INCLUSIVE groundwater

Working paper 07

Participatory modelling for quantitative water management: learning from an experiment on the Seudre watershed (France)

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1. INTRODUCTION

In many regions of the world where groundwater is overexploited, public authorities rely on hydrogeological models to assess sustainable limits for water extraction and to determine the spatial distribution of acceptable withdrawals. These models provide a simplified representation of a complex socio-hydrosystem, composed of one or several aquifer layers that are often connected to rivers, lakes, and wetlands. The conceptual and computational modeling tools used are complex and are frequently poorly understood by the stakeholders formally involved in the development of management plans based on these studies.

However, hydrogeological models can also serve as **boundary objects**, enabling scientists and non-experts to collaboratively construct a shared understanding of an otherwise invisible system. In other words, if approached collaboratively, model development can support a social learning process in which each participant contributes pieces of knowledge derived from local observations—specific locations, particular wells, or certain time periods.

This working paper focuses on this question, documenting such a collaborative approach implemented in the **Seudre River basin in France.** The experiment combined participatory modelling with the collective definition of sustainable extraction limits. This approach was intended to foster dialogue among stakeholders, support shared decision-making, and strengthen the integration of ecological considerations into water management practices. A central question underpinned this process: **what did participants learn from engaging in this participatory process?** Understanding these learning outcomes is crucial, as they shed light on how participatory methods can contribute not only to better quantitative water management but also to the design and acceptance of new sustainable extraction limits rules in practice.

2. CONTEXT

2.1. The Seudre watershed study area

The Seudre watershed is located in the west of France. It is an estuarine watershed of 750 km² with a very low gradient (0.05 ‰), covering 67 municipalities with a total population of 62,000 inhabitants. The territory is under the influence of an oceanic climate, with strong seasonal rainfall variability.

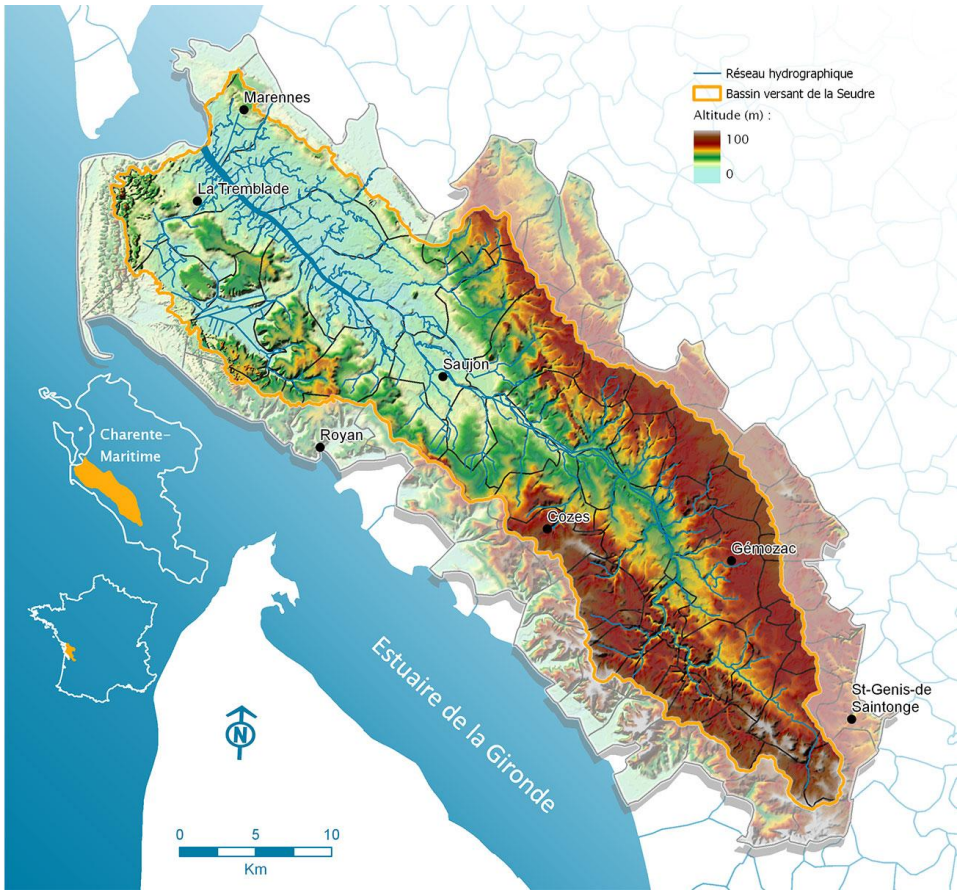

Figure 1 - Location of the Seudre watershed, altitudes and hydrography (Source: https://www.sageseudre.fr/seudre).

The Seudre Valley is located in a geological context largely dominated by limestone formations. This permeable substrate creates a close relationship between the river flow and the underground water tables, known as aquifers. Thus, the Seudre is primarily fed by the overflow of phreatic aquifers, often referred to as "accompanying water tables." The seasonal variability in the water level of these aquifers, known as piezometry, influences their interaction with surface flow.

The Seudre river basin can be split in three distinct sectors:

- The **upper basin** where the river is primarily linked with an aquifer known as the Turo-Coniacian aquifer and its network of cavities called *karst*, formed by the dissolution of limestone by rainwater. This gives it distinctive behavior characterized by significant storage capacity and rapid drainage. As a result, the Seudre is fed by the Turo-Coniacian karst aquifer during high-water periods; however, during low-water periods, it becomes "perched" above the water table and dries up naturally, resulting in intermittent flow in the sector.

- The **middle basin**, where the river primarily captures water from an aquifer formed in the Cenomanian limestone. The porosity of this aquifer is lower than that of the Turo-Coniacian aquifer, as the karst is filled with sands and clays. This results in a lower storage capacity and slower drainage. The piezometric level of this aquifer is known to remain above the riverbed elevation year-round. As a result, this sector naturally maintains permanent flow.
- The **lower basin**, downstream of the city of Saujon, is disconnected from the aquifer and under the influence of tides.

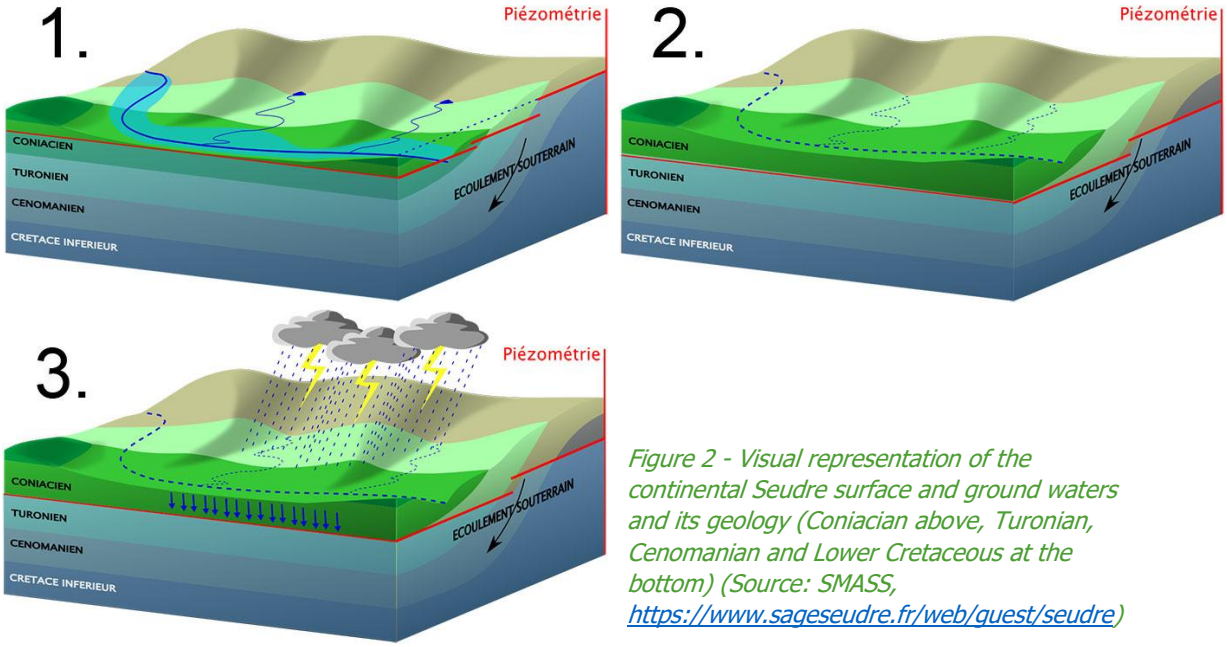

Figure 2 - Visual representation of the continental Seudre surface and ground waters and its geology (Coniacian above, Turonian, Cenomanian and Lower Cretaceous at the bottom) (Source: SMASS, https://www.sageseudre.fr/web/guest/seudre)

When the piezometric level of the aquifer is higher than the riverbed elevation, springs and the Seudre River flow by capturing a portion of the underground flow (Diagram 1 on Figure 2). This happens through winter and spring. In order to cultivate the lowlands, drainage and river rectification was heavily implemented.

When the piezometric level of the aquifer is lower than the riverbed elevation, surface flow is disconnected from underground flow (Diagram 2 on Figure 2). This happens usually in summer and leads to rivers drying up in the Upper part of the basin. To balance the situation, weirs were built across rivers to maintain water levels and allow water uptakes.

When the piezometric level of the aquifer is lower than the riverbed elevation, runoff waters recharge the underground flow (Diagram 3 on Figure 2). However, due to climate change, autumn and winter periods become drier, leading to less aquifer recharge.

2.2. The groundwater management framework of the Seudre river basin

The Seudre Basin experiences chronic quantitative deficit since the 1980s, resulting in increasingly frequent low-water periods. This deficit is due to strong pressures from water withdrawals for drinking water supply and irrigation. To restore quantitative balance, sustainable extraction limits were defined and notified by the basin coordinating prefect in 2011 for the Upper, Middle and Lower Seudre, and for the three main water uses (drinking water, industry, irrigation).

A local governance forum[1] was institutionalized in 2017 to jointly manage water resources. It is led by the Seudre basin authority[2] and the Charente-Maritime authority in charge of water storages[3]. The local governance forum aims to achieve a balance between water needs and available resources in the Seudre basin, accounting for aquatic ecosystems, as well as anticipating and adapting to climate change. Improved quantitative water management is achieved through:

- Water savings (water efficiency, behavior changes)
- Aquifer recharge (nature-based solutions to reduce runoff and maximize infiltration)
- Artificial water storage: these reservoirs are designed to store water pumped in the aquifer in winter period when the water table is high, to provide the necessary volumes for irrigation in summer period when the water table is low and rivers dry up

The aquatic ecosystems' needs were defined in a separate study and correspond to a minimum river flow at the hydrometric station of Saint-André-de-Lidon of 90 L/s. Below this threshold, the river habitat no longer supports the biological functions and behaviors of aquatic life.

In 2019, the local farmers association[4] for irrigation opposed the extraction limit defined by the prefect for agriculture use. The opposition resulted in renewed investigations of the capacities of the Seudre water resources and functioning of its rivers and aquifers, under the sponsorship of the Seudre basin authority and the Charente-Maritime authority in charge of water storages.

A working group labelled "sustainable extraction volumes"[5] was designated out of the members of the local governance forum to supervise the study from 2020 to 2021. The group was tasked to define volumes that are compatible with the needs of the environment and water uses in the Seudre basin, for the three management units (upper, middle and lower basins):

- A volume that can be withdrawn in summer for irrigation
- A volume that can potentially be mobilized in winter

The 28 group members were selected to represent a diversity of interests: State representatives, Water agency, municipalities, drinking water operators, nature protection associations, farmers associations, fishery economic comity and fishery association, as well as the 2 water management authorities.

[1] Projet de Territoire pour la Gestion de l'Eau (PTGE), more on https://www.legifrance.gouv.fr/download/pdf/circ?id=44640
[2] Syndicat mixte du bassin de la Seudre (SMBS)
[3] Syndicat mixte des réserves de substitution de la Charente-Maritime (SYRES 17)
[4] ASA Saintonge
[5] Groupe Volumes Prélevables (GP ou GVP)

This institutionalized dialog on a high-stakes topic (water balance) was one of the firsts to take place in France. The participatory process and the social learning mechanisms of the group were observed by external consultants and research teams.

3. METHODOLOGY

3.1. The participatory process

The collective definition of the sustainable extraction limits took place through a participative hydrological modeling exercise, facilitated by Ifrée[6]. This facilitator oversaw the meetings (agenda, decision-making) and facilitated discussions between scientists, managing authorities and local stakeholders. Each decision taken by the group was voted on, by using colored cards to prioritize the participants' choices.

The working group's debates were based on scientific elements, derived from simulations of a distributed groundwater model using the MARTHE software[7] developed by BRGM (Abasq et al., 2021). A BRGM researcher was present at each meeting to guide the group through the understanding of the model and its outputs. In addition, 2 members of the national authority for public dialog[8] observed the participatory process to guarantee its equity, transparency and legitimacy.

The working group met 8 times between June 2020 and September 2021 (see Table 1). Due to the Covid-19 pandemic, some meetings had to be held online.

Table 1 - Date and summary of the agenda for the eight working group's meetings

Meeting n°	Date	Agenda	Participants[9]
1	4/06/2020	- Presentation of the mandate of the working group - Framing elements. Intervention of the State representative on abstraction volumes and on low flow targets. Explanation of the concepts of summer and winter volumes - Presentation of the hydrogeological model and conditions for simulations	23
2	25/06/2020	- Validate participants' commitment to the group and address stakeholders' concerns - Begin collective selection of input conditions	17
3	01/10/2020	- Collective choices of hypothesis for the model input (breakdown of volume withdrawals over the year, hypothesis for drinking water uses and industrial uses).	14

[6] Consultancy specialised in participatory processes

[7] https://www.brgm.fr/en/software/marthe-modelling-software-groundwater-flows MARTHE is a hydrogeological model enabling 2D or 3D modeling of flows in aquifer systems.

[8] Commission Nationale du Débat Public (CNDP)

[9] Only the working group members are counted; the observers, BRGM researchers and Ifrée facilitators are not counted as participants

Meeting n°	Date	Agenda	Participants[9]
		- Collective discussion on input conditions on agriculture uses volumes: spatial distribution of abstraction points and abstraction volume	
4	06/11/2020	- Finalize hypothesis on input conditions for agriculture uses volumes	16
5	05/02/2021	- Feedback on the last questions asked and issues raised by group members - Participants decide to run the 1st simulation	16
6	10/05/2021	- Participants identify the results of the first simulations carried out for abstraction volumes. - Decision of participants on the conditions for the 2nd simulation	15
7	02/07/2021	- Feedback on the last questions asked and issues raised by group members - Decisions on the next steps to be taken by the group.	16
8	20/09/2021	- Conclusion by the working group on the definition of sustainable abstraction volumes	15

The first two meetings focused on the participatory process itself, to clarify the mandate of the group and enable active and informed commitment by all group members. Due to the high stakes of discussions, it was compulsory to take the time to build trust both on the consultation process itself and within the group (including with the facilitators and the BRGM researchers in charge of the computations).

The first four meetings were also dedicated to teaching the group basic knowledge on modelling as well as groundwater hydrology, so they could feel legitimate enough to raise concerns and take decisions at each step of the model development. Though the group was composed of non-experts, their opinion on the model's input hypothesis, simulations and results was collected and integrated at each key step.

Following the 8th meeting, the conclusions of the working group were presented to the Seudre water parliament[10]. Here's an extract: "*Given the current state of use and knowledge of the aquifers of the southern Cretaceous, we follow the BRGM's conclusions: the low water flow target at Saint-André-de-Lidon is not respected for 8/10 years, even in a context of zero withdrawn volumes for irrigation on the Seudre basin. The level of influence of neighbour basins shown by the model requires work on a larger scale.*" Following on from the work carried out by the working group, a new study will have to be launched at the scale of the southern Cretaceous aquifer of the Charente region to better understand the hydrogeological links between the Seudre and its neighboring basins.

[10] Commission Locale de l'Eau (CLE) in charge of supervising all water issues on the river basin, including floods, water quality, hydromorphology and aquatic ecosystems. More info on: https://www.sageseudre.fr/web/guest/sage

3.2. The social learning evaluation methodology

In parallel to the participatory process, another research team, led by ACTeon[11], evaluated the group's social learning. This evaluation focused on the degree of knowledge acquired about the model and how the hydrological system functions, the requirement for different water uses, how local water governance works, and deliberative learning.

To assess social learning, an ex-post evaluation was conducted, i.e once the participatory process was finalised. Social learning evaluation consists in answering assessment criteria which help in understanding the degree of learning, the types and the effects in terms of changes of practices on the water resource. In this case, the objective of the social learning evaluation was to provide insights on:

- The cognitive learning of the participants (i.e their understanding of the Seudre basin hydrosystem),
- The relational learning (i.e the evolution of the perception the participants have of the possibility to work with other types of stakeholders),
- The deliberative learning (i.e the acquisition of new skills in speaking in a group and taking collective decisions),
- And on the normative effect of the participatory process (i.e did participation in the working group changed their practices on groundwater uses).

To answer the evaluation criteria, the research team gathered information from documents related to the participatory process, from ex-post semi-directive interviews and from active observation during the meetings.

First, the research team gathered information from the Seudre management authorities (water resources characterization and diagnosis), as well as the minutes of the meetings of the working group. This initial work enabled the research team to familiarize themselves with the Seudre watershed, and the uses and management issues of the river and its aquifers.

Then, 18 semi-directive interviews were conducted, using the same interview grid structured in three parts (Appendix 1 - Interview guide), for all 14 organizations involved in the participatory process. A full list of the organizations that participated and/or were interviewed can be found in the appendix (Appendix 2 - List of participants in the sustainable extraction volumes workshops). The interviews were mainly held by telephone and videoconference.

In addition, during the 7th and 8th meeting a sociologist from ACTeon was invited to observe the deliberation and collective discussion in the making, to then give some new insights on how social learning is occurring during the participatory process.

The information gathered was then subjected to a qualitative analysis, the results of which are presented in the next section. Interview excerpts are quoted to support the analysis.

[11] A consultancy in ecological transition, whose role was to assess social learning.

4. RESULTS (FOCUS ON SOCIAL LEARNING)

This chapter analyzes the collected data to understand and characterize what the participants learned from the extraction volumes working group participatory process. The different subsections that follow reflect what the participants retained from the participatory process.

4.1. Learning about the hydrogeological functioning of the basin

The work of BRGM's hydrogeologists consisted first and foremost in taking stock of the participants' current knowledge of the hydrogeology in the Seudre basin, but also more generally of the major basics of hydrogeology (concepts, vocabulary...). Although most of the participants were not experts on the subject, many of them reported that their knowledge of hydrogeology had improved thanks to their participation in the group meetings. As the elected representative of a municipality in the basin said: "*It came gradually. At first, we talked about piezometer measurements. I learned a lot, because I didn't know much about it. It was very interesting in terms of training. We had everything we needed to make decisions*." This learning process was made possible by the teaching provided by the hydrogeologists, but also by the ongoing engagement of participants, meeting after meeting, as explained by one Seudre management authority: "*I had no idea about the interactions that could exist [underground between neighboring basins], that it could go so far. I also have a better grasp of the positioning of the water tables, having seen the maps*".

4.2. Learning about how a model works

Most participants interviewed reported that they had discovered how a model worked thanks to the group meetings. This improved knowledge seems to have been particularly significant for the Seudre water managers, who were used to working with results but had never before worked on the parameters behind the simulations. As one participant explained: "*I learned the limits of the model and the exercise. We often tell ourselves that a model is scientific, that it's either true or false, whereas there are lots of biases, it's not that much objective. Even though it's meant to be very technical, it's based on hypotheses*".

A BRGM hydrogeologist reports the case of a participant who was not at ease with the model during the first meetings, which led to tense exchanges that eventually normalized once the model was better understood: "*At the beginning [this participant] was very reticent, a little worried, not at all sure of what we were advancing. Over time, as we explained and re-explained, confidence grew. There was a little aggressiveness at the meetings, due to [reactions such as] "I don't understand, I don't master the subject". We interpreted it that way with the co-sponsor of the local dialog forum, it was a defensive position because [he] didn't know the subject*".

4.3. Learning about the agricultural sector issues and specificities

Several participants also learned a great deal about the agricultural sector, particularly in terms of farming techniques and uses of water in the Seudre basin. As one technician who took part in the meetings explained, "*I learned a lot about agriculture, as my skills in the field are close to zero*". He also added: "*Sometimes, when there were discussions about agriculture, I didn't feel competent, so I trusted the people who were speaking and who were competent in the field. It was a kind of blind trust, because without knowledge, you have to trust the people present*".

This learning process didn't just apply to participants from outside the farming sector, but also to those involved in agriculture. As one of them explained, the meetings had taught him about the history of the development of farming on the Seudre and the role of farmers on the hydrography.

4.4. Learning about the local water governance

When questioned directly on this point, only two participants explained that they had gained a better understanding of the positioning of water stakeholders through the group meetings. This relational learning focused on the positioning of the agricultural profession and environmental protection associations, as well as of water governance in the upper reaches of the Seudre. Most participants interviewed already knew the roles of the other participants within the working group. Most were used to working together in other decision-making bodies (notably the Seudre water parliament).

The evaluation also noted other types of learnings, such as:

- knowledge of the many players involved in water and the environment, and their names. As one participant explained: "*There's a multitude of acronyms, a multitude of interests: State representatives, Water agency, drinking water operators, hunters, fishermen, oyster farmers, river basin authorities [...]... There is a vocabulary to acquire that is not easy*". It also translates learning on the role these actors have in the water local governance.

- the role of individuals in the functioning of a group and its impact on the final decisions made within this framework. Several participants noted that group dynamics and the quality of a participatory process, whether positive or negative, were often a "*matter of individuals*". As one participant put it, referring to the elected heads of water management bodies: "*when you have good, impartial people, things immediately go much more smoothly*". The interventions of a farmers' representative were also praised by many interviewees. As explained by BRGM, "*hyper constructive, calm, he always asked questions that informed everyone [...]. He even helped us to think*". "*He even helped us communicate, sometimes speaking up and explaining things more clearly than we did*". His involvement in meetings was even more crucial as he was the person who highlighted the extent of the implications of the results of the MARTHE model simulations, implications that had initially not been detected by BRGM hydrogeologists. This person's participation in the group meetings thus influenced the atmosphere and tenor of the discussions and final decisions taken by the group.

4.5. Learning about how to work together

In the opinion of many of the participants interviewed, the set of players present during the group meetings was "*classic*", with many of them regularly crossing paths at other meetings in the region (notably within the Seudre water parliament, and other water parliaments or dialog forums in Charente-Maritime).

However, several participants mentioned that they had been surprised by the good understanding and work dynamics encountered during the meetings. This was largely due to the format of the meetings, the presence of a dedicated facilitator and the subjects addressed. This collective dynamic led to a learning process recollected by several participants, that of working together, particularly between water stakeholders who were unfamiliar with each other or had antagonistic positions.

A participant from the farming sector explained that he had been able to work jointly with the representative of an environmental association in the group to parameterize the model and

understand the results it produced, despite differences of opinion on many issues (including the creation of artificial storage for agriculture) and ongoing disputes between the two structures over other quantitative management issues in neighboring watersheds. In his opinion, collaboration was better than in other contexts but was not optimal either.

This group-wide learning process took shape over the course of the 8 meetings and led to Ifrée becoming less and less involved in regulating exchanges. The facilitator explains that, as the meetings progressed, the participants "*listened to each other more, they accepted my retakes more. [...] The rules had to be repeated less as the meetings progressed, for example, that we shouldn't cut each other off, that people should have time to finish what they were saying, and that instructions and exchange rules should be respected*".

4.6. Learning about how to participate and to deliberate in a group

In terms of the ability to speak in front of a group and express one's point of view, several of the participants interviewed already take part in meetings on the theme of water management, through their profession or their involvement with trade unions or associations. As one participant explained: "*I like going to meetings and explaining things to people, it often goes well, I'm able to do it*".

One of them, however, explained that his participation in working groups meetings had enabled him to progress in terms of argumentation skills, and to better "*focus his convictions, [to] then have an argumentation strategy*".

One learning point that came up frequently in discussions with participants concerned the design and facilitation methods of a participatory process itself. This learning primarily concerned the co-leaders of the Seudre river basin, who worked in conjunction with the Ifrée facilitator to organize the 8 meetings. As one co-leader put it: "*We learn from workshop to workshop. When we organize a workshop, we learn from our experiences*". This learning is largely due to the quality of Ifrée's work during these meetings, as evoked by many of the participants interviewed: "*When I see how [the Ifrée facilitator] works, [...] she has the ability to reformulate, to put people in their place, to say 'you're digressing', it's quite an art, it's a profession. [...] Experience is the only way to visualize and integrate the reality and constraints [of meeting facilitation]*". Another co-sponsor: "*Having an outside expert helped me approach the consultation process in a different, more meticulous and specialized way. On a professional level, it increased my expertise. [The process was] not new, but I think I made progress in terms of understanding participation, the public present, consultation methods, and so on*".

This learning of facilitation techniques and methods also took place among the other group participants, as explained by one of them: "*I discovered facilitation methods deployed by Ifrée, on the organization of meetings, ways of passing the floor.... It's quite intuitive, but when you see it implemented, you see the relevance of certain methods that you know theoretically or that you're already doing internally with your colleagues. These are very simple things, like sending out preparation documents before the meeting, sending out clear agendas and meeting objectives*".

The format of the participatory process and the consultation methods used during the meetings are seen as factors that have contributed to the group's good collective dynamic and to these learnings linked to participatory know-how. For several participants, the format of the meetings (small group, numerous meetings, management of speaking time by the Ifrée, colored card votes at each meeting which meant that all players had to share their opinion in front of the others)

was particularly conducive to exchanges between participants, especially those who do not usually express themselves during other meetings held within the framework of the Seudre water parliament. Voting, in particular, made it possible to ratify the decisions taken at the meeting and avoid having to revisit them later at the request of a participant.

4.7. Knowledge transfer outside the working group

4.7.1. Between the working group and other decision-making bodies

The various skills, know-how and interpersonal skills learned and reinforced during the group meetings were afterwards, in the opinion of the participants, mobilized during other concertation bodies in the region. This was made possible by the multiple roles held by some participants (for example, members of the group but also members of the Seudre water parliament or involved in other quantitative management issues in neighboring basins, etc.).

One participant explained that he had been able to use and transfer the technical knowledge he had learned at the working group meetings, in his capacity as vice-president of the drinking water authority: "*it helped me make choices*". He also explained that his participation had enabled him to pass on his knowledge of Seudre river management to some of his constituents directly concerned.

4.7.2. Between members of an interest group represented

Similarly, one participant interviewed explained that he had shared the knowledge he had acquired during the group meetings with members of his organization. This participant explained that it was not easy to share all this knowledge, some of it highly technical, acquired during the meetings, particularly with the older members of his organization: "*I shared [what I learned] internally with the members of my association, it's not easy because it's very new, [...] it surprised a lot. It's very technical. [...] [The way in which the knowledge acquired with the model can be used to reorient quantitative management] is starting to spread, [...] these are arguments that are beginning to be raised*".

4.7.3. Transferring knowledge from one basin to another

The knowledge acquired by participants has also led to a transfer of practices to neighboring basins. The coordinating prefect of the Adour-Garonne hydrographic district has asked the Charente water authority to carry out a consultation process similar to that carried out on the Seudre, for the preparation of the Seugne and Charente aval quantitative water management plans. Commenting on the co-construction of extraction volumes, one participant said: "*I think it's the only possible approach, and that it should be applied everywhere, in all [territories]. I don't see how sustainable extraction limits can be defined without going through this process. [...] At every meeting I go to, I put the Seudre forward, because it was a real success*".

5. DISCUSSION

5.1. Learning typologies

According to the discourses and results from the 4.1 to 4.3 sections, the evaluation shows that the participants of the working group did acquire cognitive learning on the hydrogeological functioning of the basin, on the limits of hydrological models and on the local agricultural sector issues, thanks to the participatory process.

Regarding the results presented in sections 4.4 and 4.5, relational learning appened during the participatory process for some of the participants. The way the participatory process is facilitated clearly promotes and helps relational learning. However, it is perhaps harder to catch this kind of learning, and it may be less visible, strong and shared among the participants than cognitive learning.

The evaluation in the 4.6 section shows that the way the participatory process was facilitated helped some participants, mainly the local administration technicians, to better their deliberative and participative know-how. The overall social learning evaluation in the Seudre basin gives insights on the success of the participatory process in scaling up the experiments and on spreading protocols and methodologies to encourage sustainable groundwater management. The results show the importance of the facilitating methods used during the participatory process, and its effect on social learning, especially on deliberative learning.

Since this ex-post social learning assessment is not based on a reference state in terms of the different types of learning abilities of the participants, it is therefore difficult to draw conclusions about the real changes in practices and normative effects that the participatory process aimed at encouraging sustainable groundwater management.

5.2. Disparities in knowledge appropriation

The various learning experiences of the working group participants listed above should not obscure the major learning disparities between individuals. While some learnings were widely mentioned and identified by group members (notably improved hydrogeological knowledge and learning how to use and parameterize the MARTHE model), others (improved knowledge of how agriculture works in the basin, participatory skills, learning to work together) were only noted by a minority of participants.

Moreover, the evaluation focused on individual social learning to then aggregate the results to see if a common understanding and a collective social learning were standing out. The individual and collective scale of social learning are hard to distinguish. Nevertheless, the evaluation descriptions give some insights into common learning for a type of actor (i.e the administration and water syndicate technicians) on how to lead a collaborative discussion.

6. CONCLUSIONS

The aim of this study was to monitor the work of the “sustainable extraction volumes” working group and the changes encountered by participants, in terms of their perceptions of water management in the Seudre basin and of participatory processes. This study is based on an analysis of the results of a survey conducted by semi-directive interviews with the participants of the working group, as well as on the analysis of the minutes of the group's meetings and the active observation of 2 of the meetings (7th and 8th meetings).

The group's work was marked by several highlights, first and foremost the discovery of the results of simulations carried out by BRGM, which illustrate the hydrogeological interconnection of the Seudre watershed with its neighboring basins. This interconnection, suspected by local players, had never been scientifically proven. This situation led the group to acknowledge the impossibility of defining an extraction volume to be included in the quantitative water management plan, and to the decision to launch a larger-scale multi-basin study to better understand the impact of water uptake from outside the Seudre basin.

Despite this discovery and the complexity of the subject, a large majority of participants praised the positive working atmosphere and the constructive exchanges between group members, even those with the most remote positions and interests.

Participation in the working group has led to a great deal of learning on the part of stakeholders interviewed: better understanding of the hydrogeological functioning of the Seudre basin, better knowledge of how the MARTHE model works, better knowledge of the agriculture practices in the basin... Some of these new skills have already been transferred by the participants to others outside the working group, whether through participation or speaking engagements in other decision-making bodies linked to water management in the basin, neighbouring basins or at departmental level, or within the institutions of which the participants are members.

Further research remains to be undertaken to better understand the hydrogeological dynamics of the Seudre basin and its interconnections to neighbouring basins to push the collective understanding further, include all the impacted and relevant stakeholders on the collective decision on defining the sustainable extraction volumes, and finally define collectively how to change the practices to respect the thresholds fixed and ensure sustainable groundwater uses.

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8. APPENDIX

8.1. Appendix 1 – Ex post interview guidance for the interviewer

The parts in italics below allow for follow-up with the interviewees, if necessary. They will not be included in the interview guide sent to interviewees in advance.

Estimated duration of the interview: between 30 and 45 minutes.

Introduction :

The Territory Project for Water Management (PTGE) project on the Seudre basin was launched in 2018. It is co-designed by the Syndicat mixte du bassin de la Seudre (SMBS) and SYRES 17 (the Syndicat mixte des réserves de substitution de la Charente-Maritime). The PTGE Seudre aims at achieving a balance between the needs and the water resources available on the territory, while respecting the proper functioning of aquatic ecosystems, anticipating and adapting to climate change.

In this context, a working group was set up to work on the following question: "*how to define volumes compatible with the needs of the environment and water uses in the Seudre river basin?*". The aim of the working group was to define for the three management units of the basin (upstream, middle and downstream basins):

- A volume that can be withdrawn in summer for irrigation.
- A volume potentially mobilizable in winter.

8 meetings were held between June 2020 and September 2021. The conclusions of the group were presented to the CLE of the SAGE Seudre[12] in October 2021.

Within the framework of the research project on groundwater management INCLUSIVE (co-financed by the Agence Nationale de la Recherche), the ACTeon research&consultancy company offered to the co-leaders of the PTGE to carry out an “a posteriori” evaluation of this collective work. The objective is to analyze the perceptions of the actors mobilized by the "withdrawable volume” working group.

Through this interview, we seek to understand the different perceptions of the stakeholders with regard to the management of the Seudre river and aquifers and the work of the "withdrawable volume" group in 2020-2021.

We will not mention your name in the analyses/articles that could result from this survey, but you could be identified through your profession: do you agree with this? If you wish, we can anonymize your answers.

You have a right of withdrawal and you can ask us to delete your answer at any time. For any additional information or need for retraction, you can contact us by e-mail (s.loudin@acteon-environment.eu).

Do you agree to be recorded during this interview?

[12] SAGE: local water development and management plan; CLE: local water commission, in charge of the SAGE implementation.

The results of this survey will be sent to you as soon as they are available.

Do you have any questions before we start?

Interview questions:

- Can you briefly introduce yourself (position and seniority, organization, role/involvement in the PTGE)

General feedbacks on the work of the group

- Can you tell me how you were involved and how the activities of the "withdrawable volume" working group went between 2020 and 2021?
    - *Have you followed the whole process, participated in all meetings?*
    - *What was your role?*

- According to you, what were the highlights of the group's work, and why?
    - *Collective highlights (for the group)?*
    - *Individual highlights (for you in particular)*

Results

- In your opinion, has the group agreed on a collective diagnosis, shared by all, regarding the hydrogeological functioning of the water resource on the Seudre catchement area?
    - *What is this diagnosis?*
    - *How did you reach this shared diagnosis? Were there any particular steps or milestones that led you to it?*
    - *On the contrary, were there any elements missing from the discussions/collective thinking?*

- Did your participation in the "withdrawable volume" working group contribute to modify your opinion concerning the long-term management strategy of the Seudre river and its aquifers? If so, how?
    - *Values*
    - *Visions*

Learnings

- What did you learn from this process?
- To go in more detail, could you please indicate what you personally remember about this process in terms of:

- **Understanding of the functioning of the Seudre basin** and its different uses (scientific, technical and local knowledge).
- **Understanding the various issues on the basin, the positioning and opinions of other stakeholders in the basin.**
- **Evolution of the perceptions, the roles and positions of the other stakeholders, and the possibilities or possible difficulties to work together** (relational knowledge).
- **Skills or know-how that support discussion and collective decision-making** (deliberative and decision-making skills)
  - *speaking up*
  - *arguing*
  - *generalizing one's thinking (seeing the global picture)*
  - *facilitating discussions*
  - *managing a conflictual discussion*
  - *setting up rules for discussion, exchanges and decision-making...*

- Today, in what state of mind do you approach the continuation of this work for the implementation of a PTGE on the Seudre basin (in particular the organization in 2022 of workshops on saving water and levers to support current water uses)? *(confidence, reservations, anticipated obstacles, facilitating elements)*
- Do you have any other information to share regarding the work of the "withdrawable volume" group? Is there anything we have not talked about that you think is important?

Thank you!

8.2. Appendix 2 – Participant list to the extraction volumes working group

Type of stakeholders	**Member of the "withdrawable volumes" working group**	**Seen in interview**
Co-sponsors of the PTGE Seudre	Syndicat mixte du bassin de la Seudre	Yes
	Syndicat mixte des réserves de substitution de la Charente-Maritime	Yes
Organization coordinating consultation on the PTGE	IFREE	Yes
Scientists	BRGM	Yes
	INP Bordeaux	yes
Institutions	Agence de l'eau Adour Garonne	Yes
	Conseil Départemental de Charente-Maritime	Yes
	DDTM de la Charente-Maritime	No
	DRAAF Nouvelle-Aquitaine	No
	DREAL Nouvelle-Aquitaine	Yes

Users of the Seudre groundwater	ASA des irrigants de Saintonge centre	Yes
	Comité régional de la conchyliculture de la Charente-Maritime	Yes
	EAU 17	Yes
	Fédération de pêche de la Charente-Maritime	Yes
	Mairie de Meursac	Yes
	Nature Environnement 17	Yes
	OUGC Saintonge (Chambre d'agriculture)	Yes