecast surveys, monitoring market prices, analysis of trends in health and nutrition and analysis of food flows reported by the National Cereals and Produce Board. The CBS forecasts are based on meteorological data such as: normal precipitation, actual precipitation, number of days of rainfall and potential evapotranspiration and water reserves in the soil.

The two case studies referred to above show that Kenya has a serious problem of water and precipitation distribution in both space and time. The Lake Victoria drainage basin has an annual and sometimes biennial flood problem. This water can be harnessed in a system of reservoirs. It could then be pumped through the western shoulders of the great Rift Valley and allowed to flow to the drylands from the eastern shoulders of the Rift Valley to the eastern part of the country which is more drought prone. This would increase the chances for irrigation and lessen the dangers of desertification and starvation in the arid and semiarid areas of Kenya. The complexity here is that the lake waters are international and are protected by riparian law.If proper quantification studies are made, however, it is believed this could be done without inconveniencing the riparian users and reduce the pressure on the marginal areas of the country being placed on them by the ever increasing population.

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