

The desiccation of southern Africa's Okavango Delta: Periodic fluctuation or long-term trend?

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The Okavango Delta is the largest inland delta on Earth, spreading over 15,000 km² of the Kalahari sands of Botswana. Though commonly referred to as a delta, it is actually a landlocked wet-fan comprising three active subsystems: permanent, seasonal and intermittent floodplains bounded by fossil floodplains that mark the coterminous extent of a more extensive wetland during the historical past (Fig. 1). Contemporary perspectives on climate change in this sub-region are dominated by two competing discourses. The first maintains that the current trend in increasing aridity is part of periodic variation within a stable equilibrium and need not be interpreted as sustained deterioration of climatic conditions. The second argues that though periodic variation is evident, close examination of this periodicity reveals a persistent downward trend; a trend that may imply only limited prospects for recovery to the wetter climatic conditions of the historical past. Recent long-term evidence compiled from disparate sources about this sub-region's climate since the beginning of the 19th century suggests that there is need to question the validity of the stable-equilibrium hypothesis.

In this sub-region, oral histories from local people offer an invaluable form of evidence about climate conditions during the historical past. Around 1800 AD, the baYeyi migrated from southern Zambia by canoeing along the Selinda spillway and distributary channels of the Okavango River to settle around Lake Ngami (Fig. 1a) where they had been attracted by the abundant presence of hippo and fish. This information suggests high floods in the Okavango Delta that were capable of sustaining perennial outflow into the Selinda spillway and permanent water presence in Lake Ngami during the first half of the 19th century. The latter is corroborated by archival evidence, with the presence of fishing boats in the background of Figure 1b pointing to perennial water residence and a productive environment. High productivity is further confirmed by documented occurrence of widespread peat fires in this area during the early 1920's, which suggest substantial papyrus growth capable of sustaining the accumulation of considerable peat deposits. These obser-

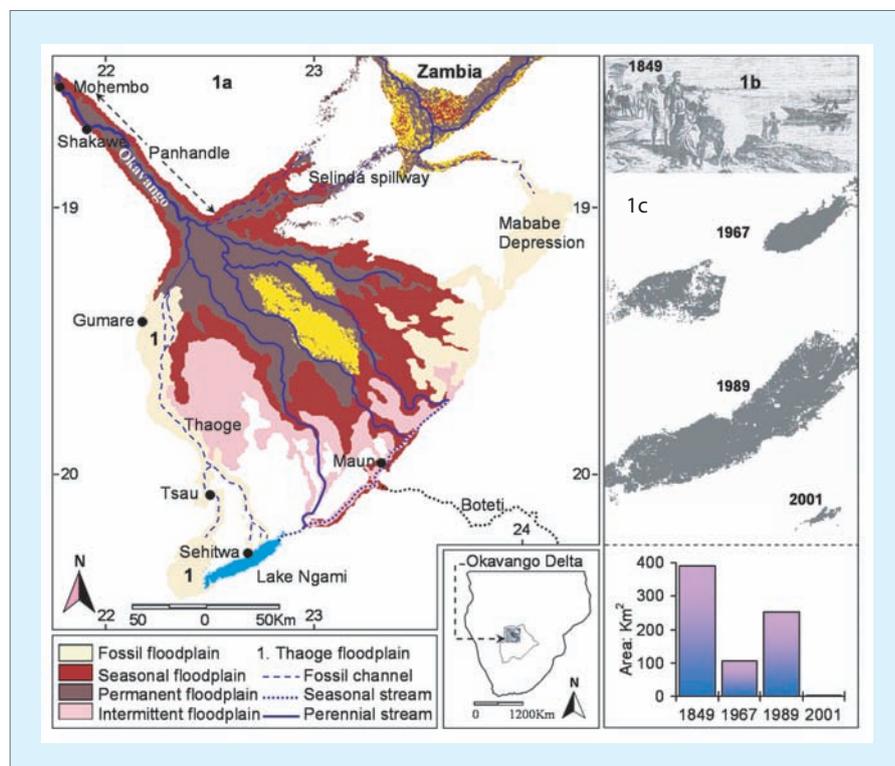


Figure 1: **a)** Position of locations mentioned in text and extent of the Okavango Delta's major subsystems; **b)** a sketch drawing of David Livingstone (early missionary explorer) and his family on the shores of Lake Ngami in 1849; **c)** Lake Ngami's surface water distribution in 1967, 1989 and 2001 as reconstructed from historical records and CORONA and Landsat imagery. For the graph in insert 1c, figures for 1849 are based on Livingstone's lower estimate of the Lake's perimeter (70 km) in 1849.

ations are indicative of a gradual decline in rainfall since the early 19th century: the drying up of the Selinda spillway during the early 1870's (Stigarnd, 1922), Lake Ngami's gradual desiccation (Fig. 1b), and virtual disappearance of peat fires in this environment by the late 1920's, all confirm a continuous drying trend (Hamandawana et al, 2005).

Though the Lake Ngami's flood régime has been characterized by periodic fluctuations, the long-term trend suggests that the hydrological system has been unable to revert to the higher flood conditions of the historic past. This proposition is supported by simultaneous floodplain desiccation in peripheries of the present Delta's permanent and seasonal swamps. For example, in the east, the Mababe Depression (captured in oral traditions as Lake Mababe) dried during the second half of the 19th century; its inflow channels from the northwest and southwest ceasing to flow by the early 1960's (Campbell and Child, 1971). In the west, the Thaoge River (described during the 1880's as

reed swamps infested by buffaloes and elephants that had to be hunted from boats (Chapman, 1886) last flowed into Lake Ngami around 1883 (Stigarnd, 1922). Since then it has retreated northward to its outflow point from the Delta's permanent swamps by the late 1960's (Fig. 1a). Given the protracted failure of these emergent floodplain environments to periodically recover, as suggested by proponents of quasi-periodic oscillations, it is quite apparent that this sub-region's climate has become increasingly drier from the beginning of the 19th century to the present. Though human interventions have contributed to floodplain desiccation (i.e. papyrus rafts causing vegetation blockages and channel manipulations by colonial authorities), evidence suggests that the sustained decrease in rainfall is the major cause of persistent floodplain contraction (Hamandawana et al., in press).

While the foregoing examples of oral and documentary evidence provide valuable indicators of the general direction of climate change, additional corroborative

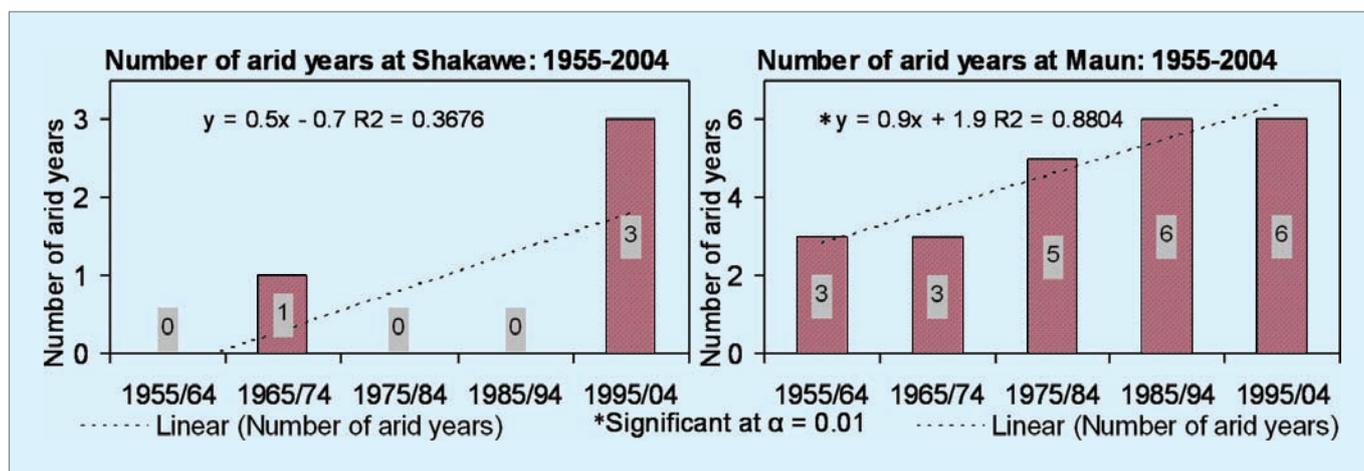


Figure 2: Frequency of arid years by decade period for Shakawe and Maun: 1955-2004.

evidence comes from trends in mapped vegetation distribution during the second half of the 20th century. In the proximal, intermediate and distal reaches of the Okavango Delta, recent changes in vegetation distribution have been characterized by transitions from reed-swamps and open grassland to woody cover dominated by drought tolerant species (Hamandawana, 2006). Between 1967 and 2001, woody cover around Shakawe and Mohembo increased by 20% while open grassland declined by 15% with these trends being statistically significant at $\alpha = 0.01$ and 0.05 respectively. In the intermediate reaches around Gumare, woody cover significantly increased by 26% ($\alpha = 0.05$) as open grassland declined by 43% ($\alpha = 0.01$). In the distal reaches around Sehitwa, *Acacia mellifera* increased by 21% while open grassland declined by 5% with both trends being statistically significant at $\alpha = 0.01$. These changes are indicative of climate-driven responses to progressive decrease

in local rainfall, which has tended to selectively facilitate the expansion of woody cover at the expense of drought-sensitive wetland and dryland grasses. Though this area's climate is widely classified as semi-arid (Aridity Index (AI) = $0.20 < AI < 0.50$), analysis of available data shows increasing frequency of arid years (AI = $0.05 < AI < 0.20$) for successive decades between 1955 and 2004 (Fig. 2).

This shift from semi-arid to arid conditions is consistent with current climate change scenarios that point to mid-continent drying in southern Africa, centered on Botswana, due to the increasing incidence of rainfall failures. In view of the pervasive nature of drying sequences during the recent past, the need for formulating appropriate policies designed to mitigate the adverse effects of deteriorating climatic conditions is now overdue. With evidence suggesting that these sub-regional trends are likely to persist, deployment of appropriately informed adaptation strategies

designed to enhance human capacities to cope with deteriorating climate conditions are urgently required. Adoption of effective strategies requires official acknowledgement of the non-transient character of the present direction of change. Thus the onus is on climate change science to inform policy formulation by providing long-term perspectives.

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Sensitivity of wetlands and water resources in south-eastern Australia to climate and catchment change

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Southeastern Australia lies within a temperate zone characterized by mild, but wet winters and hot summers with low ratios of precipitation:evaporation (P/E). Reconstructions of paleosalinity and water level from numerous crater lakes (e.g. Lake Keilambete) provide the means to monitor long-term changes to P/E, and have revealed a regional pattern of Holocene climate change (Bowler, 1981; Chivas et al., 1985; Gell, 1998; Jones et al., 1998). These records witness humid conditions and overflowing lakes in the mid-Holocene, a

rapid decrease in moisture at 5.5 kyr BP followed by a gradual trend to a variable and drier climate at c. 3 kyr BP. From c. 2.2 kyr BP the lakes refilled, though not to the mid-Holocene levels. These lakes are therefore sensitive to changes in P/E on the scale of centuries to millennia but appear insensitive to short-term climate variability. In contrast, the diatom-inferred paleosalinity records from numerous fluvial lakes across southeastern Australia across this period do not reveal the same sensitivity to long-term changes in climate. For exam-

ple, along the River Murray, Tareena Billa-bong experiences mid-Holocene freshness followed by increased connectivity to the River (Gell et al., 2005) but then a sustained period of stability until the arrival of European settlers c. 1840 AD. In the Coorong, a large back-barrier lagoon at the mouth of the River Murray system, stratigraphic and diatom evidence reveals relative resilience (Fluin et al., in press) to the P/E changes documented in the sensitive crater lakes to the east. Still further east in the coastal plain of the Snowy River, a diatom salin-