Evolution and relationship between land use and the active channel over the last half century in the Ebro basin

Évolution et relation entre l'occupation du sol et le lit actif de la rivière au cours du dernier demi-siècle dans le bassin de l'Ebre

Saioa García-Rodríguez[1], Ana Sáenz de Olazagoitia[1], Daniel Ballarín[2], Askoa Ibisate[1], Miguel Sánchez-Fabre[2], Orbange Ormaetxea[1], Ibai Ortiz de Arri[1], Galder Mentxaka[1], Valeria Pirchi[2], Juan Miguel García[2], Carles Ferrer-Boix[3], Alfredo Ollero[2]

[1]Geography, Prehistory and Archaeology Department, University of the Basque Country, saioa.garciar@ehu.eus; ana.saenzdeolazagoitia@ehu.eus; askoa.ibisate@ehu.eus; orbange.ormaetxea@ehu.eus; iortizdearri003@ikasle.ehu.eus; gmenchaca002@ikasle.ehu.eus
[2]Geography and Land Management Department, University of the Zaragoza, danielbf@unizar.es; msanchez@unizar.es; vpirchi@unizar.es; aollero@unizar.es
[3]Department of Civil and Environmental Engineering, Technical University of Catalonia, carles.ferrer@upc.edu

RÉSUMÉ

Le projet EbroHydromorph vise à étudier les changements morphologiques du cours moyen de l'Ebre (entre Logroño et La Zaida) au cours des dernières décennies, et en particulier le transport des sédiments. Dans une première phase, une étude historique des changements d'occupation des dans le bassin de l'Ebre drainant le point final de la section d'étude est réalisé, dans le but de découvrir comment cela a affecté les conditions hydrogéomorphologiques des cours d'eau. L'élaboration de la cartographie du milieu du 20ème siècle a été un travail laborieux réalisé en numérisant les usages et en la complétant avec certaines des cartes déjà établies antérieurement dans certaines zones du bassin étudié. Les occupations de sols du milieu du 20ème siècle ont été reconstruites et comparées à celles disponibles dans la cartographie de l'utilisation du sol de 2014, en analysant plus en détail la modification des surfaces des chenaux actifs de l'ensemble du bassin, en tant qu'indicateur des changements dans les flux et les apports de sédiments. Les résultats préliminaires montrent une réduction drastique des surfaces de chenaux actifs, tandis que les zones forestières, artificielles et de prairies ont augmenté.

ABSTRACT

The EbroHydromorph project aims to study the morphological changes of the middle Ebro river (between Logroño and La Zaida) in recent decades, and sediment transport in particular. In a first phase, a historical study of land use changes in the Ebro river basin draining to the end point of the study section is being carried out, with the aim of finding out how this has affected the hydrogeomorphological conditions of the river courses. The elaboration of the cartography of the mid-20th century has been a laborious task carried out by digitising the uses and completing it with some of the maps already drawn up previously in some areas of the studied basin. Land use cover of the mid-20th century have been reconstructed and compared with those available in the 2014 land use mapping, analysing in greater detail the modification of the active channel surfaces of the entire basin, as an indicator of the changes in flow and sediment inputs. The preliminary results show a drastic reduction of active channel surfaces, while forest, artificial and grassland areas have increased.

KEYWORDS

Active channel, channel adjustment, land use, morphological simplification, Ebro basin

Lit actif, ajustement du lit, occupation de sol, simplification morphologique, bassin de l'Ebre

1 BRIEF CONTEXT AND OBJECTIVE 1

The fluvial dynamics of the Ebro River and its tributaries have undergone profound transformations in recent decades due to changes in land use and changes in water use and management throughout the basin (Ollero, 2010; Besné and Ibisate, 2015).

One of the objectives of the *Ebro Sediment Observatory (OSE) project: hydromorphological impacts resulting from human activity; implications for flood risk and sediment management*, which forms part of the *SEDEXCHARE (Sediment, hydrological extremes, historical-environmental changes and fluvial resilience: the Ebro River)* (Ollero et al., 2024), is to quantify the historical changes in land use in the drainage basin of the middle course of the Ebro River from the mid-20th century to the present day, with the aim of finding out how this has affected the hydrogeomorphological conditions of the river courses, and of the middle Ebro mainstem in particular.

The overall project aims to study the 354 km free meandering middle reach between Logroño and La Zaida. In the case of the work presented here, it involves the study of the entire drainage basin up to the end point of the section at La Zaida (Fig. 1), which covers an area of 49,434.03 km^2.

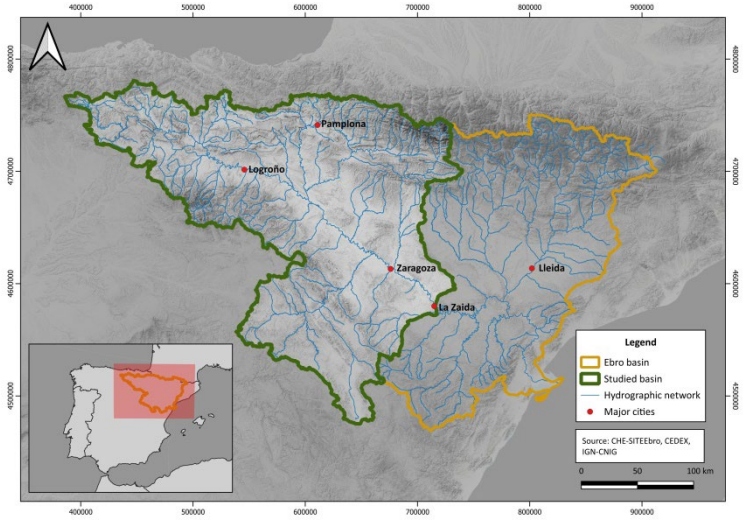

Figure 1. Studied area of the Ebro basin.

2 METHODOLOGY

By means of Geographic Information Systems (GIS) the changes in land use within the basin have been quantified, especially by analysing the evolution of the active channel.

Initially, an exhaustive search of all available cartography and aerial imagery was carried out, covering the entire basin from 1927 onwards. Due to the scarce availability of land use cartography from the 20th century, it was decided to use aerial images from the American Flight B series (1956-1957), since these images cover the whole of the basin under study. In addition to the digitisation carried out (24614 km^2, 49.8% of the basin studied), the cartography has been completed with other previously published works that have covered part of the basin (Ceballos, 1966; Government of Navarra, 2009; Heredia, 2011; Berger, 2022; Errea et al., 2023).

The classes considered in the mapping are: forest, shrubs, grassland, artificial, bare soil, crops, artificial water features, active channel. They were selected for three main reasons: i. the role that each land cover class has according to the scientific literature in the contribution of sediment and runoff that may have an impact on the hydromorphological characteristics of the streams, ii. the integration of the pre-existing classes in the mapping carried out in previous studies, iii. the ease of mapping these classes given the scale of the work.

The 1956-1957 land cover surface has been compared with a current cartography, using the information provided by the Spanish Land Cover Information System (SIOSE) of 2014. This choice is based on three main

reasons: i. the working scale of SIOSE (1:25.000) is the closest to the previous cartography available, ii. the CODIIGE classes are easily comparable with the previous classes, although with some adjustments, iii. the text field SIOSE_CODE provides detailed information on the attributes and coverages of each polygon, facilitating the analysis. After a thorough review, the CODIIGE classes were reclassified to fit our categories. In some cases, the original polygons were modified, especially in the bare soil and active channel classes.

3 PRELIMINAR RESULTS

The results gave us a land cover surface distribution for 1956-57 and 2014 that allowed us the comparison of both dates (Figure 2 and Table 1).

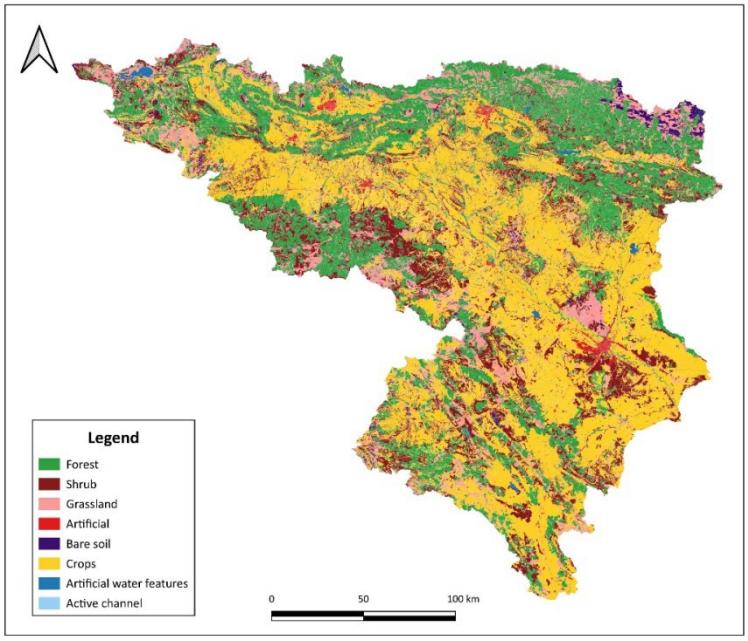

Figure 2. Land cover in 2015.

Table 1. Land cover distribution in 1956 and 2014

Land cover classes	1956 (%)	2014 (%)	Change (%)
Forest	15.74	22.12	40.51
Shrubs	24.10	17.04	-29.31
Grasslands	5.86	9.46	61.44
Artificial	0.64	2.21	245.92
Bare soil	1.72	1.39	-19.40
Crops	51.26	47.19	-7.94
Artificial water features	0.42	0.56	33.61
Active channel	0.26	0.04	-85.14
TOTAL	100	100	

The areas of active channels are the most affected, with a reduction of 85% of their surface area (Table 1 and Figure 2).

Figure 2. Example of active channel change in a river reach of Jubera River, tributary of Ebro River, between 1956 and 2014.

This has led to the colonisation by the vegetation and the stabilisation of many sediment deposits, which reduces the contribution of sedimentary material, especially pebbles and gravel, downstream, reducing the contributions to the river Ebro as the mainstem. In addition, there is a simplification in the typologies of riverbeds and channel morphology, with a reduction in the number of braided riverbeds and a loss of geomorphological heritage.

At the same time, there is a significant reduction of bare soil and sediment contributing areas, while forested areas and grassland areas have increased.

The work will be complemented by the catchment area affected by the regulation by reservoirs restricting the catchment that provides sources of sediment.

This research project, PID2022-138196OB-C32 ("The Ebro Sediment Observatory (OSE): hydro-geomorphological adjustments in response to human-induced impacts. Implications for flooding risks and sediment management (EbroHydroMorph)"), has been funded by Spanish Research State Agency.

LIST OF REFERENCES

Berger, D. 2022. *Ajuste geomorfológico de un tramo del río Linares en respuesta a impactos y presiones en el cauce y su cuenca*. Trabajo Fin de Grado. Universidad del País Vasco, 52 pp.

Besné, P., Ibisate, A. 2015. River channel adjustment of several river reaches on Ebro basin. *Quaternary International*, 364: 44-53.

Ceballos, L. (dir.) 1966. *Mapa forestal de España*. 1:400.000. Ministerio de Agricultura. Madrid, 50 pp. + cartografía.

Errea, M.P., Cortijos-López, M., Llena, M., Nadal-Romero, E., Zabalza-Martínez, J., Lasanta, T. 2023. From the local landscape organization to land abandonment: an analysis of landscape changes (1956–2017) in the Aísa Valley (Spanish Pyrenees). *Landscape Ecology*, 38: 3443-3462.

Heredia-Laclaustra, A., Frutos-Mejías, L.M., González-Hidalgo, J.C. 2013. Diferencias en la evolución del paisaje entre dos municipios prepirenaicos (Alquézar y valle de Lierp) durante la segunda mitad del siglo XX. Pirineos. *Revista de Ecología de Montaña*, 168: 77-101.

Ollero, A. 2010. Channel changes and floodplain management in the meandering middle Ebro River, Spain. *Geomorphology*, 117(3): 247-260.

Ollero, A., Ibisate, A., Ferrer-Boix, C., Martín-Vide, J.P., Ballarín, D., Castillo, P., Garcia, J.M., García-Rodríguez, S., Melián, Á., Núñez-González, F., Ormaetxea, O., Pirchi, V., Sáenz de Olazagoitia, A., Sánchez-Fabre, M. 2024. El curso medio del río Ebro: bases preliminares para su diagnóstico hidromorfológico y perspectivas de gestión y restauración. *Cuadernos de Geografía*, 112: 131-149.