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Geomorphology, hydrology, and ecology of Lake Urema, central Mozambique, with focus on lake extent changes

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Abstract

Lake Urema is one of the most important ecological features of Gorongosa National Park, located in central Mozambique, in the East African Rift System. Understanding hydrology and ecology of the lake and its tributaries is particularly important for the conservation of the Park's floodplain habitats and its biodiversity. There are concerns that hydrological boundary conditions and ecology of Lake Urema have changed in recent years. Possible causes for this change include climatic and land use changes as well as tectonic and geomorphological processes. In this study, a multi-temporal and multi-disciplinary approach was applied to investigate the dynamics and control mechanisms of Lake Urema. Principal methods comprised remote sensing analyses of time series of Landsat and ASTER data, geomorphological interpretations of a Digital Terrain Model (DTM) as well as field investigations such as analyses of water quality and sediment composition. The waters of Lake Urema have a low mineralization and pH values approximately neutral. The spatially dominant sediment type has a pure clay texture consisting of kaolinite and smectite. The sandy type consists of quartz, kali felspar, and plagioclase. The results of the supervised classifications for the satellite images from 1979 to 2000 showed that the lake's extent ranged between 17 km^2 (09/1995) and 25 km^2 (08/1979). Above average rainfall was responsible for the extreme lake size in May 1997 (104 km^2). The interpretations of the Digital Terrain Model demonstrated that alluvial fans limit the Urema basin from all sides and make Lake Urema a form of "reservoir lake". The control mechanisms of the hydrological regime of Lake Urema, such as the contribution of groundwater, are not yet fully understood. The lake's condition during the rainy season was not investigated. In the future, investigations of the sources and amounts of sediment input into the lake should be conducted.
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Keywords: Floodplain; Remote sensing; Reservoir lake; Sediment composition; Savanna; Water quality

1. Introduction

Lake Urema (LU) and the surrounding floodplain grasslands are an important, if not the most important, ecological feature of Gorongosa National Park (GNP), which was called the "jewel in the crown of Mozambique's National Parks" (Tinley, 1977) prior to the civil war in Mozambique (1976–1992). At that time the Urema floodplains were inhabited by a variety of wildlife

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including hippopotamus, buffalo, elephant, wildebeest, zebra, water buck, impala, oribi, sable and eland (Tinley, 1977).

There have been concerns that LU's extent has been decreasing for the last 20 years. The drying-up of these wetland habitats could then lead to bush encroachment with consequences for the ecosystem such as a shift from grassland species towards savanna woodland species (Tinley, 1977). Burlison et al. (1977) investigated whether a drying-up of the wetland areas of GNP is taking place. A related concern is that siltation of the lake is occurring due, presumably, to increased soil erosion.

Reasons for a change of the lake's extent can be diverse, including impacts of climate change, neo-tectonic movements, geomorphologic and anthropogenic causes. The latter include land use changes in the catchment area (deforestation) located outside GNP and the near eradication of hippopotamus, which are considered to act as an ecosystem engineer through their ability to open and maintain channels (McCarthy and Ellery, 1998).

After a comprehensive study of Tinley in 1977 about the Gorongosa ecosystem, SWECO & Associates (2004) investigated the hydrological regime of the Pungoe River Basin and Owen (2004) looked at that of the Gorongosa Ecosystem. However, hydrology and ecology of LU was never the subject of an in-depth scientific study.

An interdisciplinary and integrated approach was applied to (a) quantify LU's size variations over the last 20 years and (b) investigate the controlling factors of LU's hydrological regime, its hydrogeochemistry and sediment composition.

2. The Lake Urema area

LU and the adjacent floodplains are located in the Sofala Province/central Mozambique (cf. Fig. 1, left). They are part of the GNP (6330 km^2), (Legal Diploma 27/50, 2767, 2935) which is situated in the Urema Rift, the southern end of the East African Rift System. West of the Rift Valley are the Báruè Midlands, consisting of Precambrian gneisses and migmatites with an altitude of 300 to 800 m a.s.l. (Edição Dos Serviços de Geologia e Minas, 1968; Lächelt, 2004). Gorongosa Mountain (1863 m a.s.l.), an isolated Cretaceous granitic intrusive complex, is located within the Midlands. To the East of the Rift Valley, the Cheringoma Plateau (300 m a.s.l.) consists of a sequence of Cretaceous to Pleistocene sandstones and limestones. The Rift floor is covered by unconsolidated Pleistocene to recent alluvial deposits and has elevations below 100 m a.s.l. The deepest part of the Rift floor is occupied by LU (14 m a.s.l.).

Central Mozambique is influenced by the monsoon circulation and the impact of El Ninõ/Southern Oscillation (ENSO) events. ENSO occurred in 1982–1983, 1986–1987, 1991–1992 and 1994–1995, and caused collateral droughts in Mozambique (Eastman et al., 1996). In 1997, an excess of rainfall was reported (NOAA, 2005). A cold ENSO event in February 2000 triggered heavy floods in southern and central Mozambique (UCAR, 2005), which however had no impact on LU's catchment area. Following Köppens Climate Classification System the study area is designated as a Wet-Dry Tropical Savanna Climate (Aw) with a moist, warm season from November to April and a cool, dry period from May to October (COBA & PROFABRIL, undated). The climate station in Chitengo, situated in the Urema Rift, has registered an annual

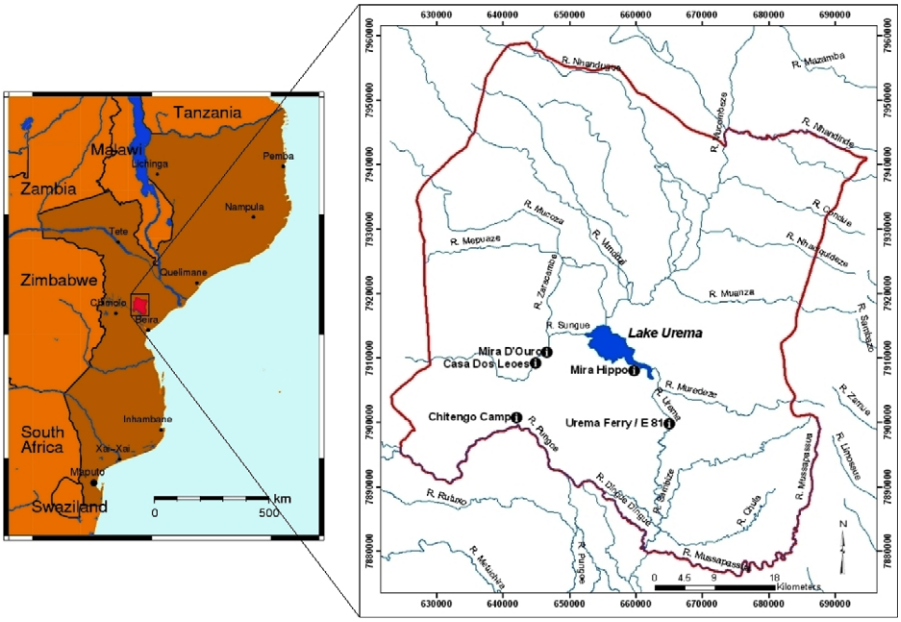

Fig. 1. Location of Gorongosa National Park (black frame in the left image) in central Mozambique; left image Wobbe (2005), right image based on IGN.FI CENACARTA (1999) and DINAGECA (1997/98).

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