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## Exp'Eau, a serious game for exploring pathways to improve water quality in agricultural catchments

Isabelle Charpentier<sup>1,2</sup>, Olivier Barreteau<sup>3</sup>, H el ene Blanchoud<sup>1,4</sup>, Mathieu Bonnefond<sup>1,5</sup>,  
Christophe Piscart<sup>1,6</sup>, Marie-No elle Pons<sup>1,7</sup>, Olivier Ragueneau<sup>1,8</sup>,  
M elanie Raimonet<sup>1,8</sup> and S ebastien Salvador-Blanes<sup>1,9</sup>

1- CNRS-INEE, LTSER-FR R eseau des Zones Ateliers, France

2- University of Strasbourg, ICube laboratory, Strasbourg, France

3- INRAE, G-EAU joint research unit, Montpellier, France

4- Sorbonne University, ETIS laboratory, Paris, France

5- CNAM, GeF laboratory, Le Mans, France

6- University of Rennes, ECOBIO laboratory, Rennes, France

7- Universit e de Lorraine, LRGP laboratory, Nancy, France

8- Universit e de Bretagne Occidentale, LEMAR, Brest, France

9- University of Tours, G eHCO, Tours, France

**Abstract.** Water quality depends on agricultural practices, but also on the land cover and the distance between the pollutant sources and the hydrosystem. Consequently, water quality and agriculture are regularly in tension in catchments. Solving this issue requires actions by farmers and other stakeholders (local authorities and catchment manager) that can act through economic instruments and rules.

Although serious games have gained interest in environmental research and management, only a few examples are targeting water quality in agricultural areas, and these poorly include the diversity of interactions.

We develop the game simulator "Exp'Eau" to evaluate and to compare different pathways by facilitating the debate on possible collective actions at the scale of an agricultural catchment.

The game is structured spatially (cell, communal territory, catchment) and socially (farmer, elected official, catchment area manager). The basin is divided into three independent boards to create an effect of distance that enables to focus on interactions between players around the same table. Some time is dedicated to collective discussions.

At farm scale, land uses are characterized by crop practices that are more or less intensive in terms of pollution. Non-farming actions include investments in agroecological infrastructures, land use changes, and training to improve practices.

A purely analog version has proved to facilitate the interactions among players around the game boards and during the collective setting. The split of the catchment into three tables is successful to embody the need for communication between players coming from different subbasins and the interdependencies at the catchment level.

**Keywords:** Water Quality, Agricultural Practices, Territorial Public Policy, Multiple Scale Interactions, Collective Action

### 1 Introduction

Water quality depends on agricultural practices, but also on the nature, the state of the land cover and the distance between the pollutant emission sources and the hydrographic network. Consequently, water quality and agriculture are regularly in tension in rural catchments. Solving this issue requires actions by farmers. This may also involve other stakeholders, such as the local authorities and the catchment management, that can act through economic instruments and rules.

Over the last twenty years, serious games gain interest in environmental research and management. Such tools are used for simulating the dynamics of social and ecological systems for which a physical experimentation is not relevant due to questions of scale and potential

consequences [1]. However, only a few examples are targeting water quality in agricultural areas as the central issue, and these do not focus on the diversity of interactions within the catchment.

To work on this issue, we develop the game simulator "Exp'Eau" in order to evaluate and to compare different pathways by facilitating the debate on possible collective actions at the scale of an agricultural catchment. Our main focus was to enable virtual social ecological experimentation through simulation, in a first step to generate new knowledge on water quality in agricultural catchment, and in a second step to facilitate discussions among stakeholders within catchments. We designed the game through ARDI workshop [2] with scientists from seven French Long Term Social Ecological Research (LTSER) platforms, completed by a few interviews of experts and the help of game designers.

## 2 Requisites

On the one hand, the diversity of processes draining pollutants from the plots to the hydrosystem allowing for their slowing down and/or their degradation, the territorial aspect and the diversity of actors, and possible levers to limit these processes are to be accounted. On the other hand, multiple constraints hinder the transformation of agricultural catchments allowing a better water quality while preserving the agricultural land use.

In such context, a serious game-type tool is appropriate to experiment with different combinations of individual and collective actions on water quality, to monitor the impacts and analyze the results.

Exp'Eau first targets a student audience to be able to repeat experiments and compare possible pathways. In a second phase, an audience of local stakeholders will be relevant to raise awareness about the collective dimension of the water quality issue, and secondly to explore possible courses of action at an actual catchment scale.

## 3 Implementation

The virtual catchment we consider is designed on the basis of the Moderbach catchment (North East of France) simplified and discretized with hexagonal tiles [3]. The hydrographic network is reorganized into an explicit flow network oriented towards a single outlet. Each tile corresponds to a land use (Agriculture, Nature, Urban), assigned according to the dominant land cover.

The game is structured according to three levels of organization, spatially (cell, communal territory, catchment area) and socially (farmer, elected official, catchment area manager). The basin is divided into three independent boards located on different tables in order to create an effect of distance that enables to focus the interactions between the players around the same table, at the exception of the times dedicated to collective interactions, as featured by the spatial layout presented in figure 1.. Each board corresponds to the territory of a municipality. Exp'Eau features three types of actions related to (1) agricultural practices, (2) the control of pollutants, and (3) a better valorization of agriculture.

Only cells with agricultural occupation are likely to generate an amount of pollution which depends on the type of crop and the agricultural practice, as well as on the presence of some agro-ecological infrastructures on the plot allowing to limit the spread of pollutants.

The farm practice action cards have the same structure. Each crop is described with two to three levels of practice that are more or less intensive in terms of use of chemicals and generation of pollutants. Practice parameters are a minimum level of technicality, levels of effort (measured in work time) and of investment (measured in units of goods), and levels of production (measured in units of goods) and of pollutant emission. All these parameters are valued on a scale ranging from 1 to 5. Cards include bonuses/malus defined as deviations from a standard weather and as a pest outbreak occurrence. Non-farming action modalities include investments in agroecological infrastructures or land use changes, and training to improve farming practices.

They are also characterized by a cost in time and in unit of goods, as well as a possible effect on the production level of the plot and the emission of pollutants.



Fig. 1. Spatial organization of a game session.

## 4 Experimentation

On a first prototype, we also developed a computerized version based on an Application Programming Interface (API server/smartphones) to facilitate the collection of the player's choices and the computation of their practice's outcomes. However, as mentioned in [4], this API was capturing the attention of the players, what was limiting the interactions between players. We could not build discussions on the interactions and interpret pathways that these simulations had generated. Therefore we simplified the setting so that players could focus on interactions.

This second prototype is a purely analog version and has proved to facilitate the interactions among players around the three game boards and during the collective setting. In this second version, the split of the game board/catchment into three tables was successful to embody the need to move so as to communicate with players coming from other geographical areas and to understand the interdependencies among farmers and municipal development at the level of the catchment.

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