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Sedimentary processes in the Isla Cristina salt-marshes: Geomorphological changes of landscape

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ABSTRACT

The Isla Cristina salt marshes, located in the Southwest of Andalusia, constitute one of the most important nature reserves in the province of Huelva. In recent decades, as a consequence of climatic factors, and in addition to the loss of forest and agricultural formations adjacent to these wetlands, there has been a decline in biodiversity and productivity, resulting in a fragile and sensitive landscape. With the development of image processing techniques and of high-resolution satellite imagery, it is possible to obtain sufficiently precise patterns of erosion. In this paper, our new patented methodology is applied in order to measure the total volume of eroded soil in the Isla Cristina salt marshes. The various causes that give rise to this phenomenon are discussed, as well as the influence of intertidal processes. The results show how the erosion processes are related to both Land Use Change (LUC) and the morphometric characteristics of these tidal salt-marshes. The increased erosion levels are due to the influence of the Guadiana, Tinto, and Odiel rivers.

1. Introduction

Although natural processes performed across the ecosystem, with all their LUC implications, have been studied worldwide, it remains difficult to extrapolate the results to other areas, especially on a small scale (Ramírez-Juidías et al., 2015b). Airborne platforms can contribute towards the solution of this problem, but the use of satellite images of Very High Resolution (VHR) presents a major advantage, since it provides the spatial information needed for the analysis on the scale of the marsh, in addition to relevant information on the relationship between climate change and soil erosion.

It is well-known that erosion constitutes one of the most important environmental risks, even to the extent of adversely affecting the carrying capacity of the environment. In the marshes of Isla Cristina, successive silting brings substantial changes to its physical form and its ecological health, giving rise to a variable flooding system related to tides, human intervention, the interaction of the wind, and the influence of rivers, among other aspects. Moreover, and as specified by Soto et al. (2015), the endogenous conditions of these marshes, mainly due to their low relief, contribute synergistically to the exogenous geodynamics of the landscape, since these conditions also constitute generating agents of processes that are derived under threat conditions.

To date, most studies on remote sensing in marshes have been carried out based on spatio-temporal changes in vegetation cover and/or abundance of existing species; these approaches are in terms of the quantification of soil loss, all based on the reflectance of different types of soil and/or plant canopy. However, new techniques of digital image processing permit the use of methodologies based on fuzzy logic, through which it is possible to obtain solutions that are very close to reality, especially when VHR images interact with data from Unmanned Aerial Vehicles (UAVs) equipped with electronic scanning radar sensors.

In this article, whose objective is the prediction of soil erosion in the marshes of Isla Cristina, the integrated analysis of environmental and topographic variables will enable the identification of the areas susceptible to phenomena of loss or accumulation of soil, for which the analysis of the flooding associated with soil drainage, and the use of digital terrain models and attainment of digital surface models (both generically called Digital Elevation Models (DEMs)), will be vital.

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2. Material and methods

2.1. Area of study

In accordance with Ojeda-Zújar et al. (2006), the area of Natural Marshes of Isla Cristina (Fig. 1), included in the estuary of the Guadiana River, consists of a complex network of dendritic drainage with canals, streams and tidelands silted by successive sedimentary drifts, which form tidal marshes associated with the mouth of the Guadiana and Carreras rivers.

With a total area of 24,980,400 m^2, the vulnerability of the space under threat (REDIAM, 2008) is classified as *very high* for 42% of its surface, as *high* for 32%, and as *moderate* in the remaining 26%.

In another vein, the climate of the area can be defined as Mediterranean oceanic, with a degree of insolation which exceeds 4200 h/year. During the winter season, characterised by a short period of low temperatures, is when most of the precipitation falls. On the other hand, the long, dry summers are mild due to the proximity to the Atlantic Ocean, and the absolute maximum temperature does not exceed 43 °C. The annual rainfall of 477 mm, is concentrated in the months of December and January, and the dry season has a deficit in the water balance from May to September, inclusive.

2.2. Data and methodology

For this study, a total of 21 control points were distributed throughout the study area (Fig. 2), each of which was georeferenced in the ETRS-89 system. In November 2014, the acquisition of images of the marshes of Isla Cristina was initiated using a UAV equipped with a radar system capable of collecting and recording the various points of the Natural Area (data taken with the UAV took place during low tide). Similarly, while the radar images were being taken, RGB (380–780 nm) images were also taken, which, together with the VHR images from the Pléiades (panchromatics of 0.5 m resolution obtained from the AIRBUS DEFENSE & SPACE platform,

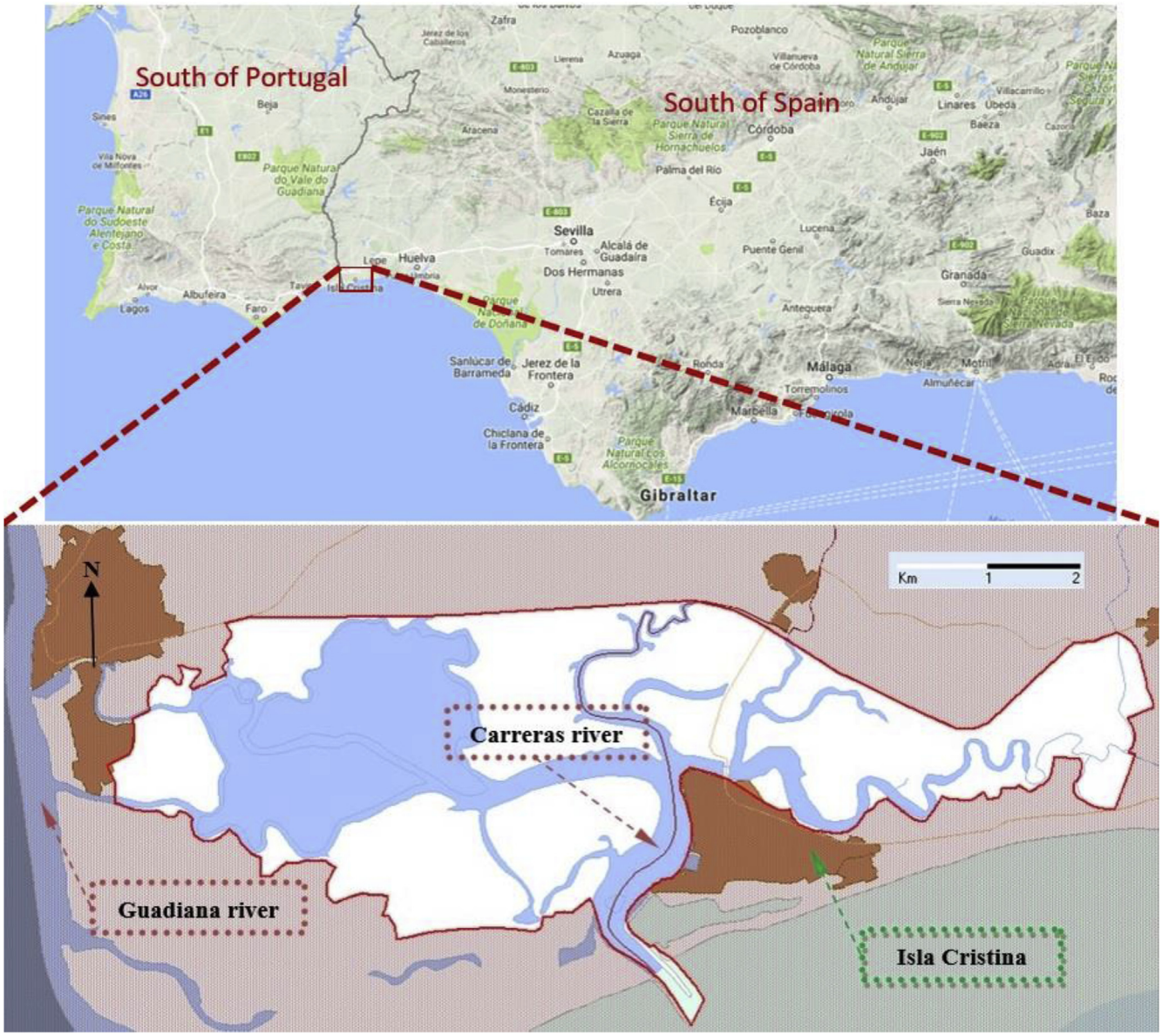

Fig. 1. Localisation of the area of study.

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