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Deltaic coasts under climate-related catastrophic events – Insights from the Save River delta, Mozambique

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ABSTRACT

The deltaic coast of the Save River is characterized by mangrove wetland, one of the most important coastal ecosystems in Mozambique. This ecosystem provides direct services to the neighbouring communities and contributes to the productivity of the marine ecosystem. This region has, however, been hit by recurrent catastrophic events that have caused negative impacts on the ecosystem and in people's lives, posing challenges for its management. In this article we use this area as a case study to structure and propose an interactive and integrated approach for coastal zone management under recurrent climate-related catastrophic events. Our results show a need for systematic interaction between the decision makers (at the different levels) and the communities to set up adaptive measures for climate-related events. Also, we noticed that the presence of the neighbouring communities is a factor to capitalize on the adaptation activities by maximizing their participation as active actors in the process. Therefore, we conclude that a continuous process of adaptation and preparedness to climate-related catastrophic events (focused on both social and ecological systems) constitutes a leverage variable to be used for sustainable management of the coastal zones.

1. Introduction

The deltaic coast of Save River is characterized by mangrove forest growing in the wetland delta of one of the larger rivers in southern Africa. This mangrove ecosystem is rich in biodiversity and a cradle for several species of plants and animals, thus representing one of the most important coastal ecosystems in Mozambique. The wood from mangrove trees is locally used for boat and house building, production of domestic utensils (such as fish traps), traditional ceremonies and for firewood. Fishery along the mangrove channels occupies more than half of the neighboring population and contributes substantially to the food security of the residents (Menomussanga and Matavel, 2011). In the upper deltaic area, the soil is highly productive and attracts people to concentrate in these areas.

At the global scale, the mangrove ecosystem is increasingly recognized for its role as a carbon sink (Breithaupt et al., 2012; Donato et al., 2011; Hopkinson et al., 2012; Kathiresan, 2011). As part of the global carbon cycle, mangrove ecosystems can sequester considerable amounts of carbon per unit area (Donato et al., 2011; Eong, 1993) by a process that involves incorporation of CO_2 into mangrove trees via photosynthesis and subsequent transfer to the soil (Kristensen et al., 2008; Suratman, 2008). This process contributes greatly to the reduction of CO_2 in the atmosphere, and plays an important role to counterbalance the increasing trend of greenhouse gas emissions (Post et al., 1990). In addition, organic matter, brought by rivers and tides, is trapped in the mangrove wetlands (Kristensen et al., 2008) resulting in thick layers of organic rich sediments, often considered as carbon pools that can counteract the scenarios of an increasing greenhouse effect.

Mangrove wetlands and other coastal ecosystems represent a hope for balancing the carbon cycle (Nellemann et al., 2009), but there are challenges to overcome. Coastal ecosystems are subjected

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to anthropogenic and natural pressure with negative results. During the last half century mangrove wetland areas have declined by approximately one third and there are estimations of an ongoing mangrove loss of more than 2% per year (Alongi, 2002; Craft et al., 2009; Valiela et al., 2001). Studies also show that many mangrove wetlands have been replaced by shrimp farms over the last few decades (Pattanaik and Narendra Prasad, 2011; Polidoro et al., 2010; Rahman et al., 2013; Tong et al., 2004), while others have been impacted by climate-related events (Paling et al., 2008; Woodroffe and Grime, 1999), such as tropical cyclones and storms as summarized by Jimenez et al. (1985).

Measures to mitigate the degradation of coastal ecosystems are being implemented in many coastal areas. However, an increasing intensity of climate-related catastrophic events, coupled with human pressure, is a limitation for the effectiveness of such implementations (Adger, 1999; Nicholls and Klein, 2005). Moreover, other regions (also the area of concern in this paper) still lack comprehensive assessment on their environmental sensitivity and on the recent modifications associated with high magnitude weather events. Therefore, in this study we show how a system analysis approach can help to identify leverage variables to support management decisions in deltaic coasts under climate-related catastrophic events. This methodology has been successfully used to discuss complex problems (Haraldsson and Ólafsdóttir, 2003; Hjorth and Bagheri, 2006; Roberts, 2007), but its application as a decision tool in coastal management is still fledgling. Specifically this study aims to: (1) review and summarize the ongoing climate-related catastrophic events in deltaic coasts, particularly in the Save River delta; (2) structure the interaction between climate-related catastrophic events and socio-ecological system; (3) identify the leverage variables in the system and discuss their relevance in an Integrated Coastal Zone Management (ICZM) perspective.

2. The Save River deltaic coast

The deltaic coast of Save River is located in southeastern Mozambique (Fig. 1). The coast is rich in biodiversity, largely represented by the mangrove forest that extends along the coast for approximately 100 km. The mangrove in the study area is unevenly distributed owing to local environmental conditions. The mangrove flourishes between the two main distributary channels of the delta (Macau Channel and Matasse Channel) and along tidal channels of the tidal flat. These channels are partially supplied by groundwater seepage and the whole wetland area is under influence of semi-diurnal and macro-tidal conditions (in reference to the nearest tide gage in the City of Beira). Within the mangrove area, thick layers of organic-rich sediments form the substratum, often sheltered from the open sea by beach ridges and coastal dunes. In the clay layers there is an abundant and diversified benthic fauna that enriches the ecosystem.

On the upper deltaic plain, two rural villages are located, Nova Mambone and Machanga, headquarters of Govuro and Machanga districts, respectively. The villages represent the densely populated areas in the study area. In 2002 the total population of the two villages was estimated to approximately 46,000 inhabitants, i.e. approximately half of the total population in the two districts; 86,300 inhabitants (INE, 1999). The districts are located on both sides of Save River, and occupy an area of approximately 9000 km^2.

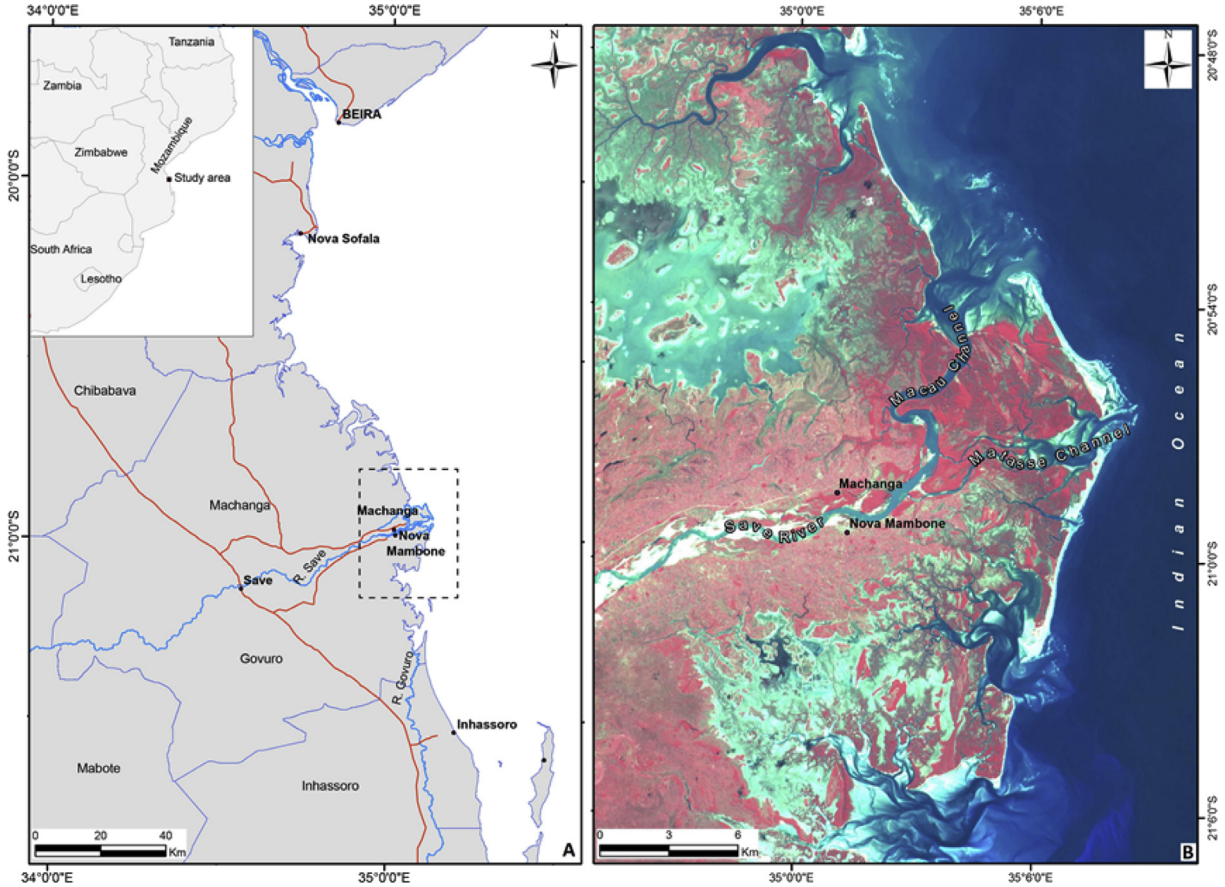

Fig. 1. **(A)** Geographic location of the study area and **(B)** Spot image from 13th April 2011 with the typical false color combination showing the physiographic aspect of Save River delta. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)