

Rainfall variability in East Africa: implications for natural resources management and livelihoods

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This note examines the effects of climate variability on natural-resources management in East Africa. The bimodal rainfall regime in much of East Africa brings rainy seasons from March to May and October to December with greater interannual variability from October to December. We discuss the impacts of rainfall extremes in 1961 and 1997 and explore three examples of natural-resources management in the context of rainfall variability: inland fisheries in East and southern Africa; fluctuations in the level of Lake Victoria; and lake-shore communities around Lake Kyoga in Uganda. The discussion reflects the complexity of linkages between climate, environment and society in the region and highlights implications for natural-resources management. These range from benefits due to improved seasonal rainfall forecasting to reduce the damage of extremes, to improved understanding of existing climate–society interactions to provide insights into the region’s vulnerability and adaptive capacity in relation to future climate change.

Keywords: East Africa; climate variability;
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1. Introduction

Rainfall fluctuations in East Africa have had significant short- and long-term effects on natural-resources systems, particularly lakes, wetlands and rivers. Rainfall over much of East Africa displays a bimodal regime with rainy seasons in March to May (MAM) and October to December (OND) moderated by coastal and topographic influences (Mutai *et al.* 1998). The bimodal regime changes gradually into a single season with increasing distance from the Equator. The rainfall regimes for both MAM and OND and the transitional periods show varying degrees of influence from the Atlantic, Indian and Pacific Oceans. The OND season in East Africa is strongly affected by complex interaction between the Indian and Pacific Oceans and exhibits higher interannual variability than MAM. Periodic circulation dipole events in the Indian Ocean tend to be associated with above-average and sometimes very extreme

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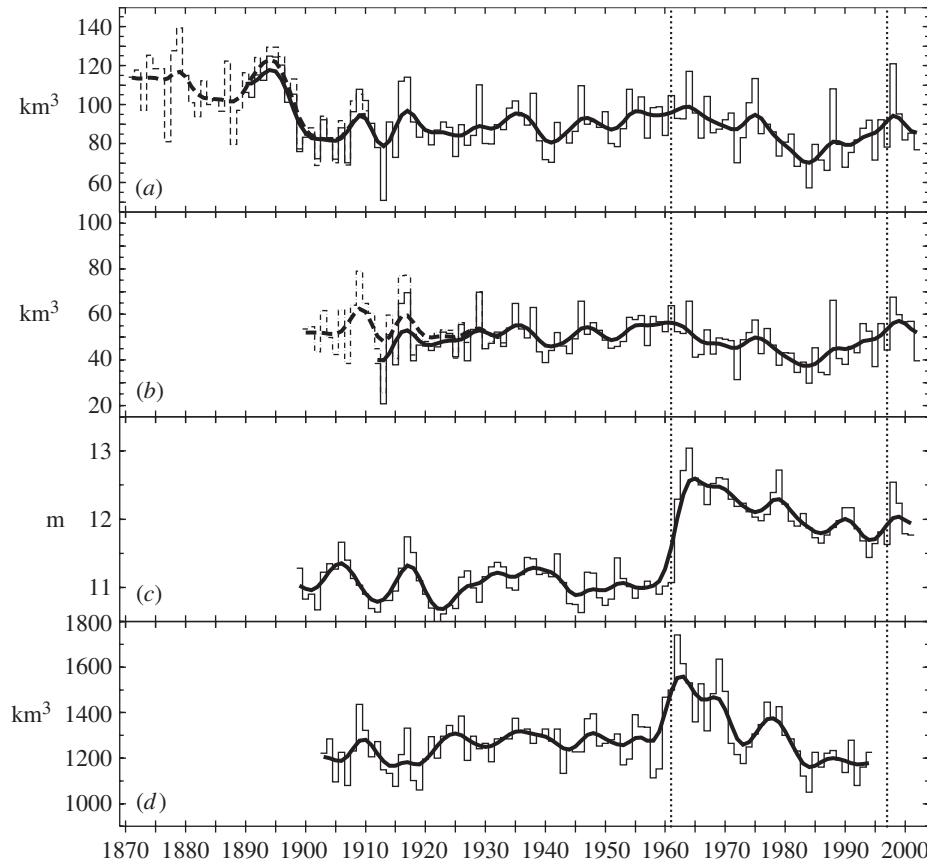


Figure 1. Annual river flows and lake levels for various periods. Note the different vertical scales. (a) Main Nile flows 1870–2002 (dashed line from Aswan, full line from a combination of Wadi Halfa, Kajarty and Dongola). (b) Blue Nile flows 1900–2002 (dashed line from Khartoum, full line from a combination of Roseires and el Deim). (c) Lake Victoria levels 1899–2001. (d) Congo flows 1903–1994 (Kinshasa). The bold line represents a 10 year Gaussian filter; vertical dotted lines show 1961 and 1997.

rainfall in OND (see, for example, Webster *et al.* (1999) and other papers in this issue). In this note we concentrate on the effects rather than the causes of rainfall variability. We examine the hydrological and socioeconomic impacts of two very extreme OND seasons (1961 and 1997) and then present a wider discussion of the implications of rainfall variability for natural-resources management in the region, focusing on three examples: inland fisheries in East and southern Africa; fluctuations in the level of Lake Victoria; and lake-shore communities around Lake Kyoga in Uganda.

2. The hydrological and socioeconomic impacts of rainfall extremes in 1961 and 1997

Two of the most extreme OND rainfall events during the twentieth century occurred in 1961 and 1997. Both events show similar spatial characteristics. They primarily

affected the area between 5–10° N and 10° S, from at least 25° E to the Indian Ocean, and produced seasonal rainfall totals of *ca.* 200–500% above normal (1961–1990). The events of 1961 were followed by very high rainfall in 1963 and a succession of wet OND seasons during the late 1960s through to the early 1980s, between 5° N and 5° S (Conway 2002). The effects of the 1961 event were greatest close to the Equator, spread west over the Congo basin and affected river flows as far north as the Sobat (a tributary of the White Nile, *ca.* 10° N) but not the Blue Nile (*ca.* 15° N, figure 1) and as far south as Lake Malawi. Massive hydrological anomalies occurred in response to extreme rainfall in 1961 and also 1963. Over the four years 1961–1964 the cumulative river flow anomaly for the White Nile upstream of the Sudd (Lakes Victoria, Kyoga, Edward and Albert), plus the Blue Nile, Atbara, Congo, Tana and Zambezi rivers was 1428 km³, roughly equivalent to the mean annual flow of the Congo (Conway 2002). The series in figure 1 shows other common features, such as high floods in 1916–1918 in the Nile basin, but they were shorter lived and smaller in extent than the floods in 1961–1962. After the 1997 event, the level of Lake Victoria rose by *ca.* 1.7 m by 1998, Lake Tanganyika by *ca.* 2.1 m and Lake Malawi by *ca.* 1.8 m; the Sudd wetland levels also rose (Birkett *et al.* 1999) and very high river flows were recorded in the Congo at Kinshasa. However, the effect on the level of Lake Victoria was shorter lived than in the early 1960s and by 2000 its level had returned to that of pre-1997 (Tate *et al.* 2004).

Both events produced major socioeconomic impacts across the region. Odingo (1962) described the record rainfalls recorded at many sites in Kenya and the social and economic disruption caused by the event in 1961. Extensive flooding occurred in the region with loss of homes and lives and damage to crops, and emergency food had to be flown in to marooned villages. Total flood damage costs at the time for Kenya were estimated to have been *ca.* £5 million. In 1997, across Somalia, Kenya, Tanzania, Uganda and Ethiopia, agricultural impacts included areas with increased yield and beneficial effects on pastures due to surplus rainfall and localized crop losses during harvest and post-harvest activities. Other impacts included considerable loss of lives and livestock due to widespread inundation, damage to housing and infrastructure, and outbreak of Rift Valley Fever after December 1997.

3. Implications of hydro-climatic variability for natural-resources management and livelihoods in East Africa

As well as the immediate impacts of extreme weather events, rainfall variability and trends in other climate factors such as temperature and wind speed have continuing impacts on food-production systems, affecting the livelihood strategies of producers, particularly the farmers, fishers and livestock keepers who live around the shores of the region's major lakes, wetlands and river flood plains. There is an emerging body of research suggesting that the dynamics of fisheries in Africa's lakes are driven primarily by climate change and that both the ecosystems and the livelihoods of fisherfolk living near these waterbodies are highly adapted to extensive fluctuations in lake size and depth, extent of flood plains and changes in aquatic productivity (e.g. Jul-Larsen *et al.* 2003). Recent research on Lake Tanganyika suggests that lake-productivity decline, driven by increasing temperature and decreasing wind speed, may be the primary reason for reduced fish catches (O'Reilly *et al.* 2003). In

river basins, it has long been recognized that flow rates and the extent of flooding are strong determinants of variations in fish catch (e.g. Welcomme 2001). This research is shifting policy agendas from attempts to manage fisheries for maximum sustainable yields towards recognition of fisheries' role as either safety net or sporadic income-generating opportunity for occupationally and geographically mobile populations (Allison & Ellis 2001). There is of course complex interaction between climate-driven variability and the effects of social change; for example, in the shallow Lake Chilwa (Malawi) there was a large increase in fishing from the 1970s, associated with a transition from subsistence to income-generating activity, around a lake which sometimes dries out (Sarch & Allison 2000). While fish populations appear to be highly resilient, recovering rapidly after the lake recovers from a drying event, management for equilibrium catches is not appropriate for fisheries of this type.

The immediate hydrological impacts of rapid fluctuations that have occurred in the level of Lake Victoria (figure 1) include disruption and damage due to temporary inundation of lake-shore areas and river flooding. Longer-term management implications revolve around the dynamic nature of water resources over time and the need for flexible management systems that consider the inherent uncertainty in the resource base. This undermines traditional assumptions of reliable yields for planning water-supply projects. Fluctuations in the level of Lake Victoria have generated controversy surrounding the potential returns of new hydro-power installations (Waterbury 2002). In certain cases, depending upon the hydrological situation, the effect on wetlands may also be large and prolonged. In the Sudd swamps in southern Sudan, where local pastoralists have a long history of adapting to floods (Johnson 1988), the area of permanent swamp increased from 2800 km² to 16 600 km² and the area of seasonal swamp increased from 11 200 km² to 14 000 km² after the early 1960s (Sutcliffe & Parks 1987) in response to an almost doubling of outflows from Lake Victoria.

The local scale of impact and adaptation is mediated by many influences, as is illustrated by the example of Lake Kyoga, in the White Nile system, downstream of Lake Victoria. People living around the shores of the lake engage in a diverse range of activities such as fishing, cultivation, rearing livestock and harvesting natural swamp products such as papyrus. The flooding of 1997 destroyed crops and homes nearest the lake and was associated with an initial decline and subsequent increase in fish catches and an increase in livestock deaths due to disease. These impacts were compounded by a drought that reduced crop yields in the season following the flooding. It appears that those most severely affected by these impacts were the households that have least assets and least diversity in their livelihood activities, in particular the landless, who were forced to cultivate close to the lake shore or depend entirely on fishing, for example. This is particularly apparent amongst refugees in settlements on the southern shores of the lake who have fled from areas of conflict and insecurity on the northern side of the lake.

4. The interaction of rainfall variability, hydrological systems and livelihoods

The interaction of extremes (droughts as well as floods) and interdecadal rainfall variability with nonlinear effects on hydrological systems such as lakes and wetlands produces complex linkages between climate, environment and society across

the region. Some key themes related to natural-resources management that emerge from this analysis are as follows.

Short-term effects: extremes such as 1961 and 1997 have caused extensive loss of life, socioeconomic disruption, damage to infrastructure and ‘shocks’ to livelihood systems.

Predictability and the role of the Indian Ocean: there are potentially wide-ranging opportunities to benefit from improved forecasting skills, not only for the extremes such as 1961 and 1997 but also less-extreme and more-localized rainfall variability in East Africa.

Medium-term implications: there is a need for ‘flexible’ management suited to the dynamic nature of natural-resources production systems under *non-stationary conditions* (as recognized in pastoralist systems); varying lake productivity and fisheries catch management, fluctuating levels of Lake Victoria and downstream flooding and hydro-power generation, inundation of lake and wetland margins such as Lake Kyoga in Uganda and the settlements and cultivation around them.

Long-term future climate change: study of the impacts and response strategies associated with interannual and interdecadal rainfall variability, which are often poorly understood, can provide insight into the region’s vulnerability and adaptive capacity in relation to current climate variability and also to future climate change.

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