

# Multi-Agent for Environmental Norms Impact Assessment



FONDATION DE COOPÉRATION SCIENTIFIQUE  
Sciences et Technologies pour l'Aéronautique et l'Espace



## Context

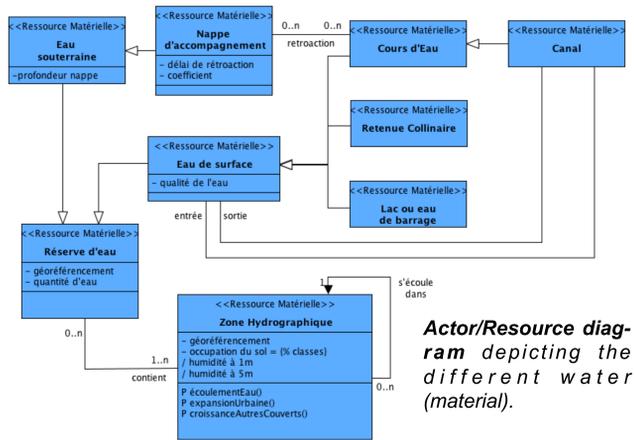
The MAELIA project develops a digital platform for simulating the socio-environmental effects of Global Changes and the implementation of various norms of governance and management of water resources. To address the direct/indirect or expected/unexpected effects of these changes and norms, the platform couples a significant number of stylized dynamics categorized within three major domains: hydrology, agriculture and social. MAELIA contributions are focused on the modeling of low-water management, which is the most strategic issue regarding water resources in the Adour-Garonne basin.

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The originality of the platform comes from a multi-agents approach where a number of software agents simulate the many actors, material and cognitive resources dynamics playing a role in water management. MAELIA is a Java-based simulation platform whose HCI is provided by the Gama framework. Only a few partial diagrams are highlighted here, they're intended to illustrate the way the platform has been designed and built.

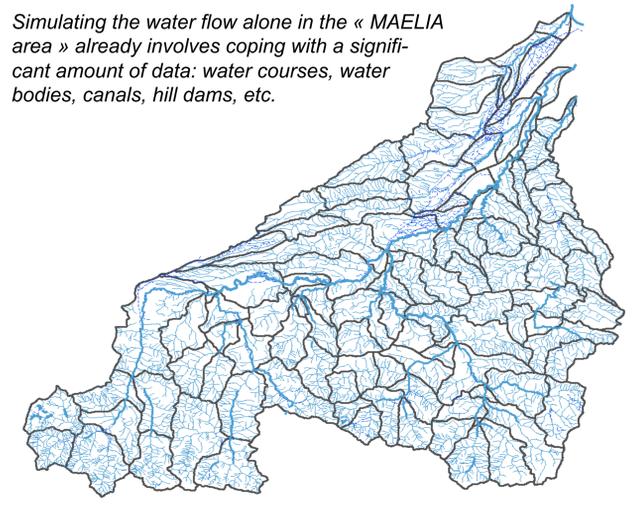
### Hydrologic aspects

MAELIA simulates the water flow through a complex network of water bodies, courses and tables (see diagram below), taking into account the numerous pressures from industry, drinking water providers and farmers.



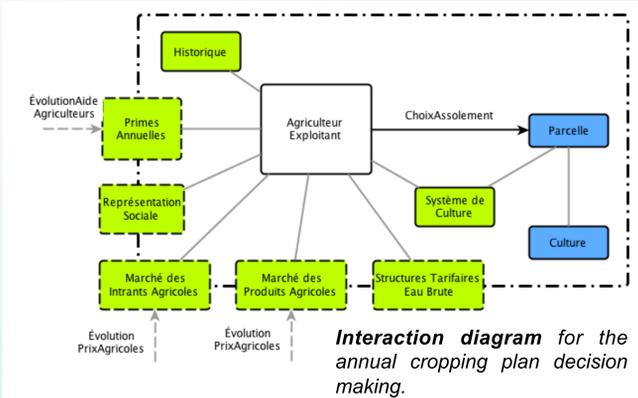
Currently, the « MAELIA area » includes ~165 hydrographic areas situated on both sides of the Garonne, in the basin upstream Portet s/ Garonne (near Toulouse). The whole Garonne-Adour basin counts 1989 such areas, say ~20 times more !

Simulating the water flow alone in the « MAELIA area » already involves coping with a significant amount of data: water courses, water bodies, canals, hill dams, etc.



### Agricultural aspects

Agricultural pressures play a major role in low-water management. Therefore, a fine-grained model of the farmer's activities is utilized. The farmer's rationality is shown through the interaction diagrams (see example below) where many cognitive resources (green boxes) are at stake in the decision making process.



A detailed and coherent space-time representation of the agricultural land use guarantees a consistent assessment of the water to be withdrawn from the different water resources.

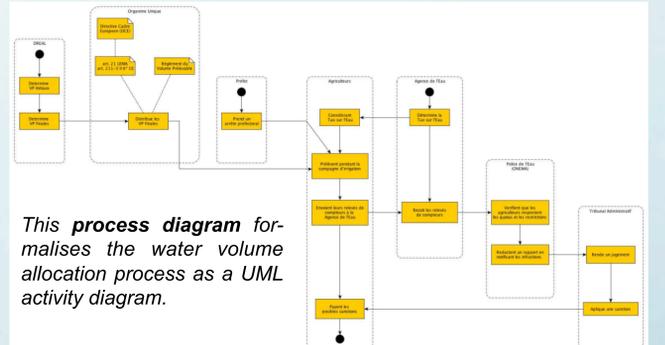


Polygons in different colors depict the variety of crops planted in the parcels. The water withdrawal for irrigation points relate each irrigated parcel to a water body (river, lake, hill reserve, water table).

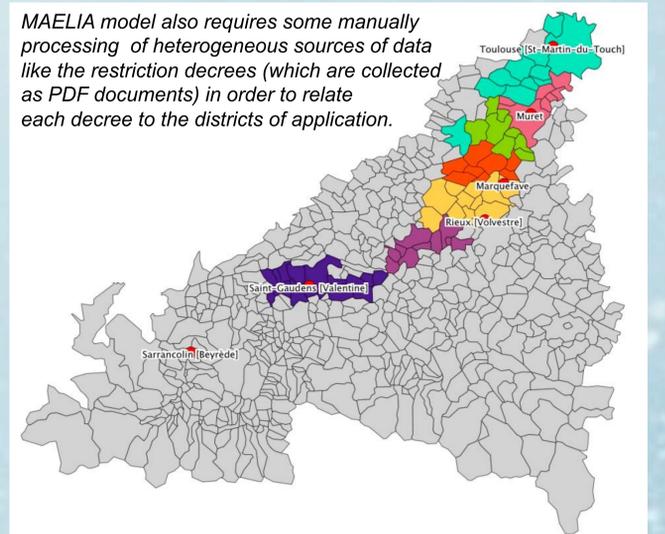
Matching irrigated parcels with the corresponding withdrawal points is one of the many challenges of data pre-processing.

### Socio-ecological aspects

The representation of norms regarding water is central in the MAELIA project. Yet, formalizing those rules from empirical knowledge into social processes (see process diagram below) is a challenge that requires collecting and mining substantial amounts of information.



Another challenge consists in combining social rules to geo-referenced data (like water resources or territories) and natural or socio-economical processes within a unique model apt for being evolved in time.

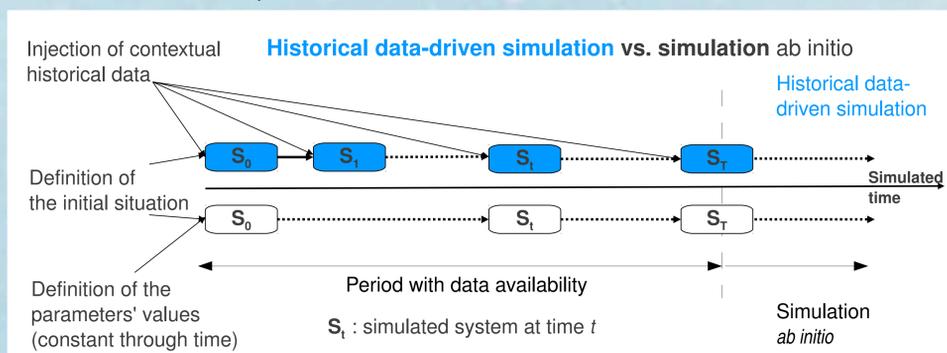


Finally, testing the effects of these laws requires the ability to run a lot of simulations, analyse the outputs and aggregate them into a composite exploitable result.

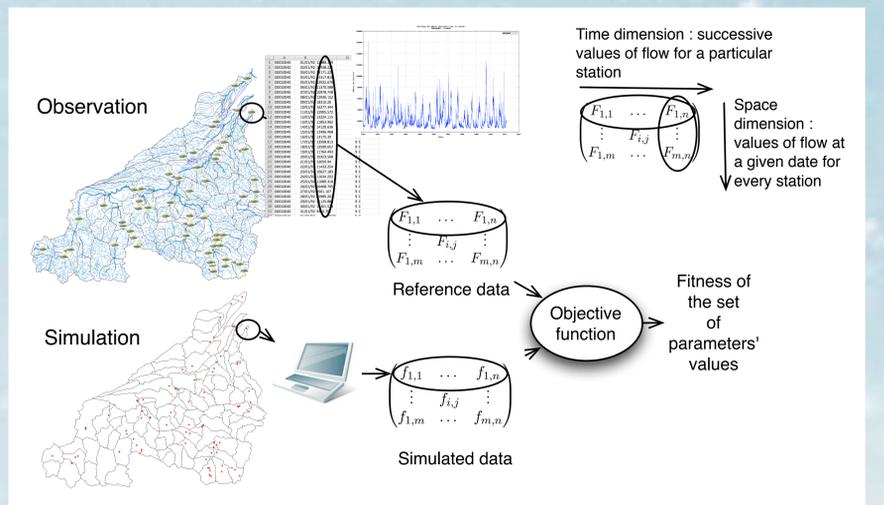
## Scenarios and Indicators

The MAELIA simulation platform allows ex ante assessment of the social, economic and environmental impacts of scenarios of evolution of water management context in the Adour-Garonne basin over the period 2000-2050. These scenarios concerns the implementation of new norms of water resource (and related resources) management and the trends and events affecting the territory (e.g. climate change; resource markets, agricultural policies, land cover change, etc.).

Two types of indicators are calculated to characterize these effects and impacts. First social, economic, environmental indicators (time series, maps, etc.) and their associated confidence indexes that are intended to decision-makers (public authorities, managers of the resources and territories). Second indicators that are dedicated to the tracking of interaction dynamics for the modelers and platform users.



Since there is rarely social constants over decades, historical data has to be injected to represent the evolving context that the model is not intended to reproduce.



Systematic evaluation of parameters' values to reproduce good water flows through time and space. The water flows data are part of the Hydro II database, which was provided by SCHAPI. The calibration process is handled with genetic algorithms and a single-objective fitness function, measuring the numerical distance between the simulated matrix of water flows and the matrix of water flows measures, for a given set of geographical measure points.