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Flood history in lower Limpopo, Mozambique

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Introduction

In Mozambique seven out of eleven provinces are affected by floods. This work presents the history of floods that affect Gaza Province, specifically the Limpopo valley.

In the Lower Limpopo River basin, flooding is the result of a combination of atmospheric and runoff processes which result in excess of water manifesting itself as flooding. The objective of the present work is to show the history and the impacts of floods that have occurred in the Lower Limpopo River up to the year 2000 in Mozambique.

In order to know the years in which flooding occurred, we first resorted to collecting documentary information from newspapers and magazines of the time, because flow records only began in the 1950s. This data later made it possible to access the daily flow data recorded at the hydrometric stations of Combomune, Chókwè, Sicacate, and Xai-Xai from 1955 to 2000.

The data from the newspapers made it possible to know the impacts and effectiveness of the structural measures to mitigate the floods, as well as the areas flooded in each year. Technical reports were also consulted, describing the evolution of the tides in each flood, the propagation time of the flood wave, and the operation of the alarm system in each year.

The interviews conducted to the affected population made it possible to collect data on the damage caused and the way which relief and aid measures were implemented for the affected population.

The lower limpopo river

Limpopo River, which enters Mozambique from the Pafuri region in Gaza Province and flows into the Indian Ocean in the form of an estuary near the Xai-Xai city in Zongoene, is formed as a result of the confluence of the Marico and Crocodile Rivers (which rise 1,500 meters above the sea level to the west of Pretoria in South Africa).

Its regime is simple pluvial or elemental of the tropical pluvial type, with a flow curve of a single maximum (in summer) and a single annual minimum (in winter). In the wettest months (December to April) 91.8% of its annual flow occurs at the E-35 station in Chókwè, Mozambique, and in the dry season (September to November) there are years when only 1.2% occurs.

The tributaries of the Limpopo River in Mozambique are the Elefantes River, on which the Massingir Dam is located, on the right bank, contributing to flooding, and the Changane River on the left bank, which receives water during the flooding period, due to its plain lower altitude.

The Lower Limpopo River is part of the Limpopo River Basin and covers an area situated between parallels 21o and 25o South and between meridians 31º and 35º East (Figure 1).

The Lower Limpopo River is a floodplain bordered by sand dunes.[1] It presents alluvial and marine deposits of the upper and middle quarternary, recent lacustrine-aluvial, marshy and aeolian deposits giving rise to terraces, sandy plains, sandy clay plains, dunes and alluvium, the slope being 0,09%.[2,3]

The climate is tropical wet on the coast (Xai-Xai) and tropical dry in the interior (Chókwè) (Figure 2), and is also affected by tropical cyclones.

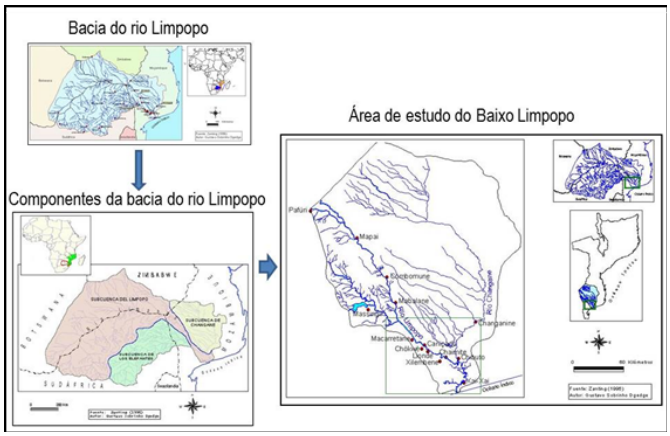

Figure 1 The area of study.[8]

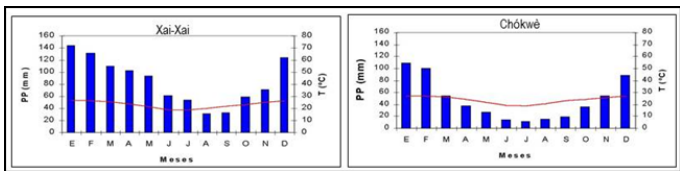

Figure 2 Climodiagram of Xai-Xai and Chókwè (National Institute of Meteorology data).

The historical floods

Apesar de as fontes documentais mostrarem notícias de grandes inundações ocorridas nos anos de 1915, 1918, 1925 e 1937, foi a partir de 1951 que se iniciou os registo de caudais no rio Limpopo.[3,4]

Por isso os dados hidrológicos mostram que as maiores inundações ocorreram nos anos hidrológicos 1954/55 (7.800m^3/s em Chókwè) e ano 1999/2000 (9.214m^3/s em Chókwè).

Even though documentary sources show reports of major floods occurring in the years 1915, 1918, 1925, and 1937, it was only from 1951 onwards that Limpopo River flow records began.[3,4] Therefore the hydrological data shows that the largest floods occurred in the hydrological years 1954/55 (7,800m^3/s at Chókwè) and 1999/2000 (9,214m^3/s at Chókwè).

In 1966, after 7 months of drought, heavy rains occurred in the northern Transvaal (South Africa)[3] and flooding occurred. After heavy rains in February 1967 flooding was also announced on the Elefantes and Limpopo Rivers.

In the year 1972 and 1975 the action of human factors on flooding was observed. The data show that the waters reached higher levels at the E-35 station of Chókwè than in 1955 due to the damming caused by the dike on the right bank that protected the "Eduardo Mondlhane" Irrigation System and the action of numerous embankments, canals and cross roads that hindered the flow of water on the plain.[3] Upstream of Gaide, the 1972 flood reached a greater extent, with levels higher than in the year 1955 due to the existing embankments south of Lhanguene. The plains were quickly flooded but for a short time.[4]

In 1972, the flood water entered from the right bank, flowing through the Limpopo river channel at the bridge in Sicacate and the Munhuana river, overflowing the right bank, entering the Lower Limpopo river and crossing National Road No. 206 (road connecting Chissano to Chibuto) in several sections.[4] The flooding in Maniquinique and Sicacate began on February 2. When the water reached the level of 10.7m on the hydrometric scale at station E-36 of Sicacate, upstream of the confluence between the Limpopo and the Munhuana, there was already a great flow of water that overflowed the Munhuana on the plain.

In the 1975 floods the dike defense action was not fully effective. Between Magula and Chiozol, where the dike was still under construction, the waters entered the plain through the unopened joint of the Mocumbini aqueduct. Waters also entered through the temporary embankment at Mascarenhas where there was no aqueduct gate yet. Between the Chókwè township and the Macarretane village waters entered through the irrigation channel which is part of this dam and blasted the dike and flooded land between Xilembene and Santana. In that year 1975, the Xai-Xai city was flooded because the water entered through the urban drainage system (sewage system) which did not yet have sluices, as well as through the overflow of the Limpopo river. After flooding the houses, the water flowed towards the plain, flooding small depressions and following the existing drainage channels.[5]

In the 1975 floods the first flood wave flows of 3,600m^3/s at Chókwè were reduced to 1,900m^3/s at Sicacate, further downstream, and to 1,600m^3/s at Xai-Xai, downstream of Sicacate.[5] In the same year, when the plain was already mostly flooded, it was found that the magnitude flows of 5,900m^3/s released at Massingir Dam, upstream of Chókwè, were reduced to 2,700m^3/s at Sicacate, downstream of Chókwè.

In the 1981 flood, for example, the waters entered the Munhuana River at Sangene and the Chiucha River and flowed along two paths: (i) the main channel itself and (ii) the corridor formed by the Munhuane River, Massatingue Lagoon and the plain between Lhanguene and the Chicumbane embankment.[6]

The 1988 floods were caused by heavy rainfall between February 11th and March 13th of the same year. The rains that fell in January 1996 caused the overflow of the Limpopo River, whose channel had remained dry until October 1995.

In 1988, flooding was caused by precipitation in the upper part of the basin. At Combomune, on the Limpopo River, above the confluence of this river with the Elefantes River, the rise in flow was not immediate. The basin response started to occur with a delay of about 7 days from the 18th of February (rainfall started on the 11th of February in Botswana). The flow response began to manifest itself at Combomune with a rapid rise in flow from 603m^3/s to 2,604m^3/s in two days. The flow reached a maximum of 3,363m^3/s on 29 February, with a water height in the plain of 7.8m, when the soils were already saturated.

The 2000 floods were caused by precipitation that had fallen since late December 1999. They were aggravated by heavy and extraordinary rainfall resulting from the low pressure that caused the following tropical cyclones: "Connie" between January 15 and February 1, "Eline" between February 8 and 23, and "Gloria" between February 29 and March 2, both in the year 2000...

The cyclone "Eline", due to its high precipitation, was the one that caused the largest flood wave. In South Africa more than 200mm of rain was recorded in a single day. In some places in Mozambique for instance in Combomune 514.6mm was registered, in Chilaulene 327.8mm, out of a total of 944.2mm that falls during the year.

In 2000 from the second flood wave, in February, Chókwè registered the inflow of the Elefantes River due to the Massingir Dam. Consequently, while at Combomune (on the Limpopo River), waters above the confluence of the two rivers, a flow of 3,111.2m^3/s was recorded on the 10th of February, at Chókwè (on the Limpopo River), waters below the confluence, 4,657m^3/s was recorded on the 13th of February. In the fourth flood wave, whereas at Combomune a flow of 2.015,3m^3/s was recorded, at Chókwè 4.095,5m^3/s was recorded. Even so, it was possible to avoid the two rivers' tips coinciding downstream of their confluence.

The 2000 floods, the largest of all, it was of four flood waves, peaking at 10,664m^3/s in Combomune and in Xai-Xai City 9,214.0m^3/s, flooding up to the height of the second floor of buildings.

Damage caused by floods

Os danos pelas inundações são elevados no Baixo Limpopo quando as pontas de cheia do rio Elefantes e Limpopo coincidem a jusante da sua confluência. Pir exemplo, em 1967, este fenoómeno assim ocorreu e as terras das planícies de Chibuto e Xai-Xai foram totalmente inundadas. Nesta última cidade atingiu-se a cota de 4,9 m e se manteve assim por dois dias consecutivos.[3]

Flood damages are high in the Lower Limpopo when the flood peaks of the Elefantes and Limpopo rivers coincide downstream of their confluence. For example, in 1967, this phenomenon occurred and the lands of the Chibuto and Xai-Xai plains were totally flooded. In the latter city, a level of 4.9 m was reached and remained so for two consecutive days.[3]

According to Montes,[5] Pavlova,[3] Bernardo[7] and Dgedge[8] flood damage is summarized in:

a. Flooding of the railway line to Zimbabwe, causing the derailment of wagons;

b. Flooding of the national road EN 205, with cuts in the slopes water below the embankment, damage to the asphalt and bridge, of the national road EN 206 with cuts and sidewalk losses, of the national road EN 208, of the national road EN 1, in the Chicumbane embankment, destruction of viaducts, bridges and erosion of the slopes and flooding and cuts of rural roads throughout the Lower Limpopo plain;

c. Overflow of the Chókwè and Xai-Xai dike and the flooding of the two.

d. Flooding of farms.

e. Displacement of people.

f. Destruction of 200 residences.

g. Destruction of the defense dike that prevented water from entering the Chinanga Lagoon.

h. Death of displaced people,

i. Cutting of communication routes and destruction of the defense dikes.

j. The 2000 floods swamped the entire lower Limpopo plain and caused damage that can be summed up as: death of 500 people, displacement of 500,000 people, 742,863 people affected, damage to all communication routes in the plain and bridges, and flooding of all towns and villages in the plain.

The impact of floods on the ecosystem

From the ecological point of view, it is rather likely that floods bring changes that lead to improvements in the natural system that manifest themselves in benefits, or in losses.

Floods impact ecosystems mainly those of the wetlands of the natural floodplain, causing ecological variations in the river corridor, lakes, lagoons, swamps and depressions of temporary accumulation of water in the period of high tide.

Lower Limpopo flooding occurs slowly, being derived from long periods of rain or the overflow of the river. The waters tend to stay for long periods of time. These periodic floods lead to an increase in the aquatic production of flood-tolerant fish species. It is common to observe an increase in species of Mozambican Tilapia (*Oreochromis mossambicus*) as well as catfish (*Clarias gariepinus*).

Floods stimulate the development of the spotted fish (*Nothobranchius orthonatus*) which lives in pools with no direct connection to river courses. This fish usually leaves its eggs at the bottom of the sediments. Consequently, in the dry period the development of eggs can be stopped when the pools or water depressions dry up. However, during the flood period, the species completes its cycle from egg to adult in a few months, which makes it a species adapted to the flood.

In areas that become wet, the post-flooding period stimulates the development of grasses such as *Echinochloa sp* and *Urochloa mossambicensis*, as well as *Sycomorus Ficus* and *African Kigelia* tree species.[9]

In small swamps the floods allow the development of aquatic macrophytes, including *Nymphea species* and *Phragmithes autralis*.

An important effect of the floods is that between Xai-Xai and Zonguene, in the estuarine area influenced by the marine intrusion, the floods reduce the high saline levels while allowing the proliferation of salt-tolerant grasses such as the *Sporobolus virginicus* and mangroves species, of which the specific composition includes *Avicennia marina, Rhyzophora mucronata, Bruguiera gymnorhyza, Xilocarpus granatum* and *Ceriops taga*.[9]

The prolonged period of floods allows the proliferation of water birds, some of which are migratory species. *Amphibious hippopotamus* benefit from floods as they allow grasses to grow for food on the banks and other species in the river channel.

During the flood period, the reduction of phytoplankton and zooplankton can be observed due to the high velocity of the river water. However, they can increase in the period of flow reduction and water retention in the floodplain, lagoons and swamps due to turbidity and variety of nutrients.[10,11]

Conclusion

The flooding in the Lower Limpopo is due to both physical and human factors. It derives from the intense precipitation that falls in the Upper Limpopo originating from tropical depressions. Contributing to the flooding are low gradients and rising sea levels due to cyclones. The latter process makes it difficult for the water to flow during the process.

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The flooding process is characterized by several flood waves, with a maximum duration of 3 months.

Infrastructure such as roads and dikes contribute to the propagation of the flood wave, due to the damming effect they cause.

The 2000 floods were the greatest in magnitude, surpassing that of 1955, which was used as a reference for all the works and studies carried out in the territory.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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