Earth Observation for ecosystem monitoring at the interface of wetland conservation and food production in Rwanda

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Introduction

Sub-Saharan African (SSA) wetlands are increasingly brought into focus as a possibility to **increase food security**. Accordingly, agricultural development in Rwanda's extensive wetland landscapes is strongly promoted. However, agricultural use is a major **reason for wetland degradation** and often **in conflict with conservation** efforts. Detailed and **up-to-date information is needed for national wetland monitoring and management** in order to balance inherent trade-offs, but still lacking in large parts of SSA. Therefore, the objectives of this research were:

- The **development of a flexible EO-based approach** for **tropical wetland delineation and characterization**
- The **testing and validation** of the approach in **Rwanda**, creating **baseline data** at high spatial resolution (10-30 m)

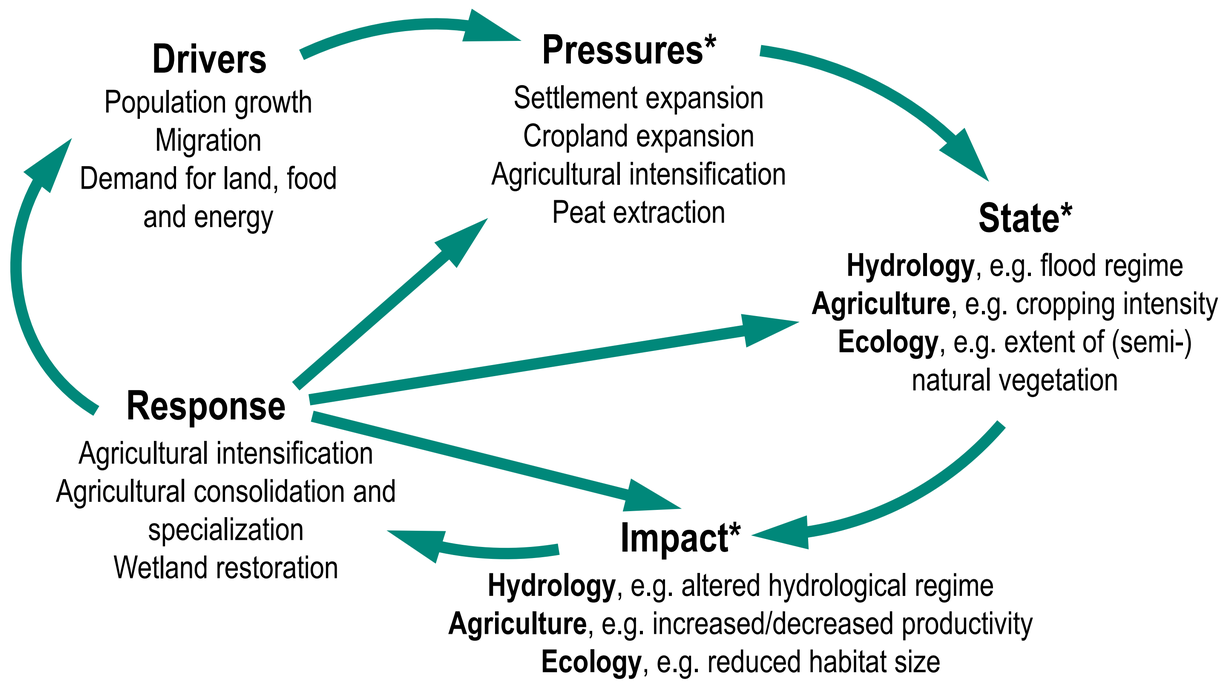

Figure 1: DPSIR scheme for wetland landscapes with selection of elements relevant in agricultural wetland development and wetland protection, compiled from scientific literature. The asterisk marks aspects the approach delivers information for.

Methodology

Potential wetlands
A weighted combination of **SRTM-derived Floodplain Index**, **Multi-resolution Index of Valley Bottom Flatness (MrVBF)** and the **Topographic Wetness Index (TWI)** were used to generate **probabilities**.

Upland

Actual wetlands
The **potential wetlands** layer and **mean NDVI** and **NDWI** derived from a 2017 **Sentinel-2** time series were used in an **object-based** classification. Post-classification editing improved the result.

Surface Water Occurrence (SWO)
49 Sentinel-1 SAR images (IW, VV polarization) **between 2014 and 2017**. Pre- processing included calibration, angle correction and topographic normalization. Each scene was **classified for water** using a **threshold** and **water frequency** calculated.

Wetland Use Intensity (WUI)
The Mean Absolute Spectral Dynamics (MASD[1]) algorithm was adapted to wetland ecosystems and created from multiple **Sentinel-2** images from 2017.

LULC classification
Six **Sentinel-2** tiles acquired in 2016 were cloud-masked and used in **an object-based image analysis**. Objects were assigned according to **spectral, spatial, geometric, thematic or topologic criteria**. Wetland delineation, SWO and WUI were additionally combined to create **variable classes**.

The **approach for multi-layer** national **tropical wetland characterization** provides data for stakeholders' needs in both **agriculture and conservation.**

Results

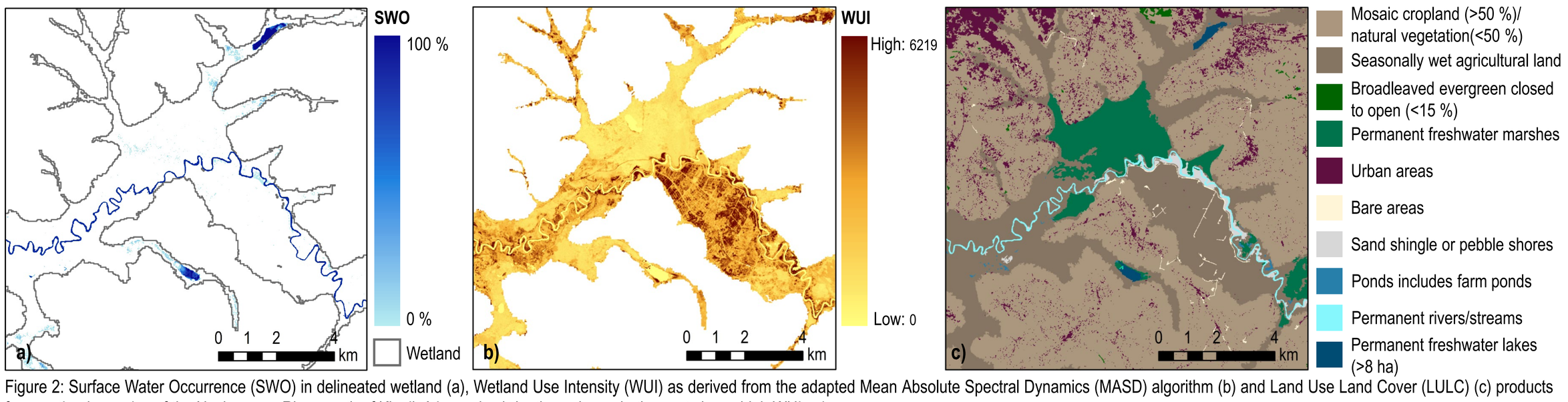

Figure 2: Surface Water Occurrence (SWO) in delineated wetland (a), Wetland Use Intensity (WUI) as derived from the adapted Mean Absolute Spectral Dynamics (MASD) algorithm (b) and Land Use Land Cover (LULC) (c) products for a wetland complex of the Nyabarongo River south of Kigali. A large rice irrigation scheme in the east shows high WUI values.

Validation

Delineation: 255 wetland slices randomly selected and reference wetland area digitized using RapidEye imagery from 2017

- median **areal difference: 15.29 %**
- median **Producer Accuracy: 90.83 %**
- median **User Accuracy: 73.90 %**

LULC: 1258 points were selected randomly for validation of stable classes; these were assigned using RapidEye and high-resolution remote sensing imagery

- **Overall Accuracy: 93,24 %**
- mean **User Accuracy: 88,30 %**
- mean **Producer Accuracy: 89,36 %**

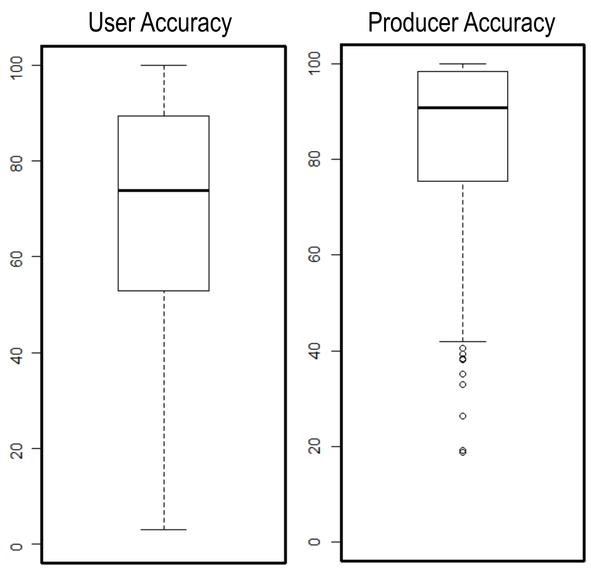

Figure 3: Boxplots of User and Producer Accuracy for the generated wetland delineation data product.

Major findings

- The **multi-layered wetland characterization approach** accurately **detects and describes wetland landscapes** in Rwanda
- **Low cost, reproducibility and repeat coverage** with **high spatial resolution Sentinel** satellites allow the incorporation into **wetland monitoring schemes**
- The datasets as well as their **combination** yield provide information on **hydrology, agriculture and wetland ecology** for governmental and non-governmental **stakeholders in both wetland conservation and agriculture**

[1]Franke, J.; Keuck, V.; Siegert, F. Assessment of grassland use intensity by remote sensing to support conservation schemes. Journal for Nature Conservation 2012, 20, 125–134.

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Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag
DLR

Acknowledgements:
We thank the German Federal Ministry of Economic Affairs and Energy for financial support (FKZ: 50EE1537) as well as the German Aerospace Center