

APPEAU : Which agrosystems and public policies for a sustainable management of water resources ?

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Abstract: Agricultural lands and activities are of major importance in spatial water management since they represent a large proportion of catchment areas and they have a large impact on water withdrawals and water pollution. It is then essential to represent correctly agricultural activities and their impact in water management and planning tools. The objective of the APPEAU project is to improve decisions in water management and planning at regional scales (catchments, irrigated areas, etc.). The project aims more specifically at developing methods and tools based on mathematical models to evaluate scenarios for a better joint planning of agricultural activities and water resources. The project includes three kinds of activities (developing models, and building and evaluating scenarios) conducted with two different approaches (with targeted partners or in participation). A transversal activity aims at dealing with generic methodological questions that are common to the various study areas and water problems of the project, at producing reference texts for the main key concepts of the project (“scenario”, “model”, “sustainability”) and to feed or improve the participative approach by models developed with targeted partners.

Keywords: water management, scenario, model, sustainability

1. INTRODUCTION

Water scarcity and water pollution questions the sustainability of the present uses of water resources. Agriculture is the main user, both by the amounts of water it takes and by the pollution it generates. Pursuing the idea of sustainable development implies to consider water as multi-source and multi-use. As a consequence, it is necessary to consider the links between agrosystems and water resources at a regional scale, the scale of public policies, to jointly question the farm viability, the ecological sustainability of water resources, the social equity and the strong links between actors and stakeholders. It is the stand point of spatial water management which consists in coordinating water fluxes management with the management of land areas which generate or regulate these fluxes (Narcy et Mermet, 2003), as well as of Integrated catchment management which promotes the catchment as the spatial unit for optimizing the allocation of land and water resources to all users (Gorredale 1992).

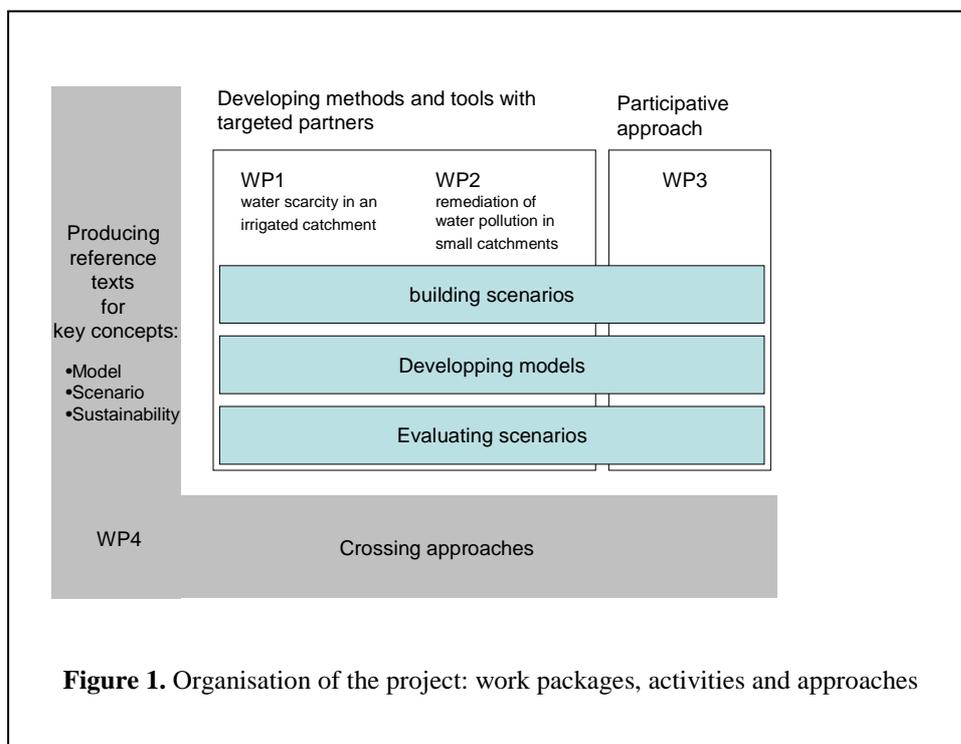
Models that represent complex and interacting environmental, social and economical processes occurring at the catchment scale are useful tools to support integrated catchment management, particularly through scenario simulation (Jakeman and Letcher 2003). Models help estimating the various often competing and conflicting demands in land and water and making them match the offer, while the use of scenario facilitates interaction and understanding between experts, stakeholders and policymakers (Alcamo 2001; Verburg et al. 2006).

2. OBJECTIVE OF THE PROJECT

The objective of the APPEAU project is to improve decisions in water management and planning on large extents (catchments, irrigated areas, etc.). The project aims more specifically to develop methods and tools based on mathematical models to evaluate scenarios for a better joint planning of agricultural activities and water resources.

3. ORGANISATION OF THE PROJECT: ACTIVITIES AND APPROACHES

The project is organised in four work packages (WP). It includes three kinds of activities conducted with two different approaches.



The activities are:

- developing and implementing mathematical models for a better water quantity and water quality planning
- building scenarios regarding agricultural context changes (particularly changes in cropping systems and cropping systems patterns) or economical and regulatory context changes.
- Evaluating these scenarios using the mathematical models developed.

The first approach consists in developing methods and tools with targeted partners, on two specific questions: the water scarcity in an irrigated catchment (WP1) and the remediation of water pollution in

small catchments (WP2). Partners are local institutions and/or water users associations. They are involved in designing, implementing and/or validating models and in building and/or evaluating scenarios. All partners are aware of the progress in the work.

The second approach (WP3) consists in conducting the three activities (modelling, and building and evaluating scenarios) in a collective organisation, gathering various actors and institutions of the study area. This implies to represent all interactions (between actors, between processes and between processes and actors) in the modelling.

These two approaches are complementary: models developed by WP1 and 2 may be required by WP3, and the participative approach of WP3 may raise new questions or constraints for model design and development. It is the objective of WP4 to analyse such complementarities. For this analysis, a good exchange between teams of the project is a condition. The WP4 aims at dealing with generic methodological questions that are common to the various study areas and water problems of the project, at producing reference texts for the main key concepts of the project and to feed or improve the participative approach of WP3 by models developed in WP1 and 2.

4. PROGRESS AND RESULTS

4.1 Work Package 1

Water scarcity is an increasing problem in many regions, due to numerous global changes. Climate change implies a higher frequency of droughts; demographic, economic and energetic changes lead to a greater pressure on water resources by a multiplication of competitive uses (Gaeckler 2007).

We developed a multi-user water allocation model at the river basin level to optimise water use under several possible scenarios (agronomic, climatic or economic). This model, called MoGIRE, represents agricultural, urban (domestic and industrial) and environmental water uses as well as the water network. MoGIRE operates the network facilities and allocates water so as to maximise the river basin agricultural and urban economic value from water use, under water delivery constraints resulting from the characteristics of the water network and the minimum flow requirements. Its implementation in the Neste system area (south-western France) is under progress. A complete description of MoGIRE is given by Reynaud and Leenhardt (2008, this conference).

Two complementary studies are conducted around the construction of scenarios.

The first one consists in proposing a new water pricing scenario. This water pricing device has been designed by using the tools of game theory and concepts developed in finance in order to meet five objectives: efficiency, and cost recovery, equity between users, financial stability for providers and intelligibility by water users. This work is detailed by Terreaux and Tidball (2008, this conference).

The second one consists in studying a methodology to describe the spatial distribution of cropping systems to describe a reference situation (reference scenario) and to facilitate a participative construction of scenarios. This methodology, based on an adequate division of the study area into support units and on the manipulation of a 3D matrix (relating cropping systems, soil types and farm types), is presented in this congress by Clavel and Leenhardt (2008).

4.2 Work Package 2

The impact of agriculture on surface and groundwater water quality is widely recognised, as a result of the global intensification of agriculture and pesticides and fertilizer use. One of the most acute problems is the increase of nitrate concentrations in the water resources owing to soil over-fertilization with animal manure and synthetic fertilizer. In some of the most intensive agricultural regions, such as French Brittany, nitrate concentration now exceeds the European Community limit (50 mg NO₃-L⁻¹) for drinking water (Molénat et al., 2002). Surface water contamination by pesticides is also a

great problem in Brittany with a high frequency of *dépassement des seuils de potabilité* in drinking water (Trépos, 2008).

The remediation of diffuse pollution (principally nitrate and pesticides pollution) is a key problem for water managers in Brittany where most of the water supply relies on surface water because of the crystalline substrate. Considering the high sensitivity of the environment (wet and mild winters, shallow groundwater) and the high proportion of agricultural area (often more than 75% of the catchment area), pollution remediation requires the optimisation of both agricultural management practices and buffering capacity of the landscape.

In order to study how water quality depends on landscape structure and management practices, previous studies have led to the development of two distributed agro-hydrological models running at a meso-scale catchment (10-500km²): SACADEAU, for pesticides, and TNT2, for nitrate (Durand et al., 2002, 2006).

The aim of the present work is (i) to improve the construction of scenarios of spatially distributed management practices and remediation techniques, especially by making full use of remote sensing data processing and modelling (Corgne et al., 2002, Tissot et al., 2005), and, (ii) to improve the usability of scenario results, especially by using artificial intelligence methods of rule learning and automatic deriving of action recommendation (Cordier et al., 2005). Currently, different approaches of the simulation of spatial distribution of land use and management have been tested and compared (Salmon-Monviola et al., 2008, Sorel et al., 2008); methods of rule learning have been implemented on scenarios results from the SACADEAU model (Trépos, 2008), and TNT2 has been modified to extent its domain of application, The next steps will include new scenario testing with TNT2 and the application of learning methods to TNT2 results.

4.3 Work Package 3

In the Drôme basin (South East of France), as well as in Lomagne area (within the Neste system in the South West of France), water scarcity needs to seek for water allocation rules. In Lomagne, the pollution of water needs also to better manage pesticide use. To compare various solutions regarding water allocation and water pollution remediation, we implemented on these two sites an integrated approach based on the development and the use of a regional simulation model with the participation of the local stakeholders (Le Grusse et al., 2008 - this conference).

A “steering group” has been created for each study site. It gathers the stakeholders’ representatives (members of professional associations, local technical advisers, and farmers). It has been involved in the collection of data to build a typology of farms and production units and a typology of cropping systems. Then a regional simulation model has been proposed by the group of researchers. Finally, researchers and members of the steering group discussed the modelling choices, and revised and validated together the model.

The regional simulation model is based on the farm and production units typologies. It is built using modelling environment softwares: “Olympe” (Le Grusse et al., 2006; Le Bars et Le Grusse, 2008) and ZonAgri (Pouget et al., 2006) that both allow :

- 1 - to represent the technical and economical functioning of farms and regions, designed as an aggregation of farms ;
- 2 - to simulate changes (prices, level of water resources, crops, and cropping systems) and its effects on farms and region incomes, resources consumption and environmental impacts that could occur.

This regional simulation model uses biophysical models. An hydrological model is used to assess as input the initial resource availabilities and to measure the impacts of withdrawals. The crop model “Pilote” (Mailhol et al 1997 and 2004) is used to assess crop water needs and yields according to the agricultural practices and the agro-climatic conditions (Gonzalès-Camacho et al., 2008 – this

conference). Other agronomic models can be used to assess the environmental impacts of agricultural techniques.

This regional simulation model has been designed to account for technical and economic choices made by farmers. In a very soon future, scenarios related to technical and economic choices will be built with stakeholders in collective gaming session, following the methodology developed by Le Bars et al. (2005). The objective is to simulate different situations with a regional model in order to define collective strategies of integrated and sustainable water management for the study areas.

4.4 Work Package 4

Presently, three key concepts are discussed and analysed within the project: “scenario”, “model” and “sustainability”. The objective is to share a common definition of these concepts and/or to make explicit the diversity of definitions.

“Scenario”

The word “scenario” is extensively used in the literature. Scenario-based approaches, scenario analyses, are part of the integrated assessment modelling approaches. They generally consider that scenarios are “stories” describing potential future developments based on the present situation and logical chains of plausible events and their interactions (Sharma and Norton 2005, Walz et al 2007). The dynamic characteristic of scenarios is put forward. It is also the case in the literature about land use and cover changes (LUCC), but in this case, in addition, scenarios have a spatial dimension (Verburg et al. 2006). In some other studies, the word “scenario” refers to some spatial land use options corresponding to a set of model input data (e.g. Bormann et al. 2007; Olchev et al. 2008; van den Brink et al. 2008). These “scenarios” have no explicit temporal dimension: the combination of events that could effectively lead to such land use options is not explicitly described or modelled. In these studies, scenarios are very often used to study their impacts in order to know if it is desirable that public policies aim at favouring such land use options. Sharma and Norton (2005) also subdivide scenario-based approaches into qualitative scenario analyses and backcasting approaches, which refer to different status of the scenario in the modelling process. These various status of the “scenario” lead to various ways for giving a name to a scenario. This may be quite confusing in a project that mixes various studies aiming at evaluating “scenarios”. What do we call a “scenario”? Do we give the same sense to a single word?

In front of an extensive use of the word « scenario », even within our project, we propose to analyse our uses of the word, try to harmonise our terminology, and provide a synthetic view of what is a “scenario” in water management studies.

Models

The word « model » is also multi-faceted and questions around models are numerous. For example, within the project, we want to rise:

- the complementarity of models: in which conditions hydrological models developed for water pollution remediation can improve integrated water management models developed for water allocation?
- the complementarity of approaches: how models developed for specific questions can enhance the development of tools in participation? How participative approaches can orientate the development of models and the choice of scenarios to be evaluated?

- the existence and advances in common methodologies: which trade-off between a correct representation of the reality and modelling simplifications? What role of models for building and evaluating scenarios for an efficient collective action?

As a first step, we developed an analysis grid to precise what we call “model” and to make explicit the quality of a model for land and water planning.

Sustainability

Further analyses will be conducted within the WP4 on the scenarios considered within the various study sites. We will analyse the means used to build sustainable scenarios and the means used to evaluate their effective sustainability.

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