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The use of remote sensing for monitoring environmental indicators: The case of the Incomati estuary, Mozambique

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Abstract

The Incomati river basin is a transboundary basin shared by three countries: South Africa, Mozambique and Swaziland. To assess the water requirements of the environment, as stated in the Tripartite Interim Agreement (TIA) signed by the three riparian countries in Johannesburg in 2002, Mozambique needs to monitor the ecological state of the river, including the estuary. A monitoring system has to be established that can evaluate the environmental fresh water requirements based on appropriate indicators that reflect the health of the Incomati estuary.

The estuary of the Incomati has important ecological functions but it also is an important socio-economic resource. Local communities depend on the estuary's natural resources. Modifications of the river flow regime by upstream developments impact on the productivity of the estuary, diminishing fish and shrimp production, reducing biomass of natural vegetation such as grasses, reeds and mangroves and increasing salt intrusion. A decrease in estuary productivity consequently affects the incomes and living conditions of these communities.

Based on an understanding of the effects of different pressures on the estuary ecosystem some indicators for monitoring the environmental state of the estuary are suggested, including the extent and vitality of mangrove forests. This latter indicator is further elaborated in the paper.

Remote sensing techniques were used to identify and quantify mangrove forests in two selected areas of the estuary (Xefina Pequeña Island and Benguelene Island). Five satellite images covering a period of 20 years (1984–2003) showed that the area covered by non-degraded mangroves significantly decreased on both islands, by 25% in Xefina Pequeña Island and 40% in Benguelene Island. Moreover, the study of biomass reflection using NDVI also showed a significant decline in biomass densities over the last 20 years.

Possible causes of these changes are reviewed: natural rainfall trends, modifications of the river flow regime, and increasing harvesting levels of mangrove woods. The findings presented in this paper show that mangrove forests are relevant indicators of the state of the estuary, which can be assessed by means of remote sensing techniques. Follow-up research is required that will establish the relative importance of the causal factors on the vitality of the estuarine mangrove forests. It is concluded that remotely sensed images may provide important data for an environmental monitoring system.

Keywords: Environmental indicators; Environmental water requirements; Estuary; Incomati; Mangrove

1. Introduction

Estuaries are delicate and complex ecosystems and represent an important socio-economic resource. They provide the community with many goods and services and support

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a variety of plants and animals, contributing with the biodiversity of riverine and marine ecosystems (DEH, 2004). The health of an estuary depends on a combination of natural events as well as human activities. It is essential to use these natural resources in a sustainable way to ensure a long lasting productivity.

Estuaries are the transition between the river and the sea and depend on the fragile equilibrium of fresh water and salt water. Estuaries, being downstream in the river basin, suffer from the pressures, events and developments upstream (Sengo et al., 2005). The impacts of these pressures are reflected directly and indirectly in the environmental state of the estuary.

Three countries share the Incomati River Basin: South Africa, Swaziland and Mozambique (Fig. 1). The level of abstraction in the Incomati River is very high; the percentage of surface water consumed is greater than 50% of the total amount of water generated in the basin (Van der Zaag and Carmo Vaz, 2003; Nkomo and Van der Zaag, 2004).

Upstream abstractions and regulation infrastructures have reduced the amount of fresh water that reaches the Incomati Estuary and, thus, modified the estuary's flow regime. Furthermore, the actual water demand of the region is projected to increase in the future as a result of further economic development and population growth. The alteration of the flow regime has a negative impact on the estuary's productivity: diminishing the fish and shrimp production, reducing the biomass of natural vegetation such as grasses, reeds and mangroves, and increasing the salt intrusion (Sengo, 2003).

Aware of the increasing pressure on the water resources of the Incomati and Maputo river basins, the three riparian countries concluded the Tripartite Interim Agreement, also known as the IncoMaputo agreement, which was signed in Johannesburg in 2002 (TIA, 2002). This agreement, among others, recognises the water requirements for the environment, and in the absence of more precise information, some minimum target environmental flows have been set. As a final agreement is scheduled to be reached in 2010, it is important that Mozambique monitors the ecological state of the river, including the estuary. A monitoring system is needed that can evaluate the environmental fresh water requirements based on appropriate indicators that reflect the health of the Incomati estuary. The focus in this study was to evaluate the state of the ecosystem by choosing environmental indicators that can be monitored using remote sensing techniques.

2. Methods and materials

Remote sensing (RS) is the science of obtaining and interpreting information from a distance, using sensors that are not in physical contact with the object being observed. The basis of this technology consists of sampling electromagnetic radiation to acquire and interpret geospatial data. From this data, information about features, objects, earth surface, oceans, and atmosphere is extracted (Smith, 2001).

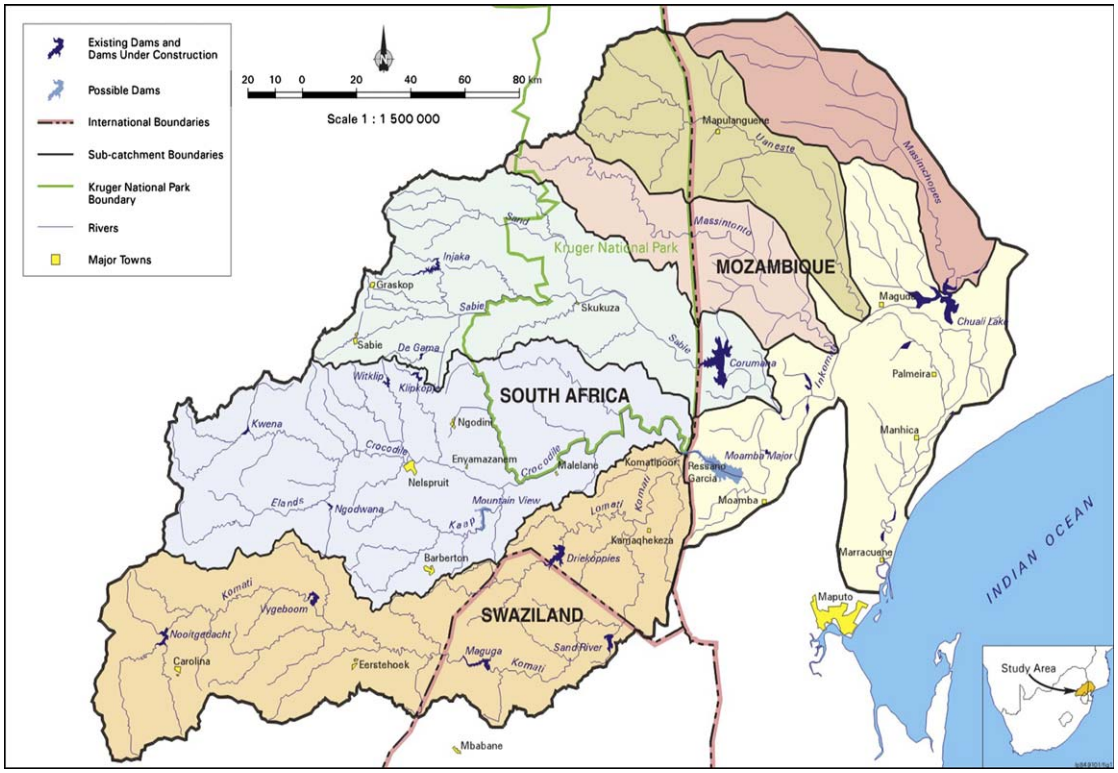

Fig. 1. Incomati river basin (*Source*: JIBS, 2001).