Long-time dynamics in a North African coastal Ramsar site: The Sidi Boughaba Lake, Morocco

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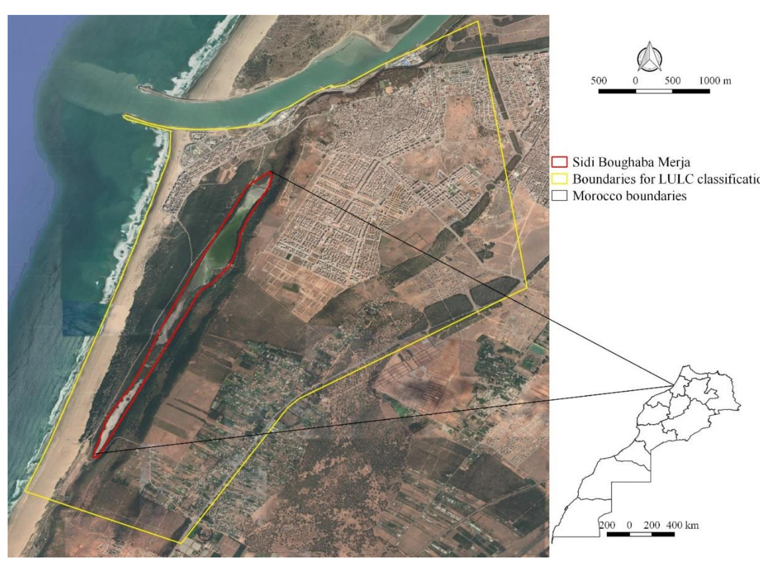
Introduction

Coastal wetlands are known in the North African region for their high levels of biodiversity, with many endemic species of plants and animals. They are playing important roles but experiencing in same time many pressures due to natural and anthropogenic drivers causing permanent, seasonal or periodic changes in their structure and functioning (Grillas et al., 2021). Comprehensive studies of coastal wetlands dynamics can be challenging to conduct due to the complexity of these ecosystems. However, Earth Observation provides opportunities for monitoring water surface dynamics (Pekel et al., 2016), understand the impacts of different drivers on wetland degradation and Land Use Land Cover Change.

This study had two objectives, to assess the spatio-temporal dynamic of *Sidi Boughaba* lake surface area (as example of north African coastal Ramsar site, north of Morocco) over 38 years (1984 – 2021) and to identify natural and anthropogenic drivers of this dynamic, mainly LULC changes and policies.



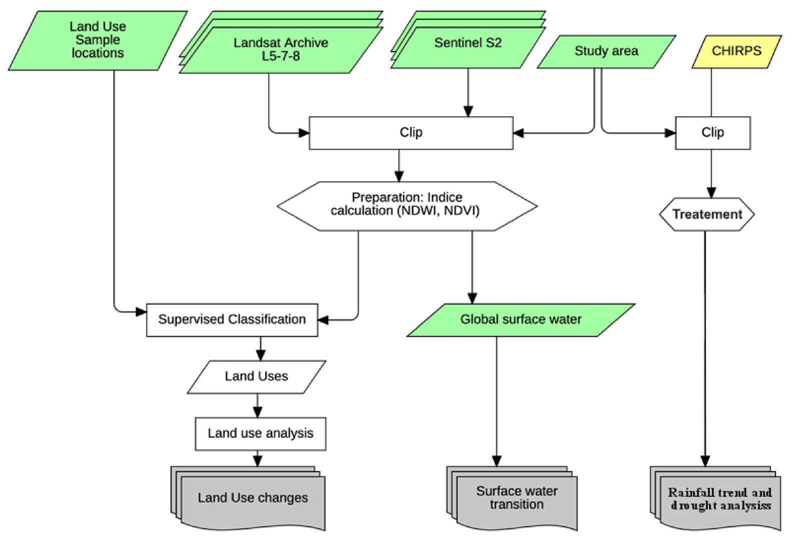
Study area location & surrounding area for LULC classification

Materials and Methods

The overall approach consists on the use of multiple datasets based on remote sensing images (Landsat archives, Sentinel, CHIRPS, Global Surface Water). All datasets were processed in a cloud computing platform providing access to satellite images and tools that greatly facilitates their use, visualization, calibration, analyze and processing (Gorelick et al., 2017).

The water transition maps were developed using the Global Surface Water dataset (Pekel et al., 2016), which provided spatially explicit information on the observed changes in state between the major classes of water occurrence (Not water, Seasonal, Permanent).

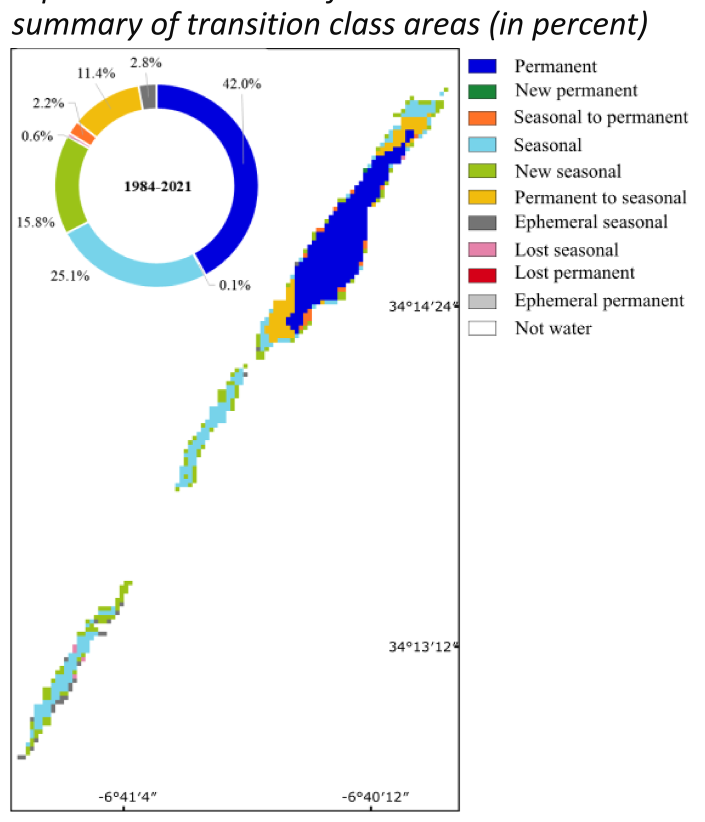
The LULC maps were produced within the surrounding area, including the sub-watershed, to analyze the long-term LULC dynamics and to derive trend statistics and indicators corresponding to each group of aggregated habitat classes.



Flowchart of overall approach

Results and Discussion

Spatial visualization of water transition and summary of transition class areas (in percent)

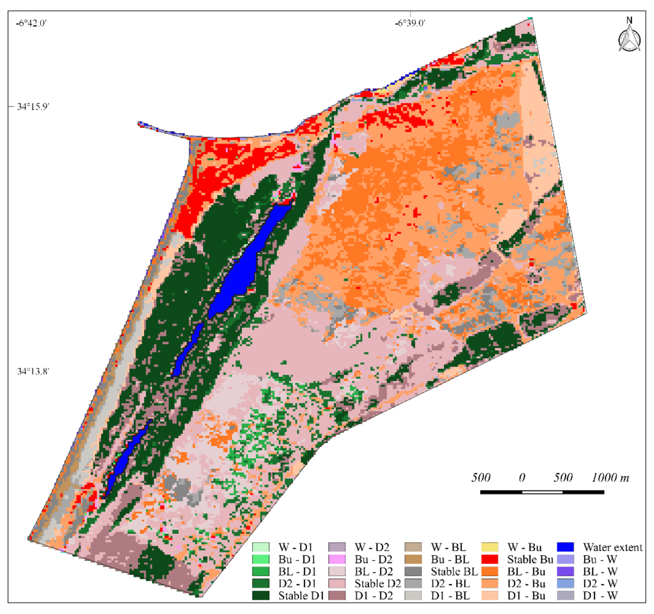


Approach used helps to produce water transition map between the initial date 1984 and the last year of monitoring 2021 and captures changes between different classes of water. Results show the representativeness of each water class transitions. The lake extent fluctuates seasonally following the rainfall pattern and gradually rises and decreases respectively during winter and summer period. The maximum extent of detected water in the lake from the first and last of the observation record covers approximately an area of 551 898 m2. Significant part of water extent (32.9 %) experienced different transitions between the two dates. An important area was affected by a transition from not water to seasonal (16 %).

The seasonal class has not changed too much, while the permanent water class has shown a significant drop in water extent 42% (2021). An extensive transition from the permanent to the seasonal water class was recorded on approximately 10 % of the global surface mainly in the center part of the *Sidi Boughaba* lake. The transition from seasonal to permanent water were noted in very restricted areas (2.2 %).

Overlying LULC maps for 1984 and 2021 allowed for the development of the LULC change map between the two dates. Spatial analysis of the LULC changes revealed landscape dynamics and highlighted different evolution processes that took place, including a regressive trend in the two vegetation classes and a progressive trend in the Built-up class. Such trends could be largely explained by increasing anthropogenic pressure with remarkable urbanistic development. The initial land uses that have not been affected by changes in cover in each class are 52.7% (409.12ha), 43.3% (579.29ha), 14.3% (76.33ha) and 69.3% (108.10ha) respectively, for the "High dense vegetation D1, "Low dense vegetation D2", "Bare Land BL", and "Built-up Bu".

The most significant conversions concerned the transition from D2 and BL classes to Bu class (respectively 41% and 52.3% of the initial D2 and BL classes), and from D1 to D2 (27.3% of the initial D1 class).



LULC changes from 1984 to 2021 (D1—High dense vegetation; D2—Low dense vegetation; BL—Bare Land; Bu—Built-up; W—Water)

While natural factors may contribute to explain some traits of the regressive dynamics, human-induced activities are the main trigger for the transformations that natural areas are currently undergoing (Sayad and Chakiri, 2010). The pressure on resources and the regressive trend recorded in the dynamic of the lake are likely to increase further in future years if effective protection measures are not implemented, especially in the context of proven global change (Grillas et al., 2021).

Conclusions

Results highlight intra and inter-annual variations in the *Sidi Boughaba* lake over the study period, including significant losses of permanent water between 1984 and 2021. The water transition maps produced in this study have improved our understanding of the extent of water areas that have experienced transitions and have allowed us to identify which part of the lake is more affected by these transitions. Changes in the dynamic and extent of the lake are mainly the result of the combined effects of natural and anthropogenic factors, including climate variability and urban expansion and agricultural policies that have led to serious consequences for surface water resources in the surrounding area. Therefore, measures to reduce pressure and protect this natural resource for future generation are necessary.

Acknowledgements

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