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Original Research Article

The need to enforce minimum environmental flow requirements in Tanzania to preserve estuaries: case study of mangrove-fringed Wami River estuary

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ABSTRACT

The importance of restoring and maintaining environmental flows for sustaining the ecosystem integrity of rivers has been recognized in policies and legal frameworks in many countries. However this is routinely not implemented in Tanzania as exemplified by the case of the Wami River estuary, which plays a vital role in processing riverine nutrients, trapping sediment, recycling nutrients in the mangroves, and supporting the ecology of the Saadani National Park and the livelihood of the local communities. Our study reveals that currently the estuary is ecologically healthy but it is threatened by both increasing sedimentation and declining freshwater flow caused by decreasing rainfall – possibly linked with climate change – and by increasing water demand in the watershed for artisanal and large scale agriculture and irrigation schemes. Environmental flow assessment for the Wami River (with exclusion of estuary) has been done and the minimum flows were recommended but they are not enforced. We recommend that the responsible authority (Wami-Ruvu Basin Water Office) enforce its own environmental flow recommendations in order to maintain a healthy estuarine ecosystem and regulate water usage in the watershed. A similar recommendation also holds for all other rivers and estuaries in Tanzania.

1. Introduction

Many rivers in the world are suffering from hydrological alterations which result in degradation of aquatic habitats. The recognition of the importance of maintaining the natural flow regime for sustaining the ecosystem integrity of rivers and estuaries has led to development of environmental flow (EF) concept and national and international organizations are emphasizing the EF as key element of integrated water resources management (Dyson et al., 2008). Various definitions of environmental flow exist; the Brisbane declaration of 2007 (http://www.watercentre.org/news/declaration) defines EF as "the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well being that depend on these ecosystems".

In Tanzania, EF assessments are supported by policy and legal frameworks such as National Water Policy of 2002 (URT, 2002), Environmental Management Act of 2004

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(URT, 2005) and The Water Resources Management Act of 2009 (URT, 2009). EF studies have been conducted in several Tanzania rivers including the Wami River (Dickens, 2011; GLOWS-FIU, 2014). The required minimum flows for Wami River for both dry and wet years were recommended. However, both studies ignored the freshwater needs of the estuary.

Estuaries are known to play an important role in human well-being and the economy, but they are increasingly threatened and, as a response, science-based management and restoration strategies are continuously evolving (Costa et al., 1994; Lindeboom, 2002; Uncles et al., 2002; Wolanski et al., 2004; Wolanski and Elliott, 2015). Much of the available knowledge is derived from large estuaries where the response to changing land and water use in the watershed is slower than that of small estuaries (Swaney et al., 2011).

The Wami River is managed by Wami-Ruvu Water Basin Office (WRWBO) while the estuary is managed by Saadani National Park (SANAPA). The estuary is a lifeline for SANAPA wildlife and people during the dry season where most of the water sources inside the park are dry. It is also the main source of income to Saadani village and adjacent coastal communities through fishery as well as through tourism. Prior to gazetting of the National Park in 2005, the estuarine condition was threatened by increased destruction of mangroves which were heavily exploited for charcoal, fuel wood, poles and salt production pans. Local communities have been complaining about decreasing catch of prawn and fish, local extinction of some fish species, changing water quality, particularly increasing water salinity in the estuary, and increasing sedimentation at the mouth of the estuary and in near shore waters where the fisheries are located. However, the majority of their claims were based on anecdotal information, with no scientific evidence to justify the claims.

In this paper we show that the Wami River estuary plays a vital role in processing riverine nutrients, in trapping fine sediment, in recycling nutrients in the mangroves, in supporting wildlife and the ecology of the National Park as well as the livelihood of the local communities. Nevertheless, this is now threatened both by increasing sedimentation and by declining freshwater flow in the Wami River due to decreasing rainfall – possibly linked with climate change – and by increasing water demand in the watershed. We show how the inclusion of the estuary to SANAPA in 2005 safeguarded the mangroves which help in trapping sediments and nutrient recycling by crabs as well as in protecting other estuarine wildlife such as hippopotami of which their populations have been observed to increase. We also indicate that the trapping of sediment by the mangroves helps buffer the seagrass meadows in coastal waters from excessive sediment load, although whether this is enough to preserve the seagrass is unknown and requires further research. Therefore, this study seeks to answer the main two questions – (i) What is the current status of Wami River estuary and (ii) What are the potential negative impacts to the estuary if recommended minimum environmental flows are ineffectively implemented.

2. Methods

2.1. Study area

The catchment area of the Wami River basin in Tanzania is about 40,000 km^2. The Wami River estuary is located between 06°07′213 S, 038°48′965 E and 06°07′155 S, 038°48′886 E (Mosha and Gallardo, 2013). The tides are semi-diurnal with a strong diurnal inequality, with spring tides reaching 4 m at the mouth. The tidal influence extends up to 8 km upstream. The average depth in the estuary is 2.5 m and 3.5 m during dry and wet seasons respectively. It supports extensive mangrove ecosystems and their associated inter-tidal organisms (TANAPA, 2003; Tobey, 2008). The main fringing vegetation types along the estuary are mangroves, palms and Acacia woodland mixed with grassland. There are eight species of mangroves but the dominant species are *Sonneratia alba*, *Avicennia marina*, *Xylocarpus granatum*, *Rhizophora mucronata* and *Heritiera littoralis*. Patchy seagrass meadows occur in coastal waters all along the coast (Fig. 1).

Hippopotami, crocodiles, and water birds are common along the estuary, while numerous wild animals such as ungulates and colobus monkeys access the upper estuary for drinking freshwater. Though small, the estuary supports one of the important prawn fisheries in Tanzania (TANAPA, 2003).

2.2. Hydrology data

Wami River discharge data from the Mandera hydrometric station (located about 50 km upstream) were obtained from WRBWO. Local rainfall data were obtained from Tanzania Meteorological Agency. Evaporation data were obtained from Nyenzi et al. (1981).

2.3. Environmental variables

Physical, chemical and biological data were obtained along a transect from the river to offshore at five sites shown in Fig. 1 at different times during dry (July–October) and wet (March–June) seasons between 2007 and 2015. Water samples were collected using a Niskin bottle near the surface, at mid-depth and near the bottom at each sampling site. From these samples, water salinity, temperature, dissolved oxygen and pH were measured *in situ*. Different instruments were used depending on the availability such as the HORIBA model U-10 and BANTE 900P portable multiparameter meters. Salinity was measured using a hand-held refractometer. A Secchi disk of 20 cm diameter was used for measurement of water visibility.

2.4. Nutrients and total suspended solids (TSS)

Water samples for nutrient and TSS analysis were collected using a Niskin bottle and stored in acid washed 1 L plastic bottles, rinsed with distilled water and re-rinsed with water from the sampling site two to three times. All samples were immediately stored in an iced cool box. In the laboratory, these samples were filtered using BOECO glass-microfibre discs (filters) grade MGC with 0.45 μm