

## **Socio-ecological indicators to evaluate Global Change effects on Mediterranean river basins. The study cases of Tordera and Besòs River Basins**

Indicateurs socio-écologiques pour évaluer les effets du changement global sur les bassins fluviaux méditerranéens. Les cas d'étude des bassins de la Tordera et de Besòs

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### **RÉSUMÉ**

Depuis 1996, le Projet de *L'Observatori de la Tordera* se charge de relever des indicateurs socio-écologiques en collaboration avec les institutions locales et régionales afin d'évaluer la situation environnementale dans le Bassin de la Rivière Tordera, situé dans les provinces de Girona et Barcelone (NE de la Péninsule Ibérique) et occupant une surface totale de 898 km<sup>2</sup>. En ce qui concerne ces indicateurs, dix lignes de recherche biologique et hydrologique ont été consolidées, cinq d'entre elles dans le cadre de la Directive Cadre sur l'Eau (2000/60/CE). On compte appliquer ce modèle de méthodologie en 2018 aux proximités du Bassin de la Rivière Besòs, avec une surface totale de 1,038 km<sup>2</sup>, qui comprend une partie de la Zone Métropolitaine de Barcelone. Pendant les années 60 et 70 le Bassin de la Rivière Besòs connut un important développement industriel et aussi une croissance démographique qui provoqua une utilisation abusive des rivières avec d'importantes conséquences sur la qualité des systèmes fluviaux et sur leur débit d'eau. En prenant le modèle du Projet de *L'Observatori de la Tordera*, on mettra en route le Projet de *L'Observatori del Besòs* qui constituera un instrument destiné à évaluer les indicateurs socio-écologiques dans un contexte de changement global. Dans ce sens, l'évolution des Terrains Occupés et des Terrains Utilisés (TOTU) est considérée comme le principal facteur du changement global de la région. Il s'ensuit que la recherche a pour but l'évaluation des implications du TOTU dans les indicateurs de la qualité de l'eau.

### **ABSTRACT**

Since 1996, *L'Observatori de la Tordera* Project carries out a long-term monitoring of socio-ecological indicators in collaboration with local and regional institutions to assess the environmental status of the Tordera river basin, located between Girona and Barcelona provinces (NE Iberian Peninsula) and with a total surface of 898 km<sup>2</sup>. Referring to these indicators, ten biological and hydrological research lines have been consolidated, being five of them included into the Water Framework Directive (2000/60/EC). In 2018 this model methodology is expected to be replicated to the nearby Besòs river basin, with a total surface of 1,038 km<sup>2</sup>, including part of the Metropolitan Area of Barcelona. During the 1960s and 1970s decades, the Besòs river basin underwent a great industrial development and also a demographical increase, which provoked an abusive use of rivers with several consequences in terms of fluvial systems quality and water quantity as well. Taking the model of *L'Observatori de la Tordera* Project, *L'Observatori del Besòs* project will be launched as a tool to assess socio-ecological indicators in a context of global change. In this sense, Land Use and Land Cover change (LULC) is considered as the main component of global change in the region. Therefore, the research aims to evaluate the implications of LULC on water quality indicators.

### **KEYWORDS**

Biodiversity, environmental status, global change, long-term monitoring projects and socio-ecological indicators

## 1. INTRODUCTION

Mediterranean areas have strong inter-annual climatic variability mainly characterized by a dry period in summers. This, in addition to a great water demand to meet the needs of the increasing population and other anthropogenic activities related such as the development of industry, intensive agriculture and tourism activities (Cudennec *et al.*, 2007), represents an evident variability in rivers discharge annual regime, from permanent to temporal. Therefore, flows are the main limiting factor in the development of biological communities linked to fluvial systems.

In that sense springs up the need to evaluate the effects of Global Change in Mediterranean river basins through the creation of interdisciplinary long-term monitoring tools involving indicators established by the Water Framework Directive (2000/60/EC) to assess the water systems ecological status.

The main aim of this study is to explore Global Change effects through Land Cover and Land Use change (LULC) analysis and to engage these changes with the water quality indicators in two Mediterranean river basins: Tordera and Besòs (NE Catalonia). As a result, the research proposes to build a transversal socio-ecological indicator that can be upscaled to other Mediterranean river basins.

## 2. STUDY AREAS AND METHODS

The Tordera and Besòs river basins have a typical Mediterranean hydrological regime and are located in the North East of Catalonia with a total surface of 898 km<sup>2</sup> and 1,038 km<sup>2</sup>, respectively.

The Tordera river, with a total length of 61 km, springs at the Montseny Biosphere Reserve at an altitude of 1,700 m.a.s.l. (Boada, M., *et al.* 2008) and it comprises three main European biogeographical regions (Mediterranean, Eurosiberian and Boreoalpine) in a relatively reduced area. The presence of Natural Protected Areas in the upper course and the pressures derived from human activities of different typology, especially those derived from strategic mobility infrastructures, such as the High-Speed Train (AVE, in its Spanish initials) or AP7 (the motorway which connects Spain and France), in the medium course; and agriculture and massive tourism activities at the lower course, make the Tordera river basin an ideal socio-ecological monitoring area.

From a hydrographical point of view, the Besòs river basin has a ramified fluvial structure composed by smaller river basins: Mogent, Congost, Tenes, Caldes, Ripoll and Besòs rivers. The total length of these six main rivers is 530 km. During the 1960s and 1970s decades, the Besòs river basin underwent a great industrial development and also a demographical increase, which provoked an abusive use of the rivers with several consequences (e.g. decrease in water levels due to the increase of water extraction for domestic and industrial uses). Besòs river basin is mostly included in the Metropolitan Area of Barcelona (AMB) comprising a high density of population at its medium and lower courses.

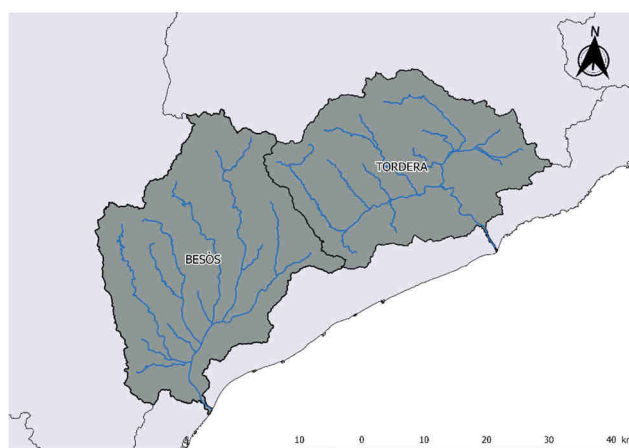


Figure 1. Map of the two study areas, Besòs and Tordera river basins.

### 2.1. L'Observatori projects

In 1996 L'*Observatori de la Tordera* was promoted as a collaboration between ICTA-UAB, the Catalan Water Agency (ACA) and the municipality of Sant Celoni. Since then, the project has had the support of

other local and regional institutions as well. Its main aim is to apply long-term monitoring methodologies and to define indicators that allow to measure the ecological status and the sustainability level of Tordera river basin. *L'Observatori de la Tordera* research lines are divided in three main areas: biological indicators (macroinvertebrates, birds, fishes, riparian vegetation, amphibians, chiropters and diatoms), hydrological indicators (hydrological regime, river continuity, morphological conditions, groundwater supply and risk of floods/droughts) and physicochemical indicators (temperature conditions, oxygenation conditions, acidification status, salinity and nutrient conditions).

In 2018, with the previous experience of *L'Observatori de la Tordera*, it is expected to launch *L'Observatori del Besòs* project to apply socio-ecological indicators which will assess the environmental status of the fluvial systems of the river basin taking into account the Water Framework Directive (WFD) and involving three main scopes: political, academic and social. A previous data compilation process is in course in order to achieve a general vision on the environmental status of the fluvial systems in the Besòs river basin. All the available information sources from 1997 to 2017 have been analysed, especially those data referred to biodiversity.

## 2.2. Stakeholder mapping and data compilation

To compile all the information related to water quality indicators, the creation of a stakeholder map is required to engage local experts from different scopes (political, academic and social) by involving them as investigators of the research lines of *L'Observatori del Besòs*. The development process of the stakeholder map is divided in four phases: 1) Identification; 2) Analysis; 3) Planning and 4) Engagement.

## 2.3. Water quality indicators and LULC correlation analysis

The research focuses on the streamflow variations in different river sections -being this factor one of the main Global Change effects in Mediterranean rivers- through statistical linear models between regional climatic variables and streamflow based on a regression analysis. On one hand, these models provide predictions which explain streamflow variations related to climate condition variations (temperature and precipitation). On the other hand, streamflow variations can be as well correlated with other factors as those produced by anthropogenic activities. Taking into account that Land Use and Land Cover (LULC) change is considered as the main component of Global Change effects in the region, a second methodological phase is required to explore the relationships between non-climatic flow variations and LULC to determine Global Change effects (Vicente-Serrano et al. 2017).

## 3. EXPECTED RESULTS AND CONCLUSION

This paper is a methodological approach to evaluate Global Change effects on water quality indicators. Through the previous experience in Tordera river basin *L'Observatori del Besòs* project will be launched with the aim to become an effective and transversal tool to define socio-ecological indicators to evaluate Global Change effects in Mediterranean river basins.

The new challenges coming from contrasting flow level and climatic conditions correlations will serve to build a more robust methodology and adaptable to the variety of circumstances that may be found in different study cases.

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