Hydromorphological evolution of large Iberian rivers: the role of anthropogenic pressure in Tagus and Minho Rivers

Évolution hydromorphologique des fleuves ibériques : le rôle de la pression anthropique dans les grandes rivières Tage et Minho

M. Rosário Fernandes1*, Francisca C. Aguiar1, M. João Martins1, Rui Rivaes1, Alban Kuriqi2, M. Teresa Ferreira1

[1] Forest Research Centre (CEF), School of Agriculture, University of Lisbon, Tapada da Ajuda, 1349-017 Lisboa, Portugal
2 Centre for Hydrosystems Research (CEHIDRO), Instituto Superior Técnico, University of Lisbon, Av. Rovisco Pais, 1049-001 Lisboa, Portugal
* (corresponding author: mrfernandes@isa.ulisboa.pt)

RÉSUMÉ

L'objectif principal de cette étude est la caractérisation de l'évolution hydro morphologique des grandes rivières Tage et Minho, et la contribution des perturbations humaines (régulation des débits) aux changements globaux. On a utilisé des images satellite pour l'analyse temporelle en choisissant des dates représentant une période pré-régulation (19ème siècle) et une période post-régulation (21ème siècle). On a observé des altérations hydro morphologiques distinctes selon le gradient longitudinal des deux rivières résultant de diverses intensités de perturbations hydrologiques couplées à des changements LULC distincts. Les résultats obtenus contribuent à comprendre les trajectoires évolutives des grands écosystèmes fluviaux de la Péninsule Ibérique et à soutenir des solutions de gestion et de restauration plus précises et spatialement explicites.

ABSTRACT

The main objective of this study is to characterize the hydromorphological evolution of Tagus and Minho rivers, using a planform image analysis, and assess the contribution of human disturbance to global change. We performed a temporal analysis by choosing dates representing a pre-regulation period (19th century) and a post-regulation period (21th century). Distinct hydromorphological alterations were observed across the longitudinal gradient of both rivers resulting from diverse intensities of hydrological disturbances coupled with distinct LULC changes. The results obtained contribute to understand the evolutionary trajectories of large river ecosystems in Iberia and support a more accurate and spatially explicit management and restoration solutions.

KEYWORDS

Fluvial morphology, historical maps, hydrological alterations, land-use change, large rivers

1. INTRODUCTION

River morphology, i.e, the shape of river channel and riverine landscapes, results from the combination of hydro-geomorphological alterations and the interplay with vegetation dynamics. Changes in the geometry of river planforms describe alterations in ecological processes, like the loss of physical habitat for biota, the disruption of the longitudinal continuity of the river and lateral disconnection between aquatic and terrestrial ecosystems (Grabowski *et al*., 2014). In large Iberian rivers these fluvial geomorphologic alterations reflect the long-history of human activities in river channels and surrounding floodplain areas (Corenblit *et al*., 2010) and can be used as a proxy of the river ecological status.

Image planform analysis and historical cartographic data have been used to characterize river geomorphology and to tackle the hydromorphological evolution of large rivers (Dufour *et al*., 2015). Patterns of stream sinuosity reduction, channel narrowing and loss of geomorphic landscape diversity were related with changes in sediments dynamics, mainly driven by human activities such as flow regulation, gravel mining, river embankments, floodplain land-conversion, intensive livestock and forestry practices surrounding river margins (Corenblit *et al*., 2010; Dufour *et al*., 2015).

The main objective of this study is to characterize the hydromorphological evolution of two large Iberian rivers, Tagus and Minho, using a planform image analysis, and assess the contribution of human disturbance (hydrological and land-use alterations) to global river change.

2. METHODS

We performed a temporal analysis by choosing dates representing a pre-regulation period (19th century) and a post-regulation period (21th century). Historical military maps and contemporaneous military maps combined with Google Earth Imagery were used to extract hydromorphological variables, such as active channel dimensions and geometry and sinuosity indexes. A Geographic Information System (GIS) was used to georreferenced the historical images and to store and organize all the spatial data. Each river was partitioned into 2500m long river stretches (Figure 1), in a total of 128km and 88km analysed for Tagus and Minho, respectively. Land-use Land Cover (LULC) data were obtained by mapping, in a 200m-buffer, by visual interpretation of the historical maps and using COS 2007 for the contemporaneous post-regulation date. Hydrological data were compiled from the Portuguese and the Spanish Water Information System (contemporaneous data) and modelled for the historical period using Soil and Water Assessment Tool software. We used ANOVA and post hoc Tukey tests to identify the pairs of time periods associated to significant mean differences in each hydromorphological variable.

2. RESULTS AND DISCUSSION

The results revealed significant hydromorphological changes and an overall reduction of the geomorphological diversity in both rivers. We observed patterns of channel narrowing and a decrease in stream sinuosity representing an overall degradation in both rivers. However, changes in Tagus were more evident, and especially relevant, in upstream sections, while Minho was particularly impaired in downstream sections. This result might be associated to the fact that Minho is considered a river with small human impacts, mostly dominated by natural flow regimes, while Tagus is considered a heavily regulated river with high population density and intensive urban and industrial development in the floodplain.

Distinct hydromorphological alterations were observed across the longitudinal gradient of both rivers resulting from diverse intensities of hydrological disturbances coupled with distinct LULC changes. The results obtained contribute to characterize the historical hydromorphological condition and to understand the evolutionary trajectories of distinct river typologies, supporting more accurate and spatially explicit management and restoration solutions for large rivers.

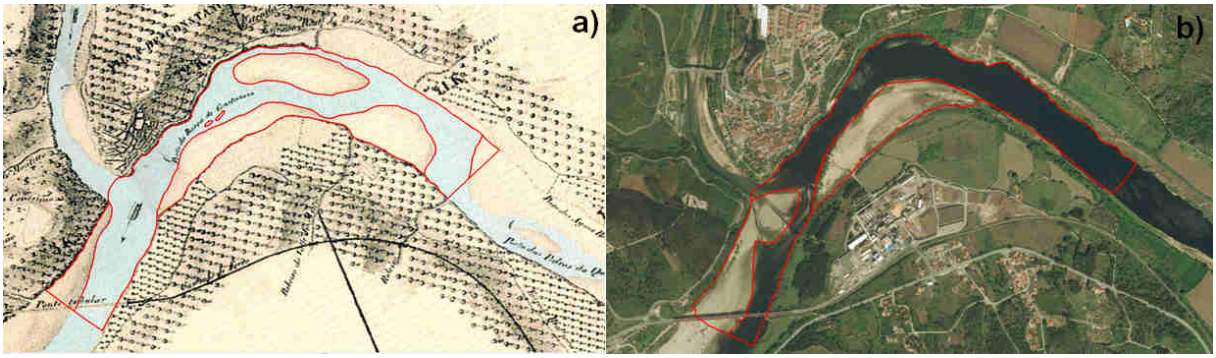

Figure 1 - Illustration of delimitation of sampling units and morphological features for Tagus (Sampling Unit 24) for the a) pre-regulation period (1898) and b) the post-regulation period (2016).

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