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Expanding wetlands: a comprehensive look to the morphological evolution of the Mara Wetland, Tanzania

Francesco Bregoli[a,b*], Alessandra Crosato[b,c], Ibrahim Migadde[b], Paolo Paron[b], Michael McClain[b,c]
[a] *Environmental Science Department, Institute for Water and Wetland Research, Radboud University, Heyendaalseweg 135, 6525 AJ, Nijmegen, the Netherlands*
[b] *Department of Water Science and Engineering, IHE Delft Institute for Water Education, Westvest 7, 2611 AX, Delft, the Netherlands*
[b] *Faculty of Civil Engineering and Geosciences, Delft University of Technology, Building 23, Stevinweg 1, 2628 CN, Delft, the Netherlands*

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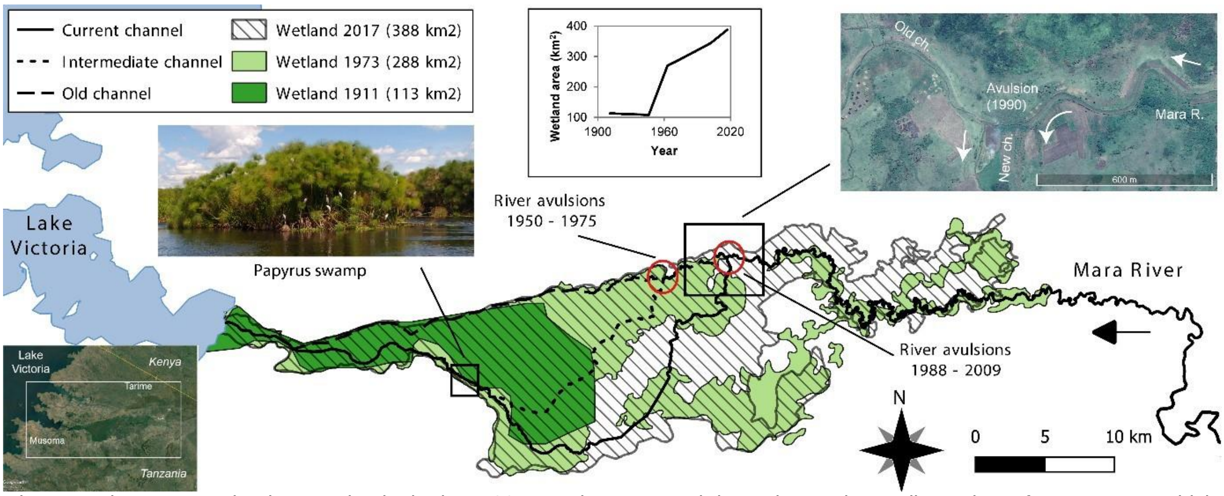

Figure 1. The Mara Wetland expansion in the last 100 years has occurred due to increasing sediment input fromupstream which has been trapped in the floodplain. River avulsions due to sediment and logs clogging has shifting the main river course toward south, inundating new areas that were previously savannah lands.

Introduction

Land conversion to crops, grazing fields and urban areas, water abstraction and sediment captured in reservoirs are among the most relevant causes of the 60-70 % of inland wetlands global surface loss in the last 100 years (Davidson 2014). However, some wetlands are found to increase in size. This is the case for the Mara Wetland in Tanzania (Mati et al. 2008; Bregoli et al. 2019). We have considered this site as a key study to understand the causes and mechanism of wetland expansion. Additionally, upstream of the study site, a dam is planned to be constructed primarily for irrigation and drinking water supply and secondarily for hydropower. It is thus important to identify the mechanisms that are responsible for the functioning of this specific wetland to take them into account during future dam operation. The Mara Wetland is a unique natural resource in a semi-arid area (McClain et al. 2014). Therefore, proper management of the future infrastructure is key to preserve the ecosystem health of the river and the wetland. This work provides a quantitative description of the past and current situations forming the basis for the identification of the causes of wetland expansion and retreat.

* Corresponding author
Email address: f.bregoli@science.ru.nl (F. Bregoli)
URL: ru.nl/english/people/bregoli-f/ (F. Bregoli)

Method

The Mara Wetland, mainly consisting in a papyrus swamp, is located at the mouth of the River Mara which discharges into the Lake Victoria in Tanzania (Fig. 1). The area receives two wet seasons with precipitation peaks in November to December and March to May. In the lower Mara River, rainfall, water surface elevation and discharges is measured at a few monitoring stations (McClain et al. 2014). To obtain further detailed data, we visited the Mara wetland in two occasions: a dry period (October 2017) and a wet period (May 2018). Access to the study sites was limited due to the remoteness, poor road conditions and poor navigability of thewetland.
During the field work we measured water and sediment discharges and bed load and we surveyed the wetland, the river and the

floodplains with an unmanned aerial vehicle (UAV) combined with GPS RTK and sonar operated from a boat at several locations (Bregoli et al. 2019). We obtained high resolution orthophoto mosaics and digital elevation models by applying structure-from-motion photogrammetry processing to the images taken by the UAV. We gathered historical maps from 1891 to nowadays, satellite images from 1975 onwards (Landsat and Sentinel) and we interviewed locals. We used the gathered data to reconstruct the wetland evolution in the last 100 years and to setup a 2D hydrodynamic numerical model, which we implemented in Delft3D Flexible Mesh (www.deltares.nl) including vegetation effects on hydrodynamic and suspended sediment fate. The model was calibrated on field data. Several scenarios of vegetation cover have been considered in order to observe the effect of deforestation and conversion from swamp to arable lands.

Results and conclusions

The analysis of the historical maps, satellite images (Bregoli et al. 2019) and sediment cores (Dutton et al. 2019) shows that major river avulsions and sedimentation increased the wetland area by 3.6 times in the last century (Fig. 1). This result has been supported by interview with local inhabitants. Causes are hydrological fluctuations and strong increasing of deforestation, grazing and farming in the whole river basin.

The morphodynamic model shows that sediments are trapped in the upstream part of the wetland as well as in intermediate sinks zones (Fig. 2). The model also shows that vegetation plays a primary role in sediment trapping and, if a conversion from wetland to arable land is actuated, the trapping efficiency of the wetland system decreases by a half (Fig. 2). This trapping efficiency drop means (e.g.) less nutrients available for the wetland ecosystem functioning, a lower natural water depuration capacity and a deterioration of the water quality being released to the Lake Victoria. Ultimately this study adds a piece of knowledge for wetland conservation, eco-hydrology and water management.

Outlook

The future dam operations, sediment trapping and water abstraction can considerably alter the wetland dynamics. The wetland expansion can be reverted in wetland shrinking and the ecosystem can be jeopardized. Its imminent construction should therefore be accompanied by an in-depth study of river and wetland morphodynamic that could be derived from our hydrodynamic model.

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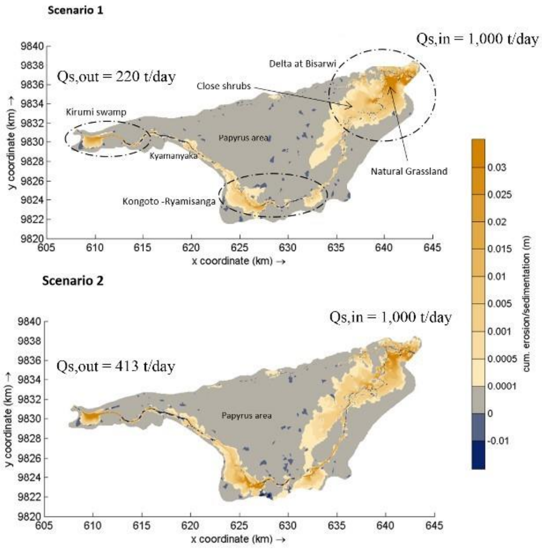

Figure 2. Erosion – sedimentation model results for two selected scenarios of vegetation cover: scenario 1 corresponds to current vegetation distribution; scenario 2 corresponds to a partial land conversion from wetland into arable land.

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