Participatory design of the spatial distribution of cropping systems to limit the risk of water crises

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The recent development of environmental public policies in Europe highlighted structural water deficit situations, of which many sub-basins of the Adour-Garonne watershed (France) where flows are regularly observed below the regulatory levels. These recurring "water crises" are mainly linked to agricultural withdrawals during periods of natural water shortage. The French law on water and aquatic habitats (LEMA 2006) seeks to balance water demand with resources and to promote territorial management through stakeholder involvement. Opportunities for water storage development being limited, this means to lower agricultural withdrawals when irrigation is a key production factor for farming systems. In these socio-ecological systems, the main issue is how to conciliate water resources protection and economic viability of agriculture by re-thinking agricultural land use, in interaction with both agricultural land and water management stakeholders?

Our work aims at developing tools and methods to tackle quantitative water management through cropping system spatial distribution (i.e. new cropping systems and/or distribution over space and time) and improving management of existing water storage. We are implementing an *agroecosystem design approach* based on a variety of modelling and participatory methods. We deal with the methodological issue of co-producing knowledge for resilience assessment at the scale of a territory using models as boundary objects to facilitate the flow of information between science and society (representation, simulation and evaluation of the socio-environmental system). We used a 800 km² irrigated territory as a case study, identified and interacted with two stakeholders' collectives: one is representative of the agricultural stakes, the other of the water management and aquatic environments stakes.

Our methodology is close to a scenario analysis approach. It follows 3 steps: (1) co-construction of a fine spatial resolution, shared, dynamic representation of the current agro-hydrosystem, (2) co-design of potential alternatives of change for cropping systems and their spatial distributions to achieve a desirable state, (3) simulation of the alternatives in a spatially explicit manner to evaluate their performance in contrasted inter-annual climatic variability scenarios. Both collectives are involved in every step of the procedure, either separately or jointly, in individual open interviews, collective mapping or designing workshops. To represent the current situation of the agro-hydrosystem (step 1), we enriched quantitative geo-datasets by mapping peoples' spatial, qualitative knowledge on bio-physical features, hydrological dynamics and distribution of cropping practices in the territory. Co-design of options (step 2) was a participatory, pro-active process where stakeholders were asked to conceptualize changes in cropping systems and their distribution within the territory, changes in water management practices (dam releases and restrictions on withdrawal), as well as evaluation criteria to assess of the alternatives potential to improve the system's resilience. In the laboratory, we formalize a spatial representation of the alternatives that fed a computer model, and ran simulations of the system's dynamics to calculate a set of indicators then submitted to participants' judgment (step 3). Each participant group produced his own alternative, and we propose a third one that integrates proposals from both groups.