

## [Using fuzzy cognitive maps for predicting river management responses: A case study of the Esla River basin, Spain \(Solana-Gutiérrez et al 2017\) \[1\]](#)

The planning and management of river ecosystems affects a variety of social groups (i.e., managers, stakeholders, professionals and users) who have different interests about water uses. To avoid conflicts and reach an environmentally sustainable management, various methods have been devised to enable the participation of these actors. Mathematical modelling of river systems is highly recommended to forecast, but we do not always have enough information to do it. In these cases, the soft and meta-models can be valid alternatives to simulate these complex systems. The Fuzzy Cognitive Maps

(FCMs) are presented as a tool that facilitates the modelling of ecological systems, functions and services.

FCM networking concepts are intertwined through causal relationships. The FCM concept spatial arrangement and the use of fuzzy logic facilitate the integration of different expert opinions. In our study, from a panel of seven experts from representatives of different social sectors, an aggregated FCM was obtained. The most central concept in the aggregated map was cross barriers, dams and weirs. Using our FCM expert model, we performed a number of simulations from different possible scenarios, such as the continuous degradation of natural conditions and the improvement of river natural conditions. A regular increment in the natural conditions generates a substantial enhance in variables as natural water flow and sediment transport. Conversely, the increment in human activities as agro-forestry production addresses to a deterioration of river banks among other variables.

In the Esla River, the FCM indicators showed an ecosystem that was greatly influenced by human activity, especially by the presence of barriers, in which the economic variables presented high network influence even though their centrality indices were relatively low. Meanwhile, the essential elements for the proper functioning of this ecosystem, as a natural flow regime, showed very low values that were visibly affected by anthropogenic variables.

FCM methodology enabled us not only to understand the perception of current fluvial ecosystems but also to generate plausible management scenarios based on expert knowledge in this field.

**Keywords:** River management, Fuzzy cognitive maps, Ecosystem modelling, Simulation

### Highlights

- Stakeholder participation is essential for modelling effective management in rivers.
- Fuzzy Cognitive Maps are a simple tool for modelling rivers for analysing relationships between concepts.
- Application of FCM in a case study of a Mediterranean fluvial management.
- FCM dealt with the connections between the ecological and social concepts of ecosystems.
- The FCMs can be used as a tool for decision making in fluvial management by forecasting responses to different policy scenarios.

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