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Re-thinking agricultural practices to improve water quality: two participatory methodologies for collaborative learning

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Abstract: In the water catchment areas (WCA) defined following the European Water Framework Directive (2000/60/EC), agricultural action plans should be developed in order to improve water quality. However, the coordination and facilitation between the various local stakeholders is not easy and does not facilitate the writing of action plans, which are often not defined regarding the specific issues of the area until now.

In this context, in order to support the design of action plans that would address specific issues of each water catchment area and that would be shared by the local stakeholders, two different participatory approaches have been designed by researchers from the French National Institute of Agronomy, involving the diversity of stakeholders concerned by the water quality problems.

The first approach, Co-click'eau, is based on the design and evaluation of scenarios of changes in agricultural practices at the scale of a water catchment area, in partnership with local stakeholders. It has been tested in 2011-2012 on three WCA in three different regions of France (Nord-Pas-de-Calais, Haute-Normandie, Centre). The second approach, experienced in Burgundy region in 2011-2012, aimed to support the process of change initiated by a group of voluntary farmers, who proposed an original action plan based on an obligation of results and not of means, and iterative assessment on a long term perspective.

The purpose of this paper is to assess collaborative learning generated in these approaches. For this purpose, we conducted semi-direct interviews in 2013 with 35 stakeholders who participated in the approaches in each WCA. This sample was built to cover the different organizations the stakeholders belong to.

Our results show that action plans in the different WCA do not always take into account the results of these collaborative approaches. However, in all the WCA, these approaches contribute to learning of the social stakeholders, in various ways: learning of technical knowledge, of methodological knowledge, about the stakes, about the others and organizational learning. Thus, we show that these approaches lead to information exchange, but also to collaborative knowledge generation.

Keywords: participatory approaches, learning, water catchment, nitrate, pesticides, stakeholders

Introduction

As agriculture is one of the main sources of water pollution in Europe, agricultural action plans should be developed in order to improve water quality, as stipulated by the European Water Framework Directive (2000/60/EC).

In France, the contamination of drinking water sources by agricultural practices is alarming. In 2011 93% of water bodies in France were contaminated by pesticides, and the figure is rising (91% of water bodies were contaminated in 2007). Although contamination by pesticides rarely exceeds the thresholds set by the Water Framework Directive, the fact that it is growing is still of concern (Dubois 2013). Concerning nitrates, the European threshold of 50 mg/l is frequently exceeded (European Commission 2011). To bypass the water pollution caused by agriculture, some water catchments are abandoned (Secrétariat d'état chargé de la santé 2012), and others require nitrate treatments (10% of catchments) or pesticides treatments (20%) for water to be distributed.

Agricultural action plans designed in connection with the European Water Framework Directive are supposed to help improve the situation. Nonetheless, some issues make it difficult, in France, to build efficient and relevant plans: multiple dimensions have to be taken into account to bring about change in agricultural practices (economic, environmental and social), and the territorial dimension of the plans requires coordination and facilitation between the various local "social stakeholders". As these issues are often underestimated, the agricultural action plans produced are mostly standardized. The actions proposed are very similar from one water catchment area to another, comprising of a check list of agro-environmental measures, and not defined according to the area's specific issues (Reau *et al.* 2013).

In this paper, we focus on the elaboration of action plans in French water catchment areas (WCA), defined as the area in which a water drop will return to the drinking water catchment. We argue that these plans' methodological design can partly or fully explain these failures. The Water Framework Directive strongly advocates stakeholder participation in farming practice change processes (De Stefano 2010) such as the elaboration of action plans in catchment areas. However it does not provide much direction on how to build 'efficient' participation which would initiate changes in agricultural practices and local dynamics to support them. The design of a participatory process has been discussed, for instance, by von Korff *et al.* (2012), and Leenhardt *et al.* (2012) who propose scenario analysis as a relevant tool for interaction between scientists and stakeholders.

In this context, this paper discusses two different participatory approaches, designed by researchers from the French National Institute of Agronomy. These approaches aim to support the design of action plans addressing the specific issues of each water catchment area with the different local stakeholders concerned by water quality problems. They are based on the co-design of scenarios, guided by the idea that participation allows for local and scientific knowledge to be integrated into environmental management (Raymond *et al.* 2010).

The purpose of this paper is to assess how collaborative learning has occurred in the implementation of these approaches. We define collaborative learning as a situation in which two or more people learn or attempt to learn something together, capitalizing on one another's resources and skills. Collaborative learning refers to Vygotsky's learning theory of the "zone of proximal development" (Vygotsky 1985) in which learners who receive help from someone can perform an activity they would not have been able to achieve by themselves: this theory strongly focusses on the social dimension of learning.

These two different approaches involving collaborative learning are described in the Materials and Methods section. The aim is to discuss in what ways these approaches promoted collaborative learning.

In order to assess this collaborative learning, we conducted stakeholder interviews to understand their own view of the problem after the exercise (elaborating the action plan of the WCA they belong to). We tried to assess how they understood the relation between agricultural practices and water pollution and their relationships with the other stakeholders after the exercise. We then drew conclusions based on these stakeholder interviews.

Materials and methods

Description of the area studied

Both approaches were tested in 2011-2012 in different WCAs, the characteristics of which are shown in Table 1. The WCAs are located in the Northern part of France, each measure between 1,700 and 4,700 hectares, and used predominantly for field crop production, winter wheat and rapeseed in particular.

Table 1: Main characteristics of the four WCA investigated

Water catchment area	A	B	C	D
Approach tested	Coclick'eau	Co-click'eau	Co-clik'eau	Brienon
Administrative region	Haute-Normandie	Nord Pas-de-Calais	Centre	Burgundy
Utilized Agricultural Area (ha)	4,650 (with 1% permanent grassland)	2,136 (with 8% permanent grassland)	1,680	1,720
Number of farmers cultivating at least one plot in the catchment area	108	44	33	50
Farms' specialization	Field crops (wheat and rapeseed)	Field crops and industrial vegetables	Field crops (wheat, rapeseed and maize)	Field crops (wheat and rapeseed)
Source of contamination	Nitrate	Nitrate and Pesticides	Nitrate and Pesticides	Nitrate and Pesticides

The Co-click'eau approach

Co-click'eau is based on the design and evaluation of scenarios of change in agricultural practices on the scale of a water catchment area ("EAU" – water in French), by various territorial stakeholders ("CO") (farmers, local authorities, advisors from chambers of agriculture, cooperatives, water agency, state agents, etc.). The scenarios are produced in a participatory way, using a linear programming web tool ("CLICK").

We define a scenario as the result of different combinations of three influencing factors: crops, crop management techniques, and the environment. In each scenario we assess the environmental and socio-economic impacts of different distributions/combinations of these factors on the scale of the water catchment area (WCA). Crops refer to those already grown on the WCA as well as other crops whose industry already exists in the region or could easily be developed in the future. Crop management techniques refer to the different ways of cultivating crops, from intensive to organic. In the assessment, we distinguished between five crop management techniques inspired by Guichard and Savini 2009 and Jacquet *et al.* 2011 (Table 2). The environment refers to areas differentiated by stakeholders on a pedo-climatic basis. Hence a same crop cultivated with the same management technique but in two different environments would not have the same results in terms of yield or quality.

Table 2: Strategies underpinning the crop management techniques used in the assessment of the Co-click'eau approach

Crop management technique	Agronomic strategy
Input intensive	Systematic use of pesticides and nitrogen
Rationalized	Pesticide treatments based on observations and triggered by thresholds and fertilization is rationalized – this refers to the crop management technique highly recommended by extension services (called “agriculture raisonnée” in French).
Integrated crop management	Introduction of prophylactic agronomic measures at crop management level while maintaining economic coherence. The use of pesticides and mineral fertilization is thus reduced. Crop rotations are not changed.
Integrated production	Integrated crop management with modification of crop sequences in order to further reduce the occurrence of pests.
Organic farming	The main principles of organic farming in field crops are: no use of synthetic pesticides and no use of mineral nitrogen for fertilization (the use of manure is allowed).

The Co-click'eau approach is divided into 6 successive steps.

1. Definition of the goals to reach in terms of water quality and choice of agro-environmental and socio-economic assessment indicators. The steering committee of the WCA defines the goals of the WCA (e.g. the objective is to reduce water pollution by nitrate and pesticides while maintaining farmer income). It then identifies a set of relevant indicators to assess the performances of the scenarios (e.g. Gross Margin, Intensity of pesticide use, Nitrogen Balance). Hence, the list of indicators can be different in each WCA. In the WCA we assessed, the agro-environmental indicators chosen were mainly pressure indicators assessing the quantity of input used (instead of indicators of impact on water quality) due to stakeholders' ease in calculating them.
2. Description and assessment of current cropping systems based on a territorial diagnosis, in order to produce a “baseline”. The baseline scenario, or “actual WCA scenario”, was determined using the diagnosis of agricultural practices (which is compulsory before elaborating action plans in all WCAs). It describes the distribution of crops and crop management techniques in each environment identified in the territory.
3. Description and assessment of alternative cropping systems in a matrix. On the basis of their local expertise and of known references, a group of technical experts (the technical committee) describes and assesses the current and alternative cropping systems, for each environment. The current cropping systems are usually a combination of “input intensive” and “rationalized cropping systems” for crops already cultivated. The alternative cropping systems consist of alternative crop management techniques for crops already cultivated (in our assessment, integrated crop management, integrated production and organic production), and of different crop management techniques for new crops.
4. Stakeholders' formulation of sets of objectives for the WCA. For example, a set of objectives could be: maximizing the Gross Margin, reducing the intensity of pesticide use and maintaining the wheat production level at x tons. The objectives can thus relate to assessment indicators chosen in the first step, crop management techniques, and the distribution of crops across the WCA. The steering committee can formulate as many sets of objectives as it wants.
5. Design and multi-criteria assessment of scenarios thanks to a linear programming model (constraint optimization model). The results of the scenarios can lead the stakeholders to formulate new objectives (step 4) and thus elaborate new scenarios.
6. Choice of a scenario to elaborate an action plan.

The Co-click'eau approach therefore mainly relies on stakeholders' local knowledge, and involves two different committees (steering and technical). Their knowledge is mobilized to set the parameters of the model, both in terms of technical description of the alternative cropping systems that could be implemented in the WCA and of the objectives assigned for the WCA. The steering committee is in charge of strategic decisions concerning the water catchment area (Steps 1, 4, 5 and 6 described above), and includes farmer representatives, representatives of the cooperatives, the regional authority, the Chamber of Agriculture, the Water Agency (funding agency), the local group of organic farmers or other development groups, and the local agricultural and environmental State authority. The technical committee is comprised of stakeholders with technical expertise allowing them to describe current and alternative cropping systems. They are farmers or advisors from the different local advisory services, such as the Chamber of Agriculture, the organic development group, and other private development groups. Some members of the technical committee can also be associated with the steering committee, and in all cases a local organizer liaises between the two committees.

Brienon approach

The second approach, called "Brienon" after the name of the WCA where the approach was tested, was put into practice in the Burgundy region in 2011-2012. It aimed to support the process of change initiated by a group of voluntary farmers. Eager to promote a process and an action plan specific to their territory and compatible with their possibilities of change, these farmers proposed an original action plan based on an obligation of results rather than of means, and on long-term iterative assessment. This approach is supported by various methodological, modelling and monitoring tools provided by the French National Institute of Agronomy.

The Brienon approach is divided into eight successive steps.

1. Diagnosis of the WCA's current situation through the gathering and analysis of data from interviews and other sources of information, particularly about agricultural practices in the WCA.
A complementary analysis of the risk of nitrate loss for each cropping system was performed in order to identify cropping systems or intercropping that generate high loss of nitrate. For this complementary analysis we used a variety of simulation tools: the nitrate loss risk grid (Lanquetuit and Sebillotte 1997), completed with a simulation tool Syst'N (Parnaudeau *et al.* 2012), and CRITER®, based on the Indigo® method (Bockstaller *et al.* 2008, Sadok *et al.* 2008).
2. Analysis of local stakeholder requests ("water consumers") regarding water quality and agriculture made during interviews.
3. Definition of goals to reach in terms of water quality in the WCA with the steering committee comprised, as in the Co-click'eau approach, of local farmers, municipalities, technical institutes, regional agencies, and the water service provider. This was facilitated with the results produced by the abovementioned analysis of local stakeholder requests.
4. Design and multicriteria assessment of new cropping systems with a group of local farmers
Farmers and INRA researchers met for a four-day cropping system design workshop. At the request of farmers, a first meeting was held with the participation of an external agronomist, who explained some of the principles underpinning the role of intercropping management in order to "trap" excess nitrate. For the other meetings the method followed the "de novo" design (Meynard *et al.* 2012, Reau *et al.* 2013), aimed at re-designing the

main cropping system (wheat-rapeseed-winter barley). The contribution of the new cropping systems designed to nitrate loss was assessed.

5. Drafting an action plan with farmers.

This action plan takes the form of a timeline describing the order of implementation of the different changes; it is accompanied by a dashboard to monitor and analyze means, actions implemented and results obtained.

6. Comparison of the farmers' multicriteria assessment with local stakeholder requests (Ravier et al, under review).

7. Validation of the action plan with the steering committee.

8. Monitoring of the action plan and annual review based on water quality results.

Stakeholders' perception of the problem and the process

Once the action plans were written and validated in the four WCAs, we conducted semi-structured interviews in 2013 with 35 stakeholders (farmers, agricultural cooperatives, municipalities, citizens, agricultural council, technical institutes, water service providers, etc.) who participated in the implementation of the two approaches in each WCA. This sample was built to represent the different organizations to which the stakeholders belong. Our interviews began with the interviewee providing an account of the approach applied in the local context of the WCA. It then addressed different issues regarding:

- the way the interviewee defined the water quality problem,
- the link made between water quality and agricultural practices,
- the technical and social changes observed since the approach was put into practice,
- the strengths and weaknesses of the approach,
- the opportunities and constraints.

Assessment of collaborative learning

We used the results of these interviews and our own observations about the processes of each approach to assess the way in which collaborative learning had occurred. This assessment is based on five different types or aspects of collaborative learning. These types are based on the analytical framework used by Daré *et al.* (2010) in a book describing various experiences of companion modelling (COMMOD), and their implications for learning. We changed a part of this framework, based on previous work (Chantre and Cardona 2013). For our case studies (protecting water quality in water catchment areas), these different types of learning are:

- **Learning technical knowledge:** this type of learning affords a better understanding of the different possible options of change in agricultural practices, and their agro-environmental or economic or social impact.
- **Learning about the issue:** it provides general knowledge on the water quality problems and on the conditions causing this/these water quality problem(s) to emerge.
- **Learning to learn:** although Daré et al (2010) do not refer to this type of learning in their work, we chose to add it to our framework. Learning to learn refers to Bateson's "second" level of learning, where the learner acquires methodologies to gain knowledge. Instead

Daré *et al* (2010) write about “communicational learning”, which we consider as one kind of methodological learning.

- **Learning from each other:** This learning refers to knowledge of each stakeholder’s skills, aims and interests, but also to each other’s beliefs, norms and morals.
- **Organizational learning :** Referring to Argyris and Schön's theory (1996), organizational learning occurs when the norms (the “theory in use”) of a whole organization are reoriented, for example due to radical changes in the organization’s environment. Daré *et al* (2010) consider that the presence of organizational learning during the implementation of a participative approach is evidence that the multi-actor approach has been a success. According to them, the multi-actor approach process becomes an organization in itself and is a factor of success for the approach.

This serves as the framework for our assessment in the Results section.

Results and discussion

After both approaches were tested in 2011-2012, we are able to comment on the action plans that had been written and the collaborative learning that had occurred in each area. However not enough time has yet elapsed for us to assess the impact of the changes implemented on water quality.

Action plans were validated in 2013 by the local steering committees in each WCA. In Brienon, the action plan that has begun to be implemented is directly derived from the co-design and evaluation workshops conducted with farmers. It seems promising in terms of changes to practices, since the farmers are willing to implement diverse changes, such as introducing a new way of managing intercropping, which are especially risky in terms of loss of nitrate. Among the three WCAs where the Co-click'eau approach was assessed, only one (B, in the Nord-Pas-de-Calais region) built its action plan on the basis of the scenarios co-designed with local stakeholders. In the other WCAs (A and C), local scenarios were also co-designed, with the participation of most stakeholders. Nevertheless, some stakeholders in the steering committee, often farmer representatives in the Chamber of Agriculture, were against using these scenarios for the action plans because they were opposed to any change in the WCA. As a result, in these two WCAs, the described actions mainly relate to already existing agricultural regulations (optimizing the use of nitrogen without specifying the method to be used, introduce intercropping). Furthermore, no goals figure in these action plans regarding the results of changes in agricultural practices.

In spite of this heterogeneity in the quality and ambition of the action plans elaborated, interviews with stakeholders in the four WCAs allowed us to identify that collaborative learning had occurred even in areas where the negotiations had not resulted in action plans with objectives of changes in practices beyond regulatory objectives (Gisclard *et al.* under review, De Malleray 2013).

Learning technical knowledge

The co-construction phase of the matrix under the Co-Click'eau approach was a key moment for the stakeholders. For the organizers of the WCA, who are not always agronomists, and generally for all members from the steering committee who had few technical skills, it allowed for the discovery of farming techniques, of new crop management techniques, of the possibility to grow new crops, and also of their agro-environmental and economic performances. For technical advisers, it seems that the description of the matrix also often enabled them to discover new crop management techniques for crops they already knew (integrated crop management, integrated production, and organic farming). The collective, detailed description of the different crop man-

agement techniques led to technical discussions on the feasibility of particular practices. In a context of negotiation on a sensitive topic (changes in agricultural practices for water quality), basing discussions on technical points and estimated performances of alternative ways of growing crops is helpful to avoid the crystallization of political positions that can occur in steering committees, "a scene where the different representations of the world come face to face" (Gisclard et al., under review). Faced with collectively validated results, some stakeholders spoke of the "demystification of organic farming", thanks to a technical description of this crop management technique. More generally, the interviews show that most stakeholders seem to have "discovered" new technical options for the WCA, such as new crops, or new crop management techniques for crops already grown.

The technical learning dynamics in the design of the action plan of Brienon are mostly linked with the workshop of cropping systems re-design. The purpose of this workshop was to provide training on mechanisms of nitrogen loss. It was welcomed by farmers, especially because they felt that these issues were rarely addressed. They appreciated that this training differed from the usual presentations on "agricultural best practice". This training has played an important role in terms of technical learning: it for example contributed to better highlighting the dependence of the cropping system on soil types, and helped the farmers focus on more risky preceding/following crop pairs. A good sign of appropriation is that the local group of volunteer farmers took the main ideas of the training on board to present them to the other farmers of the WCA after the workshop and discuss the main technical choices that had been proposed. While the learning generated by the training was mostly provided by the researchers to the farmers, the researchers also derived learning from the farmers, showing that the knowledge exchange was mutual. For instance, at the end of the workshop, when estimating operating expenses of existing cropping systems and of the co-designed systems, two farmers decided to prepare this information themselves, considering that the agronomists were not accurate enough in their economic assessment. Their proposition was then discussed with the agronomists.

Another step generated technical learning in Brienon, in connection with the last step, relating to the monitoring of the action plan, particularly field measurements. In fact the on-plot measurement of nitrate losses at the start of the winter of 2012-2013 provided real insight into the state of the basin at that time. It revealed the efficiency of cover crops to trap nitrate in some plots, as well as the significance of nitrate losses in plots receiving organic manure, which was underestimated in the first diagnosis. Although livestock farms are rare in this WCA, many plots receive organic effluents, and these strongly exacerbate nitrogen losses. All these elements enriched what had been discussed in the first training session by giving it substance and then helped to maintain interesting technical discussions among the farmers and between the farmers and the researchers.

Learning about the issue

What we call the WCA issue includes both the nature of water quality problems (does it concerns nitrate, pesticides or both? When there is a presence of pesticides, but below the norm threshold, is it worth planning actions to reduce pesticide transfers?) and the origins of these problems (if nitrate or pesticides are found in the water, do they come from agricultural sources or from other types of sources?). We noticed that the two approaches highlighted the fact that stakeholders from the same WCA did not have the same perception of the link between agricultural practices and their impact on water quality.

The need to induce learning about the issue was tackled differently under the two approaches.

It was specifically considered in Brienon's approach through the steps (2) "Analysis of the requests of local stakeholders ("water consumers") regarding water quality and agriculture" and (3) "Definition of goals to reach in terms of water quality in the WCA with the steering committee". The interviews carried out *a posteriori* show that it helped to build a common definition of the

issue. For instance, at the beginning of the process, the debate on the question of pesticides was easily mocked by some farmers, under the pretext that today, atrazine and its derivatives can be found in water, whereas the active ingredient has neither been used nor authorized for years. The Mayor of Briennon then explained how much a treatment plant would cost the town, which is in a difficult financial situation. In view of the results, farmers better understood the financial issues due to pollution by pesticides.

Under the the Co-Click'eau approach, discussions about the definition of the issue were more indirect as they were mostly linked to the debates about scenarios and objectives for the area. For this approach, we had supposed that agreement on the issue had already been reached when we arrived. But over the course of the implementation of the approach we found that there were disagreements. In fact, the interviews conducted show that some disagreements remained about the nature of the issue in the WCA and the stakes linked to it. It is therefore worth adding, as for the Briennon approach, a step to analyses local stakeholders' requests and a step to define goals to reach in terms of water quality.

Learning methods or "learning to learn " (Bateson 1972)

Following the workshop where the matrix was built (Co-Click'eau approach), some advisers stressed the importance of stating mean crop management techniques to locate farmers' practices across ideotypes such as [crop*envrionment*crop management technique] combinations. On the other hand, the approach highlighted some gaps in the diagnosis (established by consultants before the Co-click'eau approach was implemented). It has contributed to a form of awareness by stakeholders, especially technical advisors, of diagnosis methods. The understanding of the nitrogen cycle in the soil seemed highly heterogeneous from one person to another. The advisors pointed out the importance in the approach of debates on the choice of relevant indicators. Concerning nitrogen pressure on water for example, it seems that the choice of a pressure indicator reflecting the potentially leachable nitrogen at harvest allowed some stakeholders to better understand some problems caused by over-fertilization.

In Briennon, different kind of methodologies have been learnt by different stakeholders. Farmers highlighted that during the design workshop they learned to elaborate a cropping system plan over several years. The organizer of this WCA explored other ways of making a diagnosis, and other ways of working with farmers who played the role of system designers. The organizer can thus focus on the analysis of performances to expect from systems offered by farmers. For multiple stakeholders, the diagnosis of nitrate losses combining a risk grid coupled with an indicator of nitrate leaching also played a relevant role in the methods learning process, insofar as it drew on a typological approach to show the diversity of practices in the WCA, without falling into particularism, which is often of little educational value. Moreover, grouping plots from the same cropping system that share the same problems can be a source of solidarity and mutual learning among farmers. Finally, in this WCA a dashboard was established and is used by the local organizer during common field visits with farmers. Thus the establishment of a dashboard helps improve farmers' skills in terms of nitrate management during the crop and during intercropping, and in terms of prognosis of potentially leachable nitrogen following rainfall in the fall and winter.

Learning from each other

Owing to their participation in workshops where all stakeholders expressed their objectives for the WCA, the stakeholders seem to now better understand each other's leeway, especially farmers'. For example, in WCA B, the "removal of industrial vegetables" scenario showed, in spite of good environmental results, a decrease in farmers' the gross margin. This scenario was in fact emblematic of the message of farmers from this WCA: "we are open to changes in practices for the environment, but it is not possible to remove the crops that make up the bulk of our income, that is to say industrial vegetables". Learning about others also occurred in WCA A where two

advisers, one from the Chamber of Agriculture, the other from a private company, met e during the workshops as they worked on the same area. Furthermore, the common description of the matrix allowed them to specify their different visions of technical advice for farmers. This learning about others also relates to the roles and functions of the different stakeholders gathered around the table in the steering committee.

Organizational learning

For Co-click'eau, only in WCA B were the norms of a whole organization reoriented. The Group of Organic Farmers and the Chamber of Agriculture, opposed in their values before the approach was implemented, are now particularly close for the monitoring of the action plan. This lack of links between groups of organic farmers and Chambers of Agriculture is quite common in France. This is due to the fact that Chambers of Agriculture are mandated to represent the opinion of the majority of farmers, who consider organic agriculture to be too remote from their concerns. In WCA B, we suppose that the situation is different because the farmer leading the group is also part of the board of the Chamber of Agriculture. This goes to show that such links (organic farmer/chamber of agriculture) are possible. Another factor may be the fact that for several years the Chamber of Agriculture has promoted integrated crop management (through particular subsidies for example). The “jump” from integrated farming to organic was therefore not so high for this Chamber of Agriculture.

In Briennon farmers have also become active proponents of cropping alternatives, which contrasts with how they are usually seen by other stakeholders: reactive to propositions or conservative. The local group of farmers can be seen as an “organization” that was created thanks to the Briennon approach.

In these two WCAs (Briennon and WCA B), the existence of organizational learning provides evidence that the approaches have succeeded in their aim to help all stakeholders together to build an efficient action plan for water quality improvement.

We can assert that beyond organizational learning, a form of territorial dialogue is being put in place, especially between farmers and water policy makers in Briennon, and between farmers and other stakeholders in WCA B for Co-click'eau.

Lastly, we have learned a lot as researchers, not only from a technical point of view, as shown earlier, but also from this experience, to improve our approaches as explained below.

Conclusion

In this paper, we showed two examples of participatory processes designed to solve the complex and collective problem of water quality in agricultural areas. We discuss the way in which stakeholders' participation was built so as to be relevant for dealing with the problem at stake. Stakeholders' participation in the implementation of this approach is therefore different compared to the Co-click'eau approach, as is the way of exploring alternative cropping systems.

While both approaches have the same institutional framework (European Water Framework Directive), aim (supporting the elaboration of action plans) and reliance on a participatory process, there are several methodological differences. A significant difference relates to the nature of the participants invited to take part in the process. Voluntary farmers were involved in the co-design workshop for Briennon, while the whole steering committee was involved from the outset in the Co-click'eau approach.

Based on interviews carried out after the process implementation, we thus analyzed how each approach induced collaborative learning. Our theoretical proposition identifies five types of learn-

ing. This way of characterizing and breaking up the complex notion of learning can help to make some methodological recommendations for the implementation of such approaches in WCAs:

1. Firstly, ensuring that the stakeholders want to work together on a voluntary basis.
2. Ensuring that there is a joint definition of goals to reach in terms of water quality in the WCA and analyzing the requests of local stakeholders (“water consumers”) about water quality and agriculture
3. Training stakeholders on agricultural pollution mechanisms
4. Exploring different scenarios before elaborating the action plan
5. Defining tools to monitor the action plan

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References

- Argyris, C. and Schön, D. (1996). *Organizational learning II: Theory, method and practice*. Reading, Mass., Addison Wesley.
- Bateson, G. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. Bolton, MA., Chandler Press.
- Bockstaller, C., Guichard, L., Makowski, D., Aveline, A., Girardin, P., and Plantureux, S. (2008). Agri-environmental indicators to assess cropping and farming systems. A review. *Agronomy for Sustainable Development*, 28 (1): 139–149.
- Chantre, E. and Cardona, A. (2013). Trajectories of French field crop farmers moving toward sustainable farming practices: Change, learning, and links with the advisory services. *Agroecology and Sustainable Food Systems*.
- Daré, W., van Paassen, A., Ducrot, R., Mathevet, R., Queste, J., Trébuil, G., Barnaud, C., and Lagabrielle, E., (2010). Apprentissage des interdépendances et des dynamiques. In: *La modélisation d'accompagnement. Une démarche participative en appui au développement durable*. M. Etienne. Versailles, Quae, 223–250.
- Dubois, A. (2013). Contamination des cours d'eau par les pesticides. French Ministry of Ecology, No. 436.
- European Commission (2011). Report from the commission to the council and the european parliament on implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2004-2007. European Commission, 41p.
- Gisclard, M., Chantre, E., Guichard, L., and Cerf, M., en révision. Co-click'eau d'Ecophyto (2018): une démarche d'intermédiation pour la construction d'une action collective locale? En révision dans *Natures, Sciences, Sociétés*.
- Guichard, L. and Savini, I. (eds.) (2009). Vers des systèmes de culture économes en produits phytosanitaires. Tome II. Analyse comparative des différents systèmes en grandes cultures. In: *Ecophyto R&D, rapport d'expertise financé par le Ministère de l'agriculture et de la pêche et par le Ministère de l'écologie, l'énergie, du développement durable et de l'aménagement du territoire*. Paris, INRA: 1–218.
- Jacquet, F., Butault, J.-P., and Guichard, L. (2011). An economic analysis of the possibility of reducing pesticides in French field crops. *Ecological Economics*, 70 (9, SI): 1638–1648.
- Von Korff, Y., Daniell, K.A., Moellenkamp, S., Bots, P., and Bijlsma, R.M. (2012). Implementing Participatory Water Management: Recent Advances in Theory, Practice, and Evaluation. *Ecology and Society*, 17 (1): 30.
- Lanquetuit, D. and Sebillotte, M. (1997). *Protection de l'eau: le guide Ferti-mieux pour les modifications de pratiques des agriculteurs*. Paris: Association nationale pour le développement agricole.
- Leenhardt, D., Therond, O., Cordier, M.-O., Gascuel-Oudou, C., Reynaud, A., Durand, P., Bergez, J.-E., Clavel, L., Masson, V., and Moreau, P. (2012). A generic framework for scenario exercises using models applied to water-resource management. *Environmental Modelling & Software*, 37 (0): 125 – 133.

- De Malleray, J. (2013). Comparaison et caractérisation des démarches participatives de Briennon et Co-Click'Eau d'appui à l'élaboration des plans d'actions dans des aires d'alimentation de captage. Mémoire de fin d'études d'ingénieur - Lasalle Beauvais.
- Meynard, J.-M., Dedieu, B., and Bos, A.P. (Bram) (2012). Re-design and co-design of farming systems. An overview of methods and practices. In: I. Darnhofer, D. Gibbon, and B. Dedieu, eds. *Farming Systems Research into the 21st Century: The New Dynamic*. Springer Netherlands: 405–429.
- Parnaudeau, V., Reau, R., and Dubrulle, P. (2012). Un outil d'évaluation des fuites d'azote vers l'environnement à l'échelle du système de culture: le logiciel Syst'N. *Innovations Agronomiques* 21: 59–70.
- Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M., and Evely, A.C. (2010). Integrating local and scientific knowledge for environmental management. *Journal of Environmental Management*, 91 (8): 1766 – 1777.
- Reau, R., Guichard, L., and Chantre, E. (2013). Evaluation agri-environnementale pour les apprentissages des acteurs des aires d'alimentation de captage. *Innovations Agronomiques*, 31: 91–110.
- Sadok, W., Angevin, F., Bergez, J.E., Bockstaller, C., Colomb, B., Guichard, L., Reau, R., and Dore, T. (2008). Ex ante assessment of the sustainability of alternative cropping systems: implications for using multi-criteria decision-aid methods. A review. *Agronomy for Sustainable Development* 28 (1): 163–174.
- Secrétariat d'état chargé de la santé (2012). Abandons de captages utilisés pour la production d'eau destinée à la consommation humaine.
- De Stefano, L. (2010). Facing the water framework directive challenges: A baseline of stakeholder participation in the European Union. *Journal of Environmental Management* 91 (6): 1332–1340.
- Vygotski, L., 1985. *Pensée et langage*. Paris: Messidor/Éditions sociales.