



## Territorial quantitative water management

In many sub-basins of the Adour-Garonne watershed (South-West France) the river flows are regularly monitored below the regulatory low-water flow levels (LWFL). These recurring “**water crisis**” highlight **local structural water deficit situations**. They are often **linked to irrigated agriculture**, especially maize mono-cropping, as it is responsible in these basins for about 80% of water extraction during low flow period.

The French law on water and aquatic environments (LEMA 2006) seeks to ensure a local, sustainable water management (i.e. balance between water resources and demands). In some basins, this means for **agriculture to lower its withdrawal levels**. However irrigation is a key production factor for farming systems. Implementing the law therefore generated **conflicting situations** which froze the transition process.

The main issue that arises from this context is **how to conciliate water resources protection and economic viability of agriculture** ? Some scientists propose to develop integrated approaches to design **water management and agricultural strategies at watershed level where stakeholders participate strongly in the decision-making processes**. This study presents such an **integrated and participatory approach** that makes use of different modelling methods **to assist stakeholders** in designing alternative territorial organizations of cropping systems that could lower water demands and/or spread it over space and time, and improve the management of existing water storage. **Models are a mean to represent, apprehend and simulate** the spatial dynamics of the irrigated territory year after year. The **participatory design process is organized into 4 main steps**.

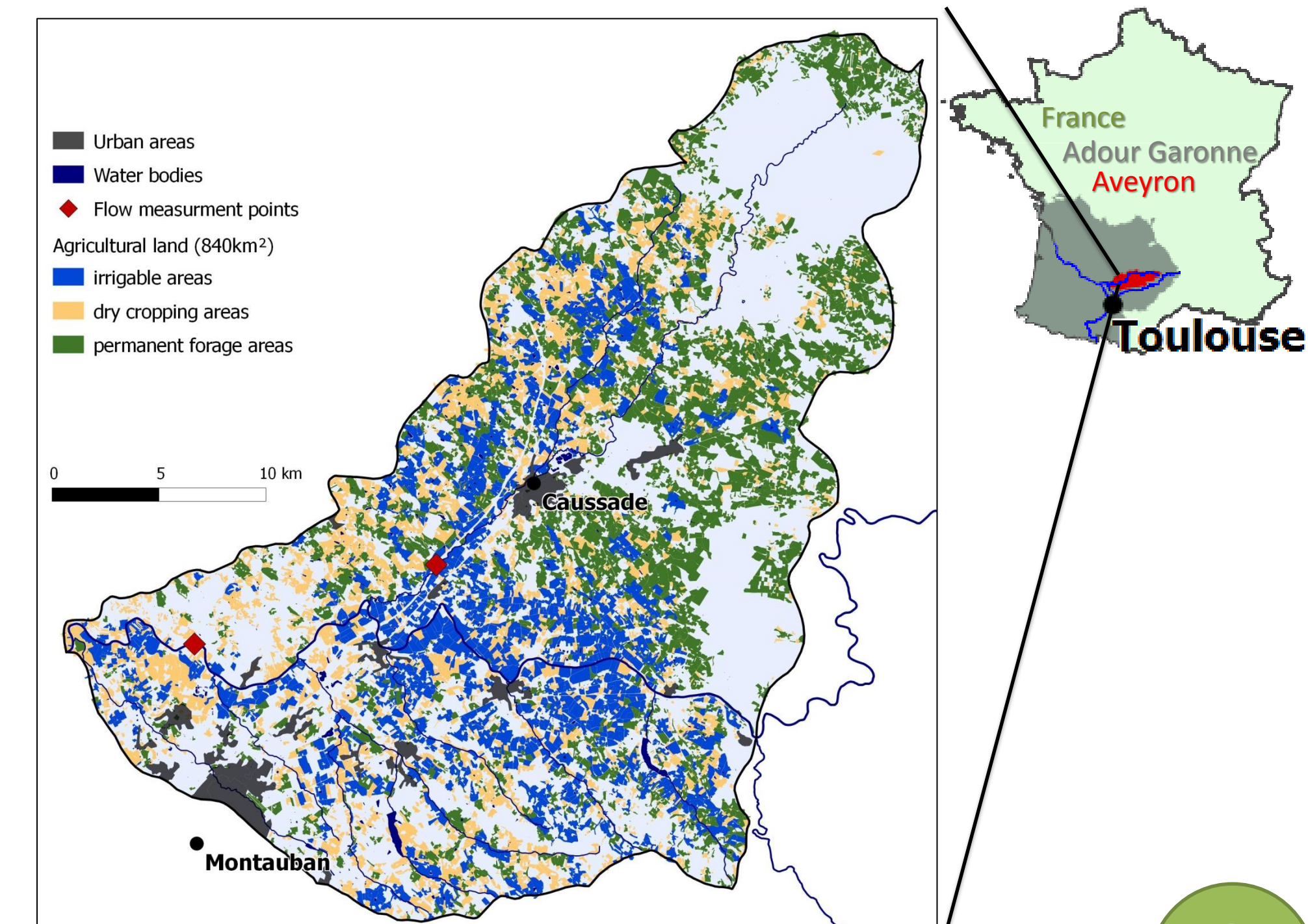


Fig.1: Location and presentation of the study site: the irrigated territory downstream of the Aveyron river basin in Adour Garonne

## 1 Building a shared representation of the system

We integrate available data and stakeholder knowledge to formalize a representation of the current bio-physical structure and dynamics of the territory (hydrological, hydraulic, agricultural and bio-physical). This information is gathered into a geographical database.

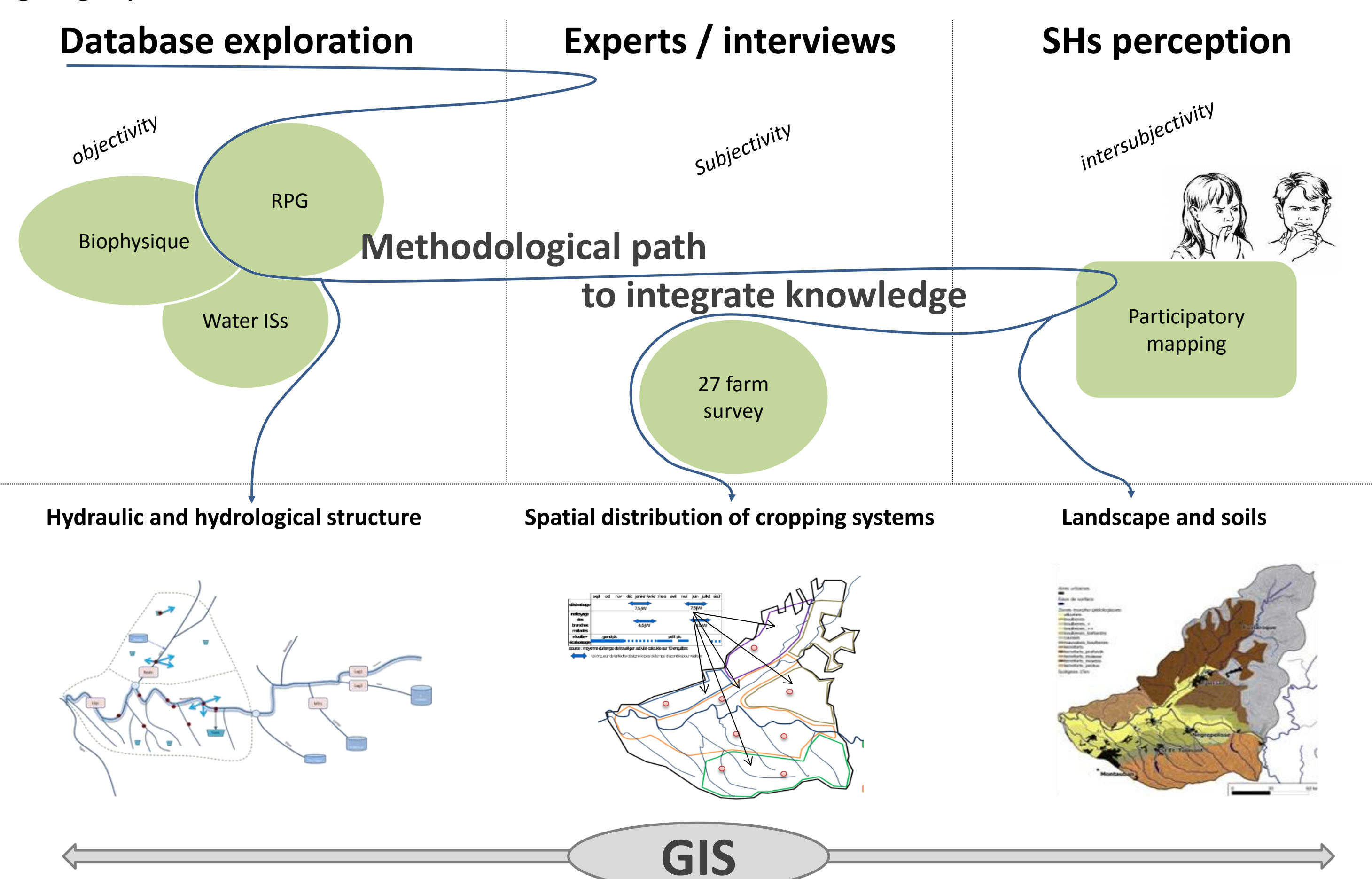


Fig.2: Diagram of the methodological procedure used to build a shared representation of the irrigated territory

By surveying 27 farming systems of the territory and operational water managers, **we formalized decision rules associated to cropping and irrigation practices as well as water management practices** (dam releases and usage restrictions). The GIS and set of rules are considered as a shared model of the irrigated territory system as they are built in interaction with participants of next steps of the design process.

## 3 Simulation of the territorial behavior

Alternatives of cropping system distribution and water management are implemented into a **multi-agent simulation platform, to assess their impacts on** :

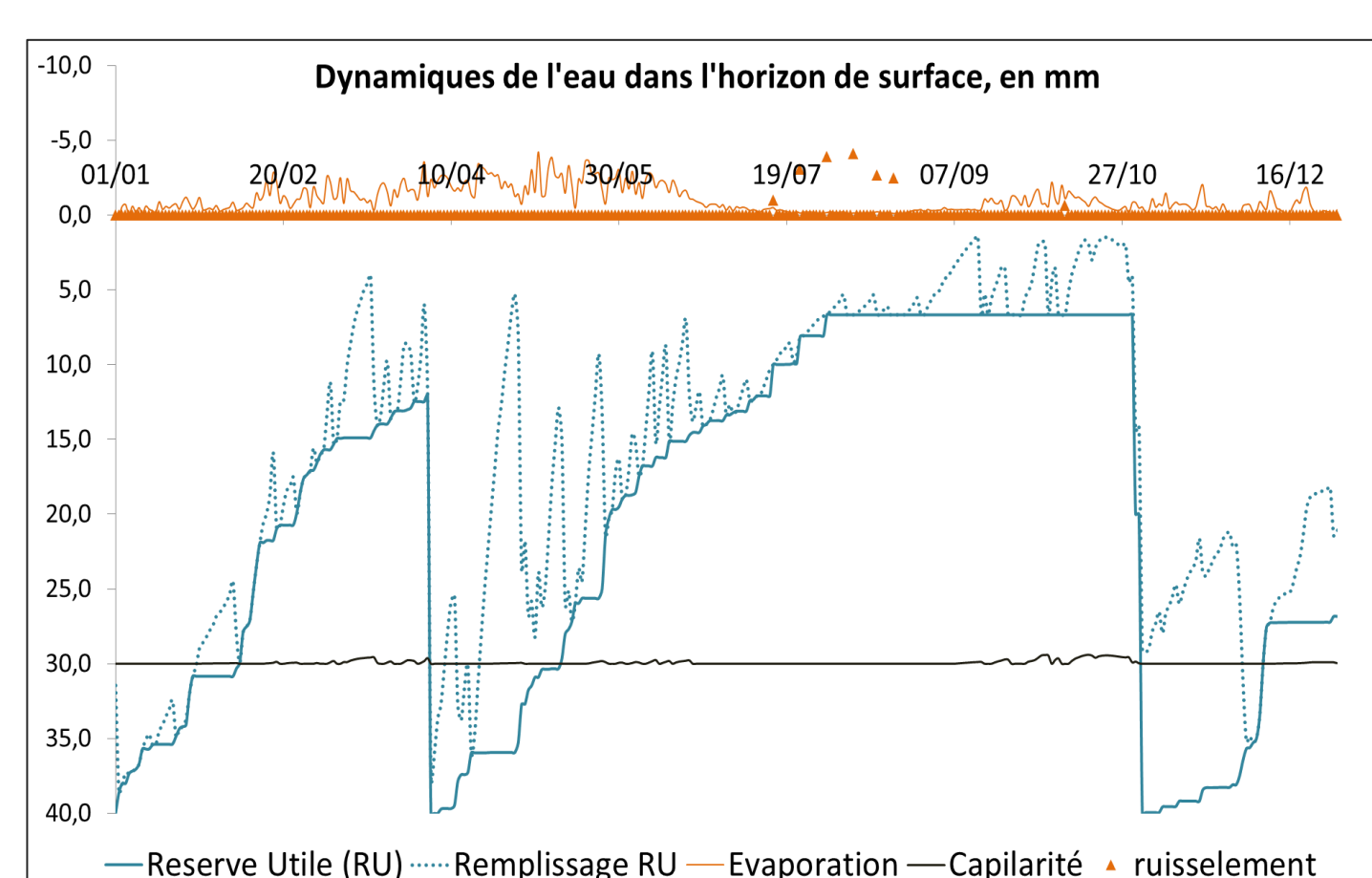


Fig. 5: exemple of outputs from the plant growth and soil water dynamics simulation model (JeudO)

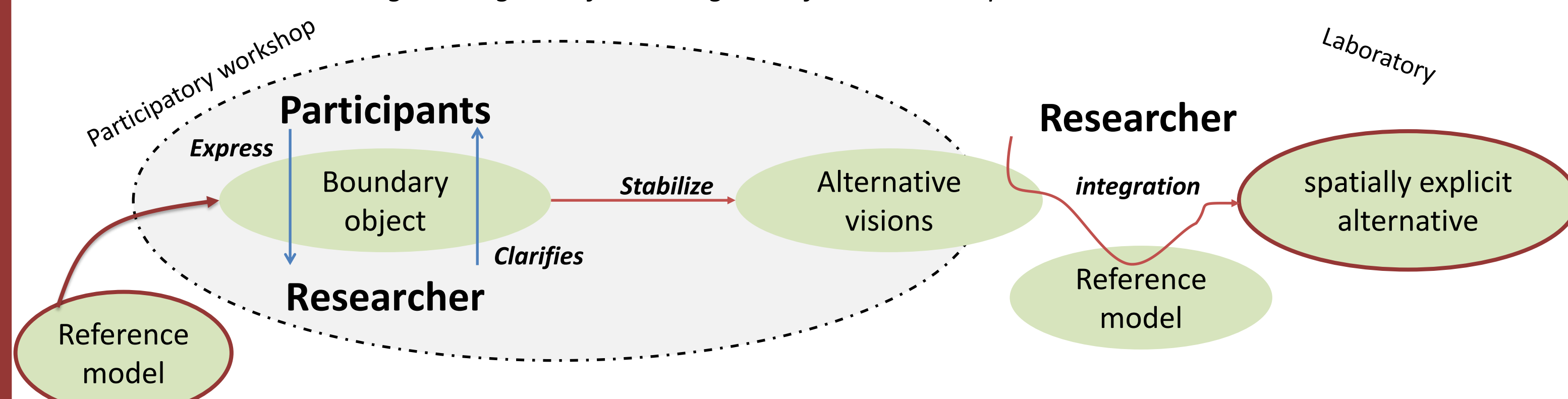
The simulation platform simulates decisions of dam releases and regulatory usage restrictions, their consequences on irrigation practices and hydrology and reverse. To evaluate robustness of alternatives in the face of intra and inter-year climate variability we use observed climatic data over the recent ten years (2002-2012).

- daily crop growth and soil water dynamics in interaction with **cropping and irrigation practices**,
- **water flows** in rivers, dam storage and groundwater levels,
- **crop yields, farm gross margins and water crisis frequency and intensity** year after year.

## Co-designing alternative distributions of cropping systems

We ask **stakeholders** of agriculture and then of environment and local state services **to express their view on possible or expected changes in current spatial distribution** of cropping systems and operational water management practices, that could reduce the probability of severe low flow while ensuring viability of farming systems.<sup>1</sup>

Fig.3 : Diagram of the design and formalisation process:



Changes expressed by stakeholders are integrated into a spatial and quantitative representation, through the use of the GIS built in step1. The formalized “alternatives” can then be submitted to the collective in order for it to refine them, making use of use information available in GIS. (e.g. Prioritize location of change using farm type)

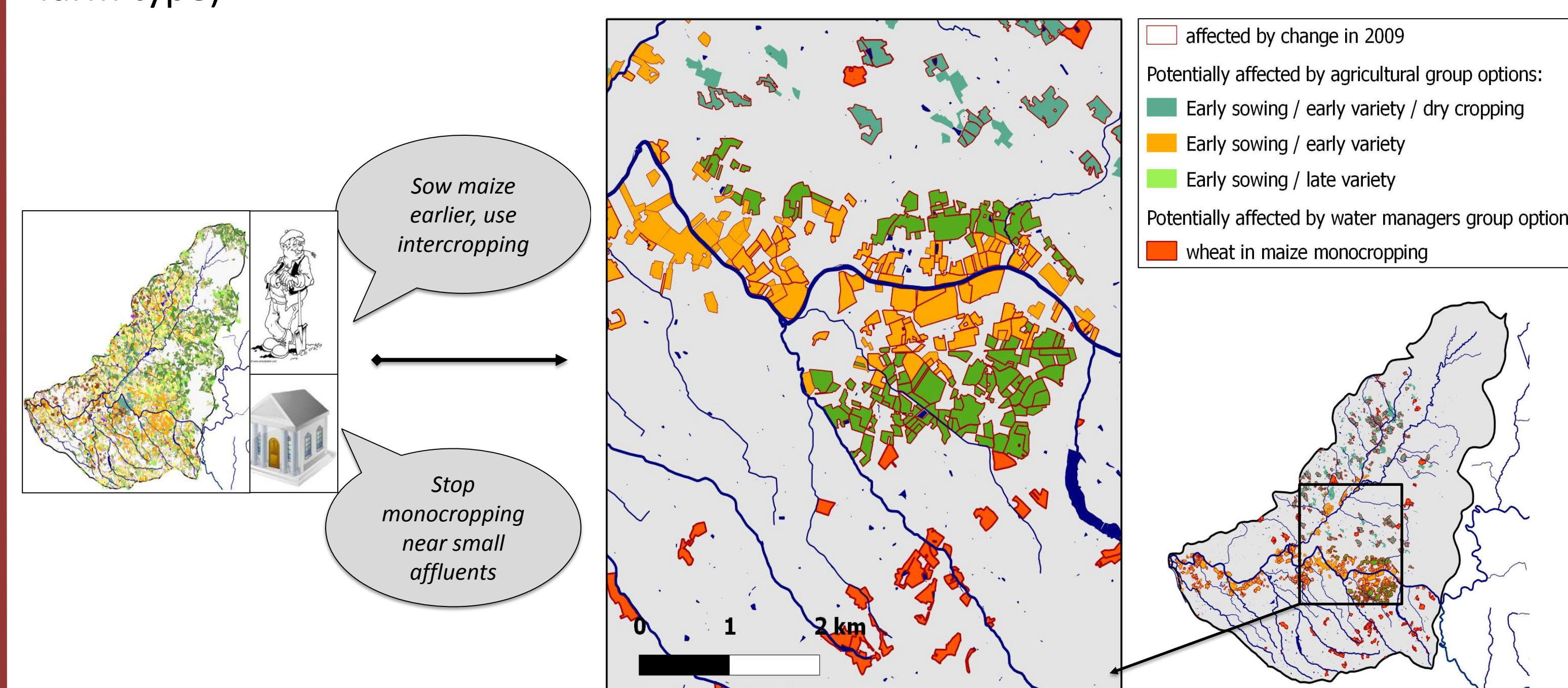


Fig. 4: Example of results: a formal representation of plots affected by change in an alternative that integrates compatible options from environment and state services group and agricultural group.

## Collective evaluation of alternatives

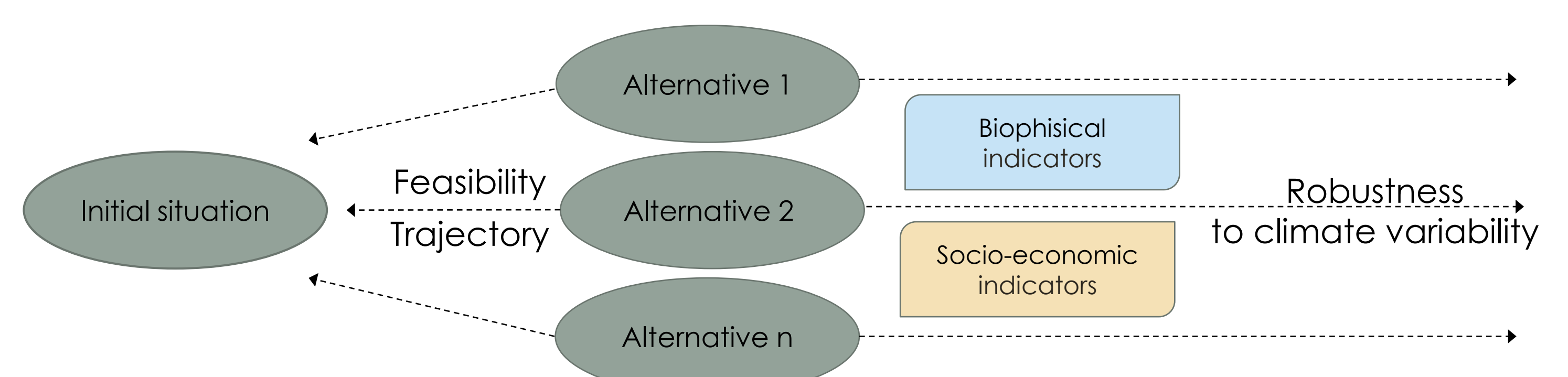


Fig. 6: Illustration of the alternatives' integrated assesment

We present an assessment based on a set of indicators, chosen and developed with stakeholders, and covering different sustainability domains and key organization levels (farm, farmer collective, sub-watershed...). We also ask stakeholders to qualitatively assess the technical feasibility of alternatives. The challenge is then to compare assessed alternatives to move towards decision making.