CELLULAR AUTOMATA AND MARKOV CHAIN ANALYSIS TO EVALUATE SOIL-WATER ECOSYSTEM REGULATING SERVICES SUSCEPTIBILITY TO LUCC TEMPORAL CHANGES

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ABSTRACT: The objective of this research is to establish a procedure for analyzing the dynamics of Land Use and Cover Change (LUCC) and water quality whose parameters can be used to make a historical evaluation of factors related to the presence of cyanobacteria in surface fresh waters. The study was carried out in two environmentally different water bodies: the As Conchas reservoir, province of Orense, Northwest Spain, and the Albufera de Valencia lagoon, province of Valencia, Eastern Spain.
Results show that in both areas, there is a considerable fraction of agriculture surfaces, although LUCC dynamics and influence in soils water storage were different, being more intense in the Albufera de Valencia where expansion of artificial surfaces and intensive irrigation farming are constant trends. The application of a LUCC spatial model with future scenarios is feasible in both areas and could contribute to the long-term evaluation of LUCC links to soil-water quality and quantity dynamics.

Keywords: Land Use/Cover Analysis, Dinamica EGO, Geospatial Modelling, Ecosystem Services.

INTRODUCTION

Land Use/Cover Changes related to water quality and quantity processes

Information on land use/cover changes (LUCC) has potentials worthy exploring for the evaluation of water quality and quantity (Lin et al. 2015). Land cover change models are also of interest for the temporary monitoring and evaluation of the behavior of cyanobacteria proliferation in surface waters. It is considered that the presence of cyanobacteria in fresh waters is also related, among other environmental factors (Mischke 2003), to land cover dynamics (Matysik et al. 2020). Among land covers, agricultural trends have a major influence, as well as their spatial distribution and distance from the water body, in water properties (Hung et al. 2020).

LUCC spatial analysis, change and future scenario models

Spatial and temporal analysis of LUCC dynamics should imply the application of quantitative models to establish the projection of historical land covers to future scenarios (Belda-Carrasco et al. 2019) and to foresee how LUCC affect ecosystem services performance, including those services related to water regulation in the interaction of LUCC with soil functions.

Study areas

The study is carried out in two water bodies environmentally differentiated: the reservoir of As Conchas in the province of Orense, Northwest Spain and the Albufera of Valencia, a Mediterranean coastal lagoon, in the province of Valencia, East Spain (figure 1).

Fig. 1 Study areas location: 1 As Conchas Reservoir, 2 Albufera de Valencia Lagoon**.**

Objectives

The general objective was to establish a procedure for analyzing historical and future LUCC dynamics and its relation with the water holding capacity of soils that could

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be related to the presence of cyanobacteria in inland freshwaters.

Specific objectives were (1) identification of spatial and temporal LUCC trends (2) creation of a change model based on historical LUCC for the future projections of land cover dynamics and (3) evaluation of past and future LUCC impacts on soil water capacity as a proxy indicator.

METHODOLOGY

Methodology has been structured in five consecutive phases: (1) identification of land cover at different homogeneous temporal moments; (2) identification of the spatial variables that contribute to LUCC temporal dynamics (changes) (3) generation of a spatial simulation model of LUCC for each of the study areas, (4) analysis of the historical changes in land cover, and future scenarios for the years 2030 and 2050, following the results obtained in phase 3, and (5) spatial and temporal analysis of the water storage capacity of soils according to each land use cover of the historical series and future scenarios.

Initial data for both study areas consisted of land cover vector layers (years 1990, 2006 and 2018), Digital Elevation Models (25x25 m pixel resolution), a vector layer with lithology information, a raster layer with imperviousness data (25x25m resolution), soils water and wetness information (25x25m resolution), and a vector layer with information on natural protected areas.

Geographical Information Systems techniques using QGIS (v. 10.14) were applied to data integration, harmonization and analysis (phases 1, 2, 4 and 5).

LUCC model and future scenarios construction (phases 2 and 3) were developed applying stochastic processes with Markov Chain and Cellular Automata techniques using Dinamica EGO software (Rodrigues and Soares-Filho 2018).

RESULTS

LUCC historical dynamics

Land use-cover types were similarly defined for both study areas: Urban (U10), Rainfed farming (A21), irrigated heterogeneous farming (A24), Irrigated citrus farming (A25), Rice paddies, only found in la Albufera de Valencia area (A26), Forest and Shrub (N30) and Water Surfaces (H50).

Differences in land cover changes are observed when comparing the study areas, that may be explained by specific territorial dynamics existing in each one. The change for the area of As Conchas (figure 2) is quite stable and with a slight deceleration over the years, being the urban covers (U10) and the agricultural mosaic rainfed (A21) the ones that grow the most, with clear reduction in the rest of the agricultural ones.

The change for the area of the Albufera of Valencia (figure 3) is accelerating over the years, being the urban covers (U10) the ones that grow the most and the agricultural ones that decrease, apart from the rice paddies (A26) that is very stable over time.

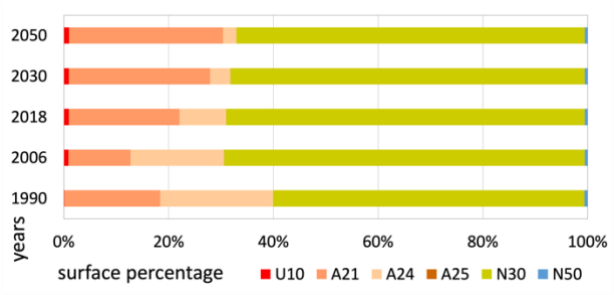

Fig. 2 Percentage of land cover for the years 1990, 2006, 2018 and the 2030 and 2050 scenarios in As Conchas.

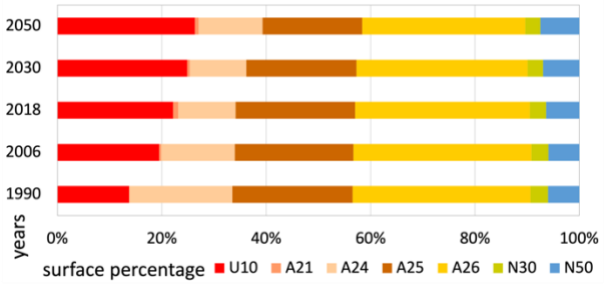

Fig. 3 Percentage of land cover for the years 1990, 2006, 2018 and the 2030 and 2050 scenarios in Albufera of Valencia.

LUCC related to water regulation (storage) soil services

The land cover dynamics are reproduced in the soil water retention capacity, with a different behaviour for both areas. In As Conchas the soil water retention capacity remains unchanged (figure 4), mainly due to the low overall increase in urban covers (U10).

On the contrary, in the Albufera of Valencia the soil water retention capacity is reduced (figure 5), being the urban covers (U10) the ones that most influence for a much greater waterproofing of the soil, which increases the surface runoff.

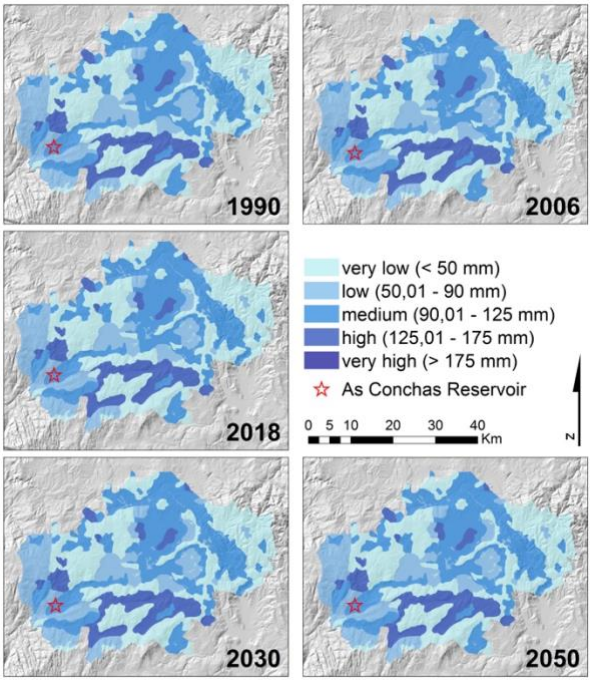

Fig. 4 LUCC-Soils water retention capacity in As Conchas Reserovir.

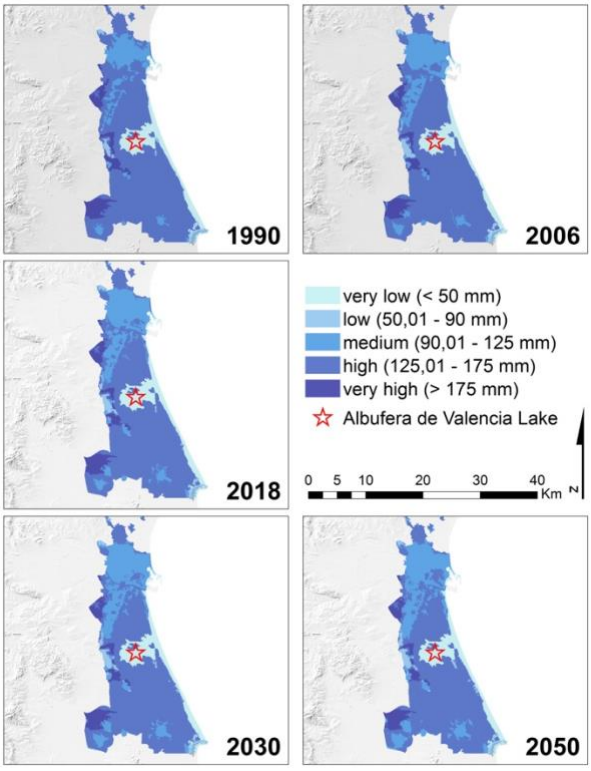

Fig. 5 LUCC-Soils water retention capacity in Albufera of Valencia.

CONCLUSIONS

LUCC analysis linked to the geospatial model for the generation of future scenarios allows relating water parameters with historic trends and future evolution of land cover. The LUCC scenarios obtained with the model allow us to obtain water storage scenarios related to the historical trends in land cover and their future scenarios.

More stable LUCC trends are identify in the area of As Conchas compared to LUCC intensification of artificial surfaces found in the area of the Albufera of Valencia. LUCC are related to the capacity of water storage in the soil that in turned should be linked to water quality. Therefore, the application of a spatial model with LUCC scenarios is feasible in both areas. This model could contribute to the long-term evaluation of LUCC links to soil-water quality and quantity dynamics.

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