Private business and local collaborative watershed management: the case of Volvic in France[1]

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Abstract

This paper provides empirical evidences that help understand rationale behind participation of private businesses in collaborative watershed management and the conditions in which it can be effective. We focus on the case of Volvic where Danone has initiated from 2005 onwards a watershed protection program in partnership with local public authorities in order to sustain the flow of two water services, i.e. water quality and availability. We develop a comprehensive analytical framework based on the most recent developments of Ostrom's socio-ecological framework. We identify a number of attributes of the SES system that are likely to explain innovative feature of the local action situation (new local governance arrangements and economic incentives) involving the agricultural sector and aimed at reducing the use of chemical inputs and improving the management of cattle effluents in the area.

1 Introduction

Groundwater is a resource that delivers essential services[2] for humankind such as *purification of water and its storage in good quality, active biodegradation of anthropogenic contaminants and inactivation and elimination of pathogens, nutrient recycling, and mitigation of floods and droughts* (Griebler et Avramov 2015; Knüppe et Pahl-Wostl 2011).

Ensuring water quality and availability is one of today's most pressing challenges. Worldwide demand for water has accelerated drastically over the past decades, due to booming population and the subsequent increase in food and drinking water needs. It also diversified as the demand from private businesses and industries increased, driven by the expansion of related markets, particularly bottled

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[2] the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily 1997)

waters and sodas, and fostered by key political decisions such as the privatization of water supply or hydroelectricity production.

Together with rapid urbanization and industrialization of societies, the recent drastic intensification and expansion of agriculture are amongst the main human activities that currently threaten water quality and availability. Unsustainable pumping for irrigation purpose and the diffusion nitrate and eutrophication are well-documented examples of such phenomena.

Early approaches to water management were mostly based on state-driven, technical solutions i.e. public planning and funding of hydraulic infrastructures or treatment facilities. Scientific and technical expertise played a key role in identifying problems and proposing solutions through rigid management plans and restrictions on land-use rights (Pahl-Wostl et al. 2012). According to critics (Gleick 2003; Holling et Meffe 1996), these solutions failed to take into account the complexities of natural phenomena at-stake and economic and social factors that shape human behavior. Managing groundwater is indeed particularly challenging. One overall challenge is the common pool characteristics of groundwater and groundwater services. Other challenges include institutional fragmentation of public mandates, sectoral policies and planning processes, which often work in isolation; the invisible character of groundwater, which makes it difficult to understand the characteristics and behavior of the resource ; the fact that pollutants leakages are slow, contamination is hard to detect and can persist for many years.

It is now widely accepted that the main obstacles to the sustainable management of water resources are to be found in the realm of governance (Pahl-Wostl et al. 2012). Building upon the Integrated Water Resource Management approach (IWRM)[3], collaborative approaches to water governance recently emerged as less-centralized solutions, which govern water and land-uses at the level of ecological units (ex. Watershed, river basin, aquifer) and specifically address the need to coordinate multiple needs and interests of state and non-state actors, occurring at multiple scales (Pahl-Wostl et al. 2010). (…) This type of governance has often been documented in the case of river basin where collaboration between different state agencies and local authorities, upstream land users and downstream water users is needed. Situations where aquifer management involves cooperation within small groups of rather homogenous users have also received particular attention from the common-pool-resource (CPR) scholarship (Cox 2014).

These corpuses of empirical studies revealed that the success of this type of approach depends on the fit with characteristics of the socio-ecological system in which it is embedded. For example, the literature on CPR identified a range of characteristics that influence the success of decentralized management of CPR (e.g. resource of small size, small group of homogenous users, etc.). In parallel,

[3] IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare, paving the way towards sustainable development, in an equitable manner without compromising the sustainability of vital ecosystems" (Global Water Partnership, 2000, 22)

some scholars pointed out several structural characteristics of governance regimes (e.g. vertical and horizontal integration, diversified financial resources, etc.) that influence the likeliness to build effective adaptive management of such complex resources.

The participation of private businesses in collaborative watershed management and the conditions in which it can be effective have rarely been studied in the scientific literature. However, evidences suggest that in some contexts, a business case for watershed protection leaded a private business to invest in water-related common and public goods. For example, Nestlé implemented in Vittel what is often presented as a perfect case of Payment for Environmental Services (PES), which targets farmers in the source's water catchment (Depres, Grolleau, et Mzoughi 2008; Perrot-Maître 2006). The Coca-Cola Company also developed a Global Water Stewardship Program to protect affected watersheds that are also the source of their manufacturing plants. Besides, in many cases, the approach underlying private businesses' intervention is reportedly based on collaborative watershed management. For example, Danone develops collaborative protection programs in the watershed of their bottled water brands', including in France (Volvic, Evian, Badoit, Salvetat) and in Indonesia (Aqua).

In this paper, we focus on three specific questions: (i) the rationale for private businesses' participation in collaborative watershed management, (ii) the nature of interventions and local governance implications of private actors' involvement and (iii) the factors that influence the success of such interventions especially in the case of Danone watershed protection program.

To address these questions, we develop a comprehensive analytical framework based on the most recent developments of Ostrom's socio-ecological framework (McGinnis et Ostrom 2014), which enable us to analyze the characteristics and dynamics of complex water management and governance systems.[4] Our assumption is that the emergence and performance of such systems depend on the characteristics of the context in which they are embedded. We focus on the case of Volvic bottled water where private business plays a significant role in collaborative management of a groundwater resource. In Volvic, Danone has initiated from 2005 onwards the development of a actions plan for watershed protection involving local public authorities and some of which targeting land-uses (forestry and agriculture) in order to ensure the flow of two water services, i.e. water quality and availability.

2 Method

2.1 Framework of analysis

Implementing a diagnosis approach allows going beyond the mere identification of regularities in the conditions influencing the likelihood of self-organization that the CPR scholarship has historically focused on (Basurto, Gelcich, et Ostrom 2013). Indeed, it helps teasing out what makes each

[4] A governance system encompasses structural features and transient processes at both rule making and operational levels.

resource use problem unique, i.e. which of the attributes of a particular SES system are likely to have a major impact on particular patterns of interactions and outcomes (Ostrom 2009). It simultaneously helps identifying what makes each case generalizable and comparable across setting , as it provides a common set of variables to compare similar SES (Basurto, Gelcich, et Ostrom 2013). In this paper, we develop a diagnosis approach based on the modified version of Ostrom's SES framework (McGinnis et Ostrom 2014).

This framework is primarily organized around first tier variables (Fig. 1). The Resource Units (RU) are composing the Resource Systems (RS) while the Governance Systems (GS) define and set rules for Actors (A). All of these variables influence Interactions with the system (I) and Outcomes (O), and also create feedbacks. These variables also interact with the broader (exogenous) Related Ecosystems (ECO) and Social, Economic, and Political Settings (S).

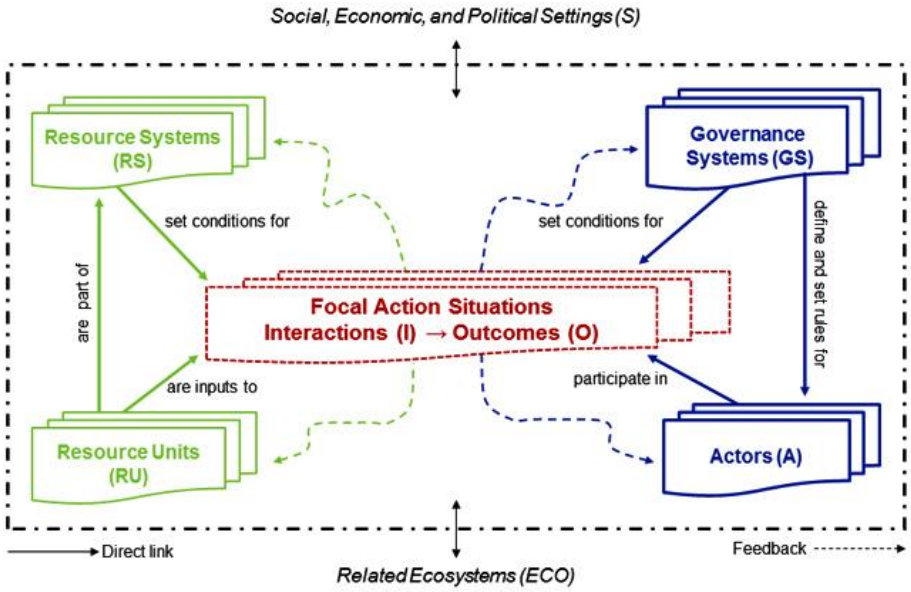

Fig. 1. Revised SES framework with multiple first-tier components. Source: (McGinnis et Ostrom 2014).

In this paper, the resource system encompasses the Volvic aquifer and the land uses located in the water infiltration area (hereafter called *impluvium*). Volvic *impluvium* spreads across four communes of the department of Puy-De-Dôme and is located in Clermont-Ferrand urban agglomeration, which population was 284,672 inhabitants in 2004 (Fig. 2). Main resource units include groundwater, soil and rock substratum, livestock, pasture, crops, forest, wildlife (including pests such as voles). Governance systems include the government and other organizations that are involved in the management of the resource system but also the specific arrangements, incentives and rules related to the use of the resource system, and how these are made. Actors include local authorities and government agencies, land users including farmers and forest owners, Danone, public syndicate in charge of the production of drinking water, environmental associations and research/academic institutions.

These first-tier variables are then made up of multiple second-tier variables identified based in many empirical studies. It is useful in the design of data collection methods as it provides a large and common set of variables likely to influence the sustainability of a particular SES system. “The choice of relevant second or deeper levels of variables for analysis (from the large set of variables at multiple levels) depends on the particular questions under study, the type of SES, and the spatial and temporal scales of analysis” (Ostrom 2009). In our particular case study, we try to explain the intervention of private sector and the subsequent observed changes in actions situations for the management of an aquifer. Our research thus emphasizes some variables, as they appeared to be more important in explaining private sector intervention and outcomes.

2.2 Data collection

We conducted about 20 semi-structured interviews in 2016 with relevant local stakeholders, including famers, local public authorities, researchers, Danone’s local representative and relevant staffs of NGOs and public administrations with a mandate in Volvic watershed.

We reviewed relevant scientific and grey literature as well as all relevant public policies and strategies with a focus on our target area to better characterize some variables of the SES.

This work was completed with the analysis of data from public databases (ADES…), statistics (demography…) and maps (river basin, nitrate directive…) and a local farm survey (REF).

3 Results

This section presents the results of our research based on the SES framework and its main determining factors. We start by depicting the context, then describe the resource at stake, the main actors and the governance mechanisms.

3.1 Action situation

In this section, we describe the local activities and interactions between actors that are closely linked to the provision of water services, i.e. water quality and availability. We also provide a quick description of the main social and environmental outcomes.

3.1.1 Harvesting

The watershed is mostly covered with forest (53%) (Fig. 2). However, forest resources remain largely unmanaged. The main reason is to be found in the tenure characteristics. Indeed, the vast majority of forests (86%, 1900 ha) is private and tenure is distributed among 2606 smallholder owners who own on average 0.95 ha (inside and outside the *impluvium*) and are reportedly old (70% are above 60 years old) and not necessarily living near the *impluvium* (living in average 17.5km far from the *impluvium*). Only 65ha of private forest (3.4%) have drafted a management plan for timber extraction. Public forest (288ha) is managed extensively for the production of timber and chestnuts according to a management plan jointly drafted by the community of commune (administrative level) inside which the *impluvium* is located.

Agricultural land accounts for about 41% of the watershed and represents the main actively-managed land-use (Fig. 2). We identified 18 farms with at least part of their land overlapping with

the *impluvium*. Farm size is relatively small as compared to regional standards. Indeed, it ranges from 24 to 250 hectares, with an average of 107 ha. The size of land in the *impluvium* per farm ranges from 14 to 122 ha, with an average of 43 ha. Production of beef cattle is the main system in the water catchment and is generally extensive. Indeed, the mean number of livestock units per farm is 77, with a high variability ranging from 10 to 198 units. Besides, permanent pasture is the dominant land-use in the *impluvium* (94% of agricultural land). Temporary pasture is also foundand is usually integrated in a rotation with cereals such as Triticale (1-2 years in a 10 years cycle, representing about 40-50 hectares every year or 6% of the agricultural land of the *impluvium*)

Two main stakeholders use and distribute the water from Volvic aquifer. Danone uses about 17% of the aquifer water outflow per year (90 L/s). SMUERR is a public syndicate gathering 33 downstream communes, including Volvic, and is in charge of distributing drinking water to about 60,000 downstream household. It uses 32% of the water flow (about 167L/s).

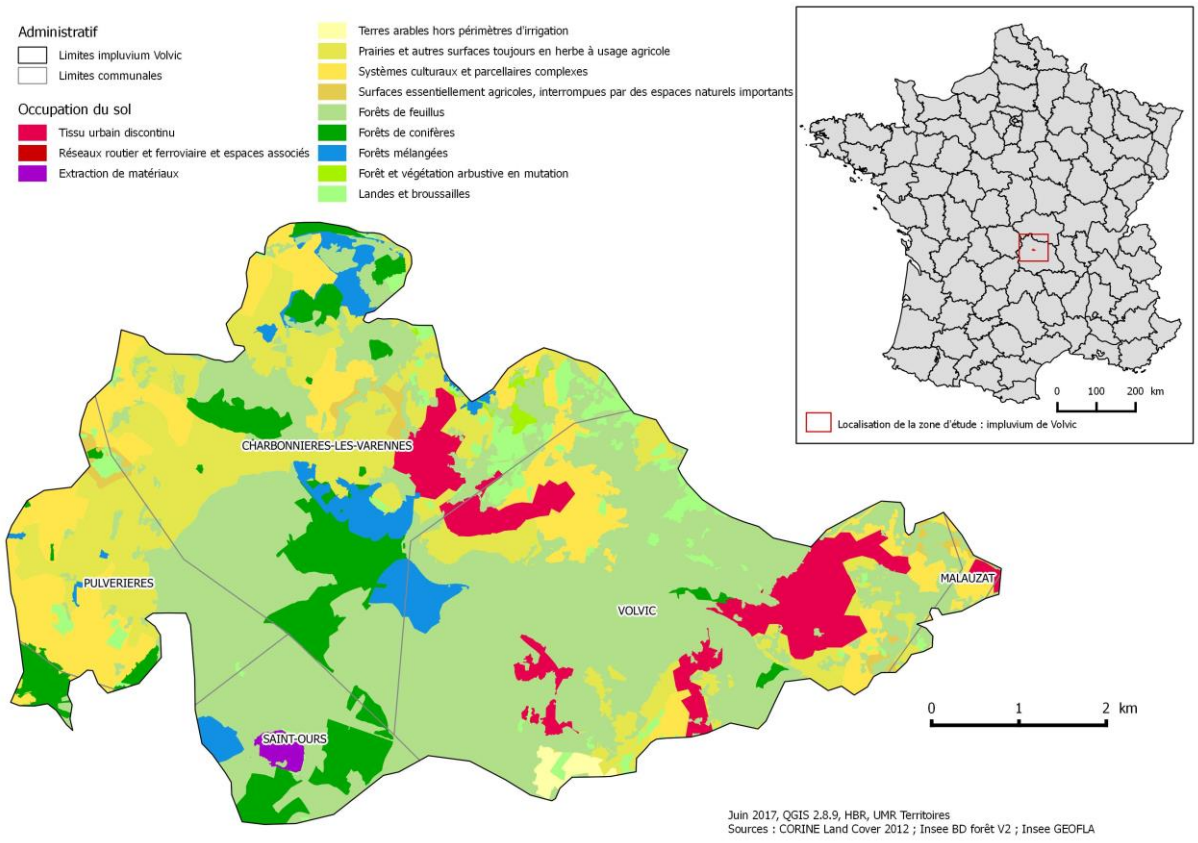

Fig. 2. Land-use map in the Volvic impluvium

3.1.2 Monitoring and research

Both the aquifer and the agricultural activities on the *impluvium* are regularly monitored by multiple government agencies with overlapping mandates, in order to control the compliance with the legal

framework. Indicators include water quality, water availability and extraction levels but also agricultural practices such as the use of agricultural inputs or the management of effluents.

What is quite particular in the Volvic case is that knowledge development has been significant. Indeed, extensive research work has been carried out in the field of hydrogeology and agronomy. The focus on technical aspects aimed at reducing uncertainties regarding the characteristics of ecosystem services, at improving the quantification of risks of degradation of ES flow and at designing technical solutions to reduce these risks.

More specifically, there is a long history of hydrogeological research on the Volvic watershed and aquifer, but also on neighboring similar volcanic aquifers used to produce public drinking water. Noticeably, this research was instrumental in advancing in the understanding of the hydrogeological system, in defining the boundaries of the Volvic impluvium and in characterizing pollutant transfer in the system[5]. Between 2009 and 2013, the LIFE-SEMEAU project,- funded by the European Commission and leaded by Danone, developed a model of the hydrogeological system in order to better estimate the theoretical impact of local land-use practices on the provision of water services.

More recently, significant research has been developed in the field of agronomy, generally leaded by researchers from VetAgro Sup, a local academic institution. This research focuses on the assessment of specific agricultural practices, including in particular the management of cattle effluents and the control of vole outbreaks[6], in order to estimate the risk of diffuse pollution and to develop sustainable control methods.

3.1.3 Local partnerships

Various governance arrangements based on public-private emerged around the management of the water catchment, particularly since the mid 2000's.

From 2005 onwards, Danone initiated in Volvic a water catchment strategy that involves public stakeholders and land managers (farmers in particular) in order to prevent water from pollution, water shortage and improve its brand reputation. They created a local association called CEPIV (Environment and protection committee of the Volvic water catchment area) that gathers the 4 municipalities having land in the watershed and Danone. Its mission is to develop a concerted action plan for the protection of the *impluvium*.

Another committee was created in XX in order to follow up the extractive use of Volvic aquifer outflow, particularly the compliance with extraction legal rights. It also reviews new demands of extraction. This committee gathers representatives from Danone, SMUERR and two state agencies (DREAL and DDT). It is unique at the regional scale.

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[5] Barbaud J.Y. (1983): Etude chimique et isotopique des aquifères du Nord de la Chaîne des Puys, Temps de transit et vulnérabilité des systèmes de Volvic et d'Argnat, PhD, Université d'Avignon et des Pays du Vaucluse, 1983 (in French)

[6] Vole outbreaks impact the quality of pasture and induce significant rehabilitation costs for farmers. It is a major problem in this part of France.

A third significant local partnership involves a local academic institution (VetAgro Sup) and CEPIV. It focuses on developing research work linked to agriculture in general and more specifically to the biological control of vole outbreaks (see previous section).

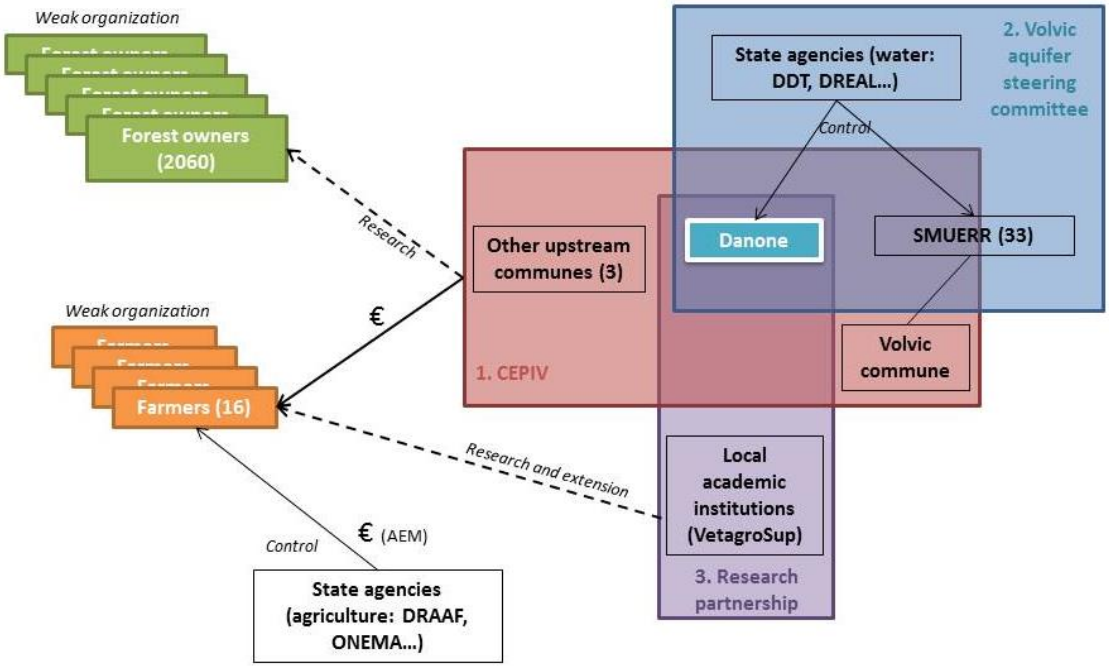

Fig. 3. Local governance of water services. Source: authors

3.1.4 Local subsidies

The main locally-designed interventions aimed at enhancing the provision of water services are based on an incentive approach. Initially, CEPIV's economic incentives targeted urban areas – the improvement of individual water sanitation facilities- and transport infrastructures – reduction of the use of chemical herbicide on the railway. However, more recently, CEPIV initiated additional schemes targeting agriculture in order to reduce or prevent the use of chemical inputs and to improve the management of cattle effluents. Agricultural subsidies now represent a significant share in CEPIV annual budget, which is about 300,000€ in total. Participation of farmers is always voluntary. However, we distinguish different types of financial mechanisms. First, CEPIV invests in shared agricultural equipment or machinery, covering both initial investment and running costs. For example, CEPIV supported the purchase of composting equipment but also cover some of the composting costs by financially supporting the farmers' organization operating this machinery. Second, CEPIV provides free-of-charge agricultural services to farmers. For example, CEPIV hired two vole hunters operating in the water catchment. Third, CEPIV compensates some of the individual opportunity costs induced by the adoption of pro-environmental practices. For example, CEPIV provides subventions to support conversion to organic agriculture, topping up government subventions.

3.1.5 Social and environmental outputs

As in the rest of the region, the economic viability of beef cattle farms is fragile. We estimate the average monthly revenue per full-time family worker using regional statistics for extensive cattle systems of similar size. We find that it reached 967€ in 2014, which is below the national minimum net salary (1133€ per month in 2014). It is also worth noting that subsidies represent about 330% of this net revenue (38420€ per year in 2014).

Although environmental indicators (water quality and availability) are historically good, various sources suggest that the risk of degradation is not nil. First, available public data show relatively stable water table levels of the aquifer since 1984 (DREAL). However, some reports suggest that the outflows of these volcanic groundwater systems are decreasing. Indeed, they proved to be sensitive to the effective infiltration deficit which has occurred in the area between 1998 and 2006 and may have decreased when considering the long run. It is also interesting to note that recently fish farms operating downstream and relying on Volvic water sued Danone as they argued that they were experiencing a sharp decrease in water availability. Although they lost the trial, it reflects the possible emergence of use conflicts around the limited availability of Volvic water.

Second, public data suggest that the water quality of the aquifer has been historically very good with no significant crisis. However, a national study on mineral water quality published in 2013 by a consumer association found infinitesimal traces of atrazine in Volvic bottles. Atrazine is an herbicide that was banned in France in 2001 but that was used by the National Railway Company in Volvic. Other reports suggest that the level of nitrates in Volvic water is rather high and has increased over the past decades, although remaining below legal safety. Finally, our interviews revealed that SMUERR was created as a response to a pollution event that occurred in 1982 after a local land reform induced significant clearing of hedgerows in the *impluvium*.

3.2 The resource system and units

In the following section, we disentangle the links between the characteristics of the different units composing the overall resource system and the provision of target water services. We show that the system is actually full of complexities, which makes the long-term supply of water services uncertain.

3.2.1 The hydrogeological system

Overall, the hydrogeological structure of the resource system is well-understood and relatively circumcised (it does not involve any deep water flow). "*Much of the variscan crystalline substratum, which is considered as impervious, is covered by lava flows and scorias produced by Quaternary strombolian volcanoes (Boivin et al., 2009) (Figure 1). Lavas were channelized into paleovalleys dug in the crystalline basement. In sectors where the crystalline substratum is outcropping, runoff is predominant and water infiltrates at the contact with volcanic formations*" (LIFE SEMEAU report). Research on contaminant transfers in such basaltic lava flows suggest that there is a dual flowpath system supplying volcanic springs: "*water flows in an environment analogous to a fissure system, and slightly interacts with a low porosity matrix*" (Bertrand et al. 2015).

In this context, Bertrand et al. conclude that "*although lava flows are vulnerable to point source pollution due to the rapid transfer of water within fractures, the saturated scoriaceous layers located*

between massive rocks should suffice to strongly buffer the transit of pollution through dilution and longer transit times" (Bertrand et al. 2015).

The hydrogeological characteristics of the system are also such that water availability and quality are strongly interlinked. Aquifer vulnerability to contamination depends greatly on the sustainability of the quantity of groundwater, and thus on the recharge rate (Bertrand et al. 2015). In this regard, replacement of the system is efficient as 100% of effective rainfall infiltrates and reaches the aquifer. This effective rainfall depends on climatic parameters but also on the type of vegetation that evapotranspirates (see in later sections).

These hydrogeological features are instrumental in explaining historical data on water quality and availability (see previous section). Indeed, risks of water services degradation are buffered by the hydrogeological characteristics but are not nil.

3.2.2 Water

The outflow is relatively small (520L/s), especially considering the fact that it is used both for public and private purposes.

An important feature of Volvic water is its local economic significance. Danone bought Volvic in 1992 and it then became one of its major mineral water brands. Production reaches about 1.2 billion bottles a year, 30% of which are commercialized on the French domestic market and 70% are exported in 65 countries, including Germany, UK and Japan as the main export markets-. Sales revenue was of 465.8 million euros in 2015.

The water resource unit is also unique and replaceable only at high costs. This is particularly true for Volvic water marketed on the French market. Indeed, the delivery of a license to commercialize mineral water in France is conditioned to a steady and unique mineral composition. Besides, any treatment that would modify this unique mineral composition is forbidden On the other hand, Volvic water could in theory be replaced for its public use, but it would be very costly. For example, SMUERR had to build an Arsenic treatment plan in 2012 after EU legislation changed (from 50 to 10 micrograms per liter): investment costs were about 1.8million euros and annual operating costs are about 500,000€. Switching to another source of public drinking water also represent significant investment costs. For example, there are currently significant investments to connect SMUERR's distribution network with other networks, as part of a broader basin strategy aimed at increasing the resilience of public water distribution system to possible major crisis (including terrorism). Estimated budget for the connection with the downstream Allier network is about 8 million euros.

3.2.3 Forestry and agricultural decline

The LIFE-SEMEAU model suggests that characteristics of forest cover influence water availability in the aquifer. First, forest cover is positively correlated with the availability of water in the aquifer. For example, agricultural decline that would move forest cover from 53% to 80 % would reduce the flow of the source of 6%. Conversion of young forest regrowth (390 ha) in extensive grasslands would increase the flow of the source of 5%. Second, the dominant tree species also influence water availability. Currently, the forest of the *impluvium* is composed of 47% of deciduous forest, 23% of coniferous forest and 30% of young forests populated by pioneering species. Converting coniferous forest in deciduous forest would increase the source flow rate of 9%. Finally, reports and experts also

suggest that intensive exploitation of forests would result in the development of motorized activities / mechanization that would in turn increase the risk of hydrocarbons pollution.

Past forest cover has been relatively stable in the last decades. In the future, decrease of forest cover is not likely, even in the event of booming fuelwood or timber prices. Indeed, the risk is relatively circumcised: there are about 839 Ha of accessible forests out of 1704 Ha of private forests (where harmful management practices are more likely to emerge). Besides, the potential profitability of forest management at the individual level would remain low: LIFE SEMEAU project show that the average size of forest plots by forest owner is less than 1 Ha and that the maximum profitability of clear cuts per hectare is low.

Local stakeholders are rather concerned with a possible increase in forest cover. Farmers indeed argue that the current livestock crisis and the subsequent small market value of local agricultural products might eventually lead to agricultural decline and abandonment of grassland due to farm bankrupt and low rates of farm succession. Currently, most farmers market their untransformed agricultural products through conventional value chains where prices are low and where demand in both domestic (falling domestic consumption of meat) and export demands (Italy) tend to decrease. We have seen in section XX that it does not allow them to generate sufficient revenue. Local famers agree on the fact that we have now reached a tipping point in terms of capacity of remaining farms to expand and buffer the loss of pasture.

However, interviews suggested that different local dynamics might take over and the buffer the possible increase in forest cover resulting from this dynamic. First, the fact that Volvic *impluvium* is located in a peri-urban area make it prone to urbanization and to the use of agricultural land for domestic animals such as horses. Such changes have already started in the *impluvium* and are not satisfactory from a water quality perspective. Second, the development of short-value chains and labels are regarded as one way to increase the price of agricultural products at farm gate. Among the 16 farmers of the area, four of them have developed strategy to enhance their products outside the traditional supply chains (direct sale, short-value chain with local supermarket) or through labels (organic agriculture and label rouge). This scenario is satisfactory from a water quality perspective as these initiatives are often associated with pro-environmental practices.

3.2.4 Agriculture and diffuse pollution

The main concern associated with agriculture is the adoption of practices that would lead to leaching of nitrate or substances in the aquifer.

The current breeding systems generate limited risks in terms of nitrate or phosphate leaching (LIFE SEMEAU). For example, the average nitrogen pressure is very low (on average 64 Kh / Ha) and generates only very limited risks (12 Kg / Ha maximum) (LIFE SEMEAU). One reason is that farming systems are relatively extensive. The average load is 0.7 livestock unit per hectare. Besides, farmers generally comply with norms regarding livestock building, manure storage in the field and manure spreading. However, a LIFE-SEMEAU report also notes that "*the lack of knowledge of the regulations and the lack of predictive reasoning (plan of fertilization) can lead to risks of excessive intake on certain plots*" (study Life-Semeau 2012).

However, studies also show that the risk of leaching is much larger in plots where the rotation triticale/temporary pasture is implemented. The main reason is that farmers use of extra inputs in this type of system as compared to permanent pasture. More specifically, farmers apply on average herbicides twice and fungicide once within the triticale cycle (before ploughing, in the pre-emergence phase). Besides, they also apply an extra 67 to 100.5 kg / ha of nitrogen as mineral fertilizer between March and mid-March on temporary pastures and triticale (basic pasture organic fertilization is about 30 t / ha / year of manure or 25 t / ha of compost). Currently, the risk associated with this specific system is rather circumcised as the rotation triticale-temporary pasture is long, with a maximum of two consecutive years of triticale, and does concern only 40 ha. However, farmers and experts reported that the increase of the surface of crops is a likely scenario. Indeed, growing more cereals and oilseeds is seen as a relevant strategy in a context of cattle crisis because it would allow reducing costs associated with straw and more importantly animal feed purchase. This strategy would also be one way to adapt to the current market demand characteristics, i.e. the falling domestic demand for meat and the increasing demand for cereals..

Risk of leaching would also be particularly high in the case of vole outbreaks. This type of event happens every 4-6 years and is more likely to occur in permanent meadow systems, the Volvic area being particularly affected. Vole outbreaks constitute significant economic issue for farmers because they generally induce significant impact on pasture quality and productivity and livestock health. Control practices of vole outbreak can potentially negatively impact groundwater quality: few farmers started growing crops in their land rotation to repair vole damages on their grassland and few others reported to have used bromadiolone. This situation explains why Danone decided to invest in the development of biological control methods in partnership with Vetagro Sup.

3.3 The actors, motivations and interests

In this section, we focus on the three groups of actors that proved to be the most influential in the management of the resource system, i.e. Danone, local authorities (4 communes, the community of communes, SMUERR) and farmers. We assess their motivation and interest to contribute to water services. We show that while economic interests prevail, a social norm based on a better understanding in the relationship between land-use changes and practices and the water environmental and social/economic diffused among actors and is probably instrumental in explaining subsequent changes.

3.3.1 Danone

Maintaining the brand reputation and credibility is the first reason that leaded Danone to invest in watershed management. Indeed, starting from the end of 2000's, Danone developed a communication strategy based on the natural character and the high level of protection of the catchments of its bottled water. In Volvic, the link with the volcanoes and the natural environment were particularly emphasized. This strategy emerged as a result of the drops in sales that occurred during the 2008 economic crisis but also as a response to increasing criticisms questioning bottled water industry's environmental footprint and casting doubts on the real added-value in terms of health benefits of consuming bottled water as compared to tap water. After sales picked up in 2009, some marketing surveys showed that the link with nature is particularly important to explain the increase in demand for Volvic. In this context, it is thus reasonable to believe that noticeable changes in the apparent healthiness of the natural environment of Volvic or the occurrence of infinitesimal

traces of pollutants in Volvic water would affect the brand image and sales. This might explain why Danone took the 2013 consumer association's report very seriously and organized a consultation with farmers / local stakeholders upstream in order to investigate the possible cause of Atrazine residues found in Volvic water, although they were far below legal standards.

A second reason is to sustain market access. Delivery of mineral water licenses to operate is generally linked to the compliance with strict rules regarding the quality of water. These rules are also specific to the countries where Volvic water is commercialized. For example, the legal standard for Arsenic in 10µg/L in Europe while it is 0µg/L in Japan – one if the main export market for Volvic. This is probably a significant motive for Danone because Volvic brand was exposed to such crisis. In 2011, a batch of Volvic and Evian bottles were rejected by Chinese authorities due to excessive levels of nitrites. However, it did not have long-term consequences on the access to the Chinese market and on the overall brand image. Volvic was also indirectly impacted by the ban of Perrier water from the USA in 1997 as both brands belong to the same group, Nestlé. As a result of this crisis, Nestlé had to sell the fruity water brand of Volvic ("oasis") and later on Volvic itself to Danone.

A third reason is a switch in paradigms for watershed management. Although Danone bought Volvic in 1992, the firm effectively took over the management of the company in the early 2000's. This time corresponds to a clear switch in the paradigm for watershed management. Before Danone took over, Volvic Water Company's strategy was based on land acquisition – it owns as much as X ha inside the *impluvium*. Several interviewees mentioned the fact that Danone imported the collective watershed management it developed in Evian. Indeed Danone created in Evian the same type of public-private partnership as in Volvic in 1992. In this context, starting from 2005, they decided to replicate this experience in the *impluvium* of all the group's water brands produced in France and in some other countries such as Indonesia.

3.3.2 Local authorities

Local authorities and more specifically Volvic commune have multiple interests having Danone operating Volvic plant in the area. First, their interest is economic. The bottling plant provides about 1000 direct local jobs and thus contributes to rural vitality. Local employment is one of the key objectives of local development plans (Grand Clermont PAAD, commune urban planning documents). Besides, Danone pays a local tax directly transferred to Volvic commune and based on the number of bottles sold on the domestic market. This income represents about 2.3 million euros per year for the commune (36 % of the total budget).

Second, their interest is linked to the provision of public service. Downstream communes, gathered in one public syndicate (SMUERR), indeed have the public mandate to supply 60,000 downstream households with drinking water. SMUERR is allowed to use water treatments technologies to ensure the safety of drinking water. For example, they built an arsenic treatment facility and also use

[7] In 1990 the company had to recall all its bottles from 6 countries after the solvent benzene was found in some bottles exported to the USA. Sales dropped from 1 billion to 600,000 bottles within a year and Perrier struggled to reach this before-crisis level of sales for almost two decades.

chlorine to treat the water. However, SMUERR also has interest in reducing the risk of human-borne pollution in the watershed because it saves treatment costs (see section XXX). Before CEPIV was created, SMUERR had already been implementing actions to protect the water catchment, such as the creation of a pond to divert waste water and the acquisition of about 7ha of land. Their interest also lies in the fact that activities linked to watershed management are significantly sponsored by Danone – costs are shared. The fact that SMUERR stopped direct actions and instead chose to participate in CEPIV committee was explicitly justified by the fact that CEPIV had much larger financial and technical capacities.

Third, collaboration with Danone also improved local authorities' awareness of the *impluvium* boundaries and the links between land-uses and water quality/availability. We postulate that it strengthened their willingness to be involved in collaborative watershed management and to better take it into account in public planning. SMUERR was already aware of these links before CEPIV was created. However, the extent of the *impluvium* was not clearly known so that SMUERR's actions were taken at a much smaller scale: the perimeter of protection was about 10% of the *impluvium* area. Besides, watershed management was not really considered in public planning before CEPIV was created (Salma) while it is now quite explicit in public planning documents (see Grand Clermont).

It is finally worth noting that there are significant disparities in terms of interest in watershed management among the four communes having part of their territory on the watershed. This is clearly reflected in the differences in efforts put in watershed conservation between Volvic and the three upstream communes. Volvic invests about 100,000 euros in CEPIV budget. Besides, when Volvic municipality updated its urbanization plan, it removed plots located inside the *impluvium* from the list of constructible areas because it is a significant source of potential pollution, whereas other communes continue allowing urbanization inside the *impluvium*. Finally, it is worth mentioning that upstream communes often complain that they are working for Danone and Volvic when complying with environmental norms, while receiving much smaller benefits from increased protection.

3.3.3 Farmers

Farmers' contribution to the provision of water services is not straightforward, as they do not benefit directly from water services. In this context, semi-structured interviews with farmers revealed different levels of adoption of pro-environmental practices. For example, only one farmer is engaged in conversion to organic agriculture while most farmers participate in –and are satisfied with- the vole control activities.

Farmers' willingness to participate in CEPIV initiatives seems to be primarily driven by economic motives, i.e. a comparison of personal costs and benefits. Indeed, farmer's main concern is to receive sufficient and fair remuneration for their work, including environmental services they produce. This concern has to be understood in the broader context of the current cattle crisis (see section X). On the one hand, adoption of pro-environmental practices is more probable when induced costs are sufficiently compensated for. During the focus group discussion, farmers complained that they were not receiving sufficient financial compensation for the regulatory services their current extensive agricultural practices and farming systems provide to downstream stakeholders. Besides, adoption rate is higher when labor costs are also (i.e. on top of investment

cost) bore by CEPIV. Indeed, vole control and composting, which received the broadest support among farmers, are the activities that are completely externalized.

On the other hand, adoption of pro-environmental practices is also more probable when target changes are perceived as beneficial or as a technical improvement. For example, farmers who do composting perceive it as a more effective way to improve pasture fertility from an agronomic point of view; the growth rate of organic agriculture market and the fact that prices are rather steady as compared to conventional prices seems to have motivated the only conversion in the area; control of voles also received broad support because farmers noticed that it contributes improving the productivity of pastures and reduce cost of pasture rehabilitation.

Interviews also revealed that other non-economic drivers are instrumental in guiding farmers' adoption of pro-environmental practices. Indeed, some farmers adopted such pro-environmental practices without CEPIV support. Becoming aware of their role in providing water services and water-related social services (employment) downstream leaded farmers to take into account the potential consequences of their actions by adjusting their decisions regarding the use of chemical inputs and the management of effluents, even in the absence of incentives (social responsibility). Besides, having the feeling of autonomy in decision-making seems also important. Farmers stressed that there is no regulation that would force them to implement technical changes promoted by CEPIV, and that it is important to them to feel that they are free to make their own decisions. For example, the only farmer engaged in conversion to organic agriculture reported that he first declined CEPIV support in order to be able to make an independent decision.

3.4 Governance

In this section, we focus on the governance characteristics that play an instrumental role in influencing the provision of water services. We show that the formal institutional setting is instrumental in explaining the interventions we observed in the system, as they define liability rules and justify the relevance of private incentives. We also show that the governance structure mixes characteristics of a centralized system lead by Danone with characteristics of a collaborative system based on broader participation.

3.4.1 Liability rules

Water distributors, SMUERR and Danone, are by-law liable for the quality and the quantity of water they distribute. For example, the French Law requests any groundwater user, in our case SMUERR and Danone, to obtain an authorization from the sub-regional administration ("département") to drill, pump and distribute groundwater. These public decisions also define caps of water quantity (in L/s) these two stakeholders are allowed to pump. Besides, water distributors are also by-law liable for the quality of water. The French law requests SMUERR to distribute tap water that meets the safety standards for drinking water. We have also already highlighted the fact that national legislations of export countries have specific water quality (safety) standards that bottling companies have to comply with. The specificity of the French law is that it imposes additional constraints for bottled mineral water as compared to tap water: mineral content has to be stable over time and no treatments are allowed. These extra rules emphasize the need to select sites that are naturally protected and to engage in risk prevention.

The formal institutional setting does not emphasize the liability of land users in regard to water quality and availability, particularly in the case of Volvic. Indeed, most land in the *impluvium* is under the private property regime. This status gives absolute rights-of-use to land-owners inside the perimeter of ownership (Article 544, Civil Code). In practice, land-owners have the right use their property as they want, as long as this use doesn't go against any legal prohibition. To limit the scope of land ownership, the State can impose special legal restrictions in order to conciliate their activities with the protection of groundwater. In France, the legal framework is particularly developed to control nitrate leaching from agriculture. However, Volvic *impluvium* is not defined as a nitrate-sensitive zone. There is, however, an official perimeter of protection for the public catchment point, inside which local authorities can set restrictions of use to protect the water resource. However, it covers only 1/10th of the *impluvium* and has been really used, particularly since CEPIV started. Finally, the Volvic *impluvium* overlaps with different types of protected areas (PNR, RNR, ZNIEFF, etc.). However, the ones that are legally use-restrictive (RNR) do not overlap with agricultural land (see map).

3.4.2 Economic incentives for land users

Various public agricultural subsidies (EU, national, sub-national) are available in the Volvic *impluvium*. For example, in 2013-14, farmers owning land in the Volvic *impluvium* received on average 21,500€ of public subsidies per full time worker.

Only a small portion of these subsidies, about 19% in amount in 2013-14, specifically aimed at inducing changes towards pro-environmental agricultural practices or at compensating the provision of environmental services by agriculture. They include in particular agri-environment measures, subventions to organic agriculture (conversion, investment), subsidies for the investment in new equipment to switch to pro-environmental practices and subsidies for the renovation of animal-husbandry buildings. Remaining public payments contribute indirectly to water services, as they address the issue of agricultural decline: subsidies for installation of new farmers, on-farm processing of agricultural products but also maintenance of agriculture in areas with natural constraints and pillar-1 payments.

In the Volvic *impluvium*, water services are indirectly compensated for, and it seems to be even more the case since the 2015 CAP reform. Quantity-wise, farmers reported that 2015 CAP payments were late since (not paid until now) and that they expect smaller amounts of payments. Prior to the 2015 CAP reform, the main agri-environment measure (AEM) available locally aimed at stabilizing the surface of permanent pasture in areas threatened with agricultural decline and at maintaining sustainable practices in terms of fertilization, animal load, etc. Multiple ecosystems services, particularly the protection of water and biodiversity were hence targeted by this measure. Since 2015, AEM are tailored according to territories specific and significant environmental issues, which must be argued in agri-environmental project. The only PAEC overlapping with the Volvic *impluvium* covers only part of it and essentially focuses on biodiversity and wetlands conservation. The focus on groundwater services is thus marginal.

The provision of public subsidies in the agricultural sector is strictly framed, as France has to comply with legally binding international trade agreements and European Union legislations. It limits the volume of agricultural subsidies available, it constraints the scope of eligible situations and actions

but also implies relatively heavy administrative procedures. These constraints contribute explaining the strong reliance on private incentives in the case of Volvic. Indeed, private sector intervention allows creating a clear and locally tailored, relatively light in terms of bureaucracy and most important sufficient funding mechanism. Indeed, CEPIV pools about 300 k€ from two downstream stakeholders, which Danone can even top up if necessary.

3.4.3 Governance structure

The Volvic aquifer is *de facto* integrated in the broader water governance system, which has been organized after the 1992 Water Law at the scale of larger hydrological units, i.e. the Masterplan for Water Development and Management (SDAGE) at the basin level and the local Water Development and Management Plan (SAGE) at the sub-basin level. Integration with public governance is actually even broader, i.e. it reaches other sectors beyond the water sector, because all public decisions, programs and guidance documents applicable within the scope of the SAGE and taken in the field of water, including land-use and urban planning, by the administrative authorities must be compatible or made compatible with the SAGE strategic plan.

All in all, local arrangements such as CEPIV or the Volvic aquifer steering committee add a new and even more decentralized level to preexisting water governance system. Locally, connectedness with broader public governance is effective because local authorities and state agencies are actively involved in these local governance arrangements.

In the SDAGE “Loire- Bretagne”, the Volvic aquifer is defined as a “safeguard area for future drinking water supply”. This strategic role explains why the Volvic aquifer receives specific attention in various public planning documents and more generally from public authorities. For example, the “Grand Clermont territorial coherence scheme” (the main public planning document) clearly emphasizes the protection of the Volvic *impluvium* as one of its strategic objectives. The creation of the aquifer steering committee involving Danone and relevant state agencies is a direct consequence of the classification as strategic resource.

It also explains why there are strong synergies between public and private planning but also across levels and sectors of public planning. For example, we notice clear consistencies between the SAGE Allier-Aval strategic objectives that are specifically applicable to the Volvic *impluvium* and both the CEPIV and Volvic aquifer steering committee interventions. Indeed, it emphasize the need improve the provision of groundwater services (quality, availability) by defining draft a strategic plan for the monitoring and use of volcanic aquifers and by reducing the risk of diffuse pollution (improve cattle drinking points, improve management of effluents and reduce pollution from the use of pesticides).

3.4.4 Decision-making processes

CEPIV and the steering committee share a common approach to preexisting watershed management policies. Indeed, SAGEs in particular were designed as decentralized, consultative and collective tools, which goal is to find a sustainable balance in the planning process of hydrological units, between the protection of aquatic environments and the satisfaction of different uses” (Piégay et al 2002). In this framework, local Water Commissions (CLE) - composed of representatives of local authorities, users and state representatives of relevant public institutions- play the role as the consultative body responsible for drafting the SAGE.

However, new local governance arrangements did not initiate broad active stakeholders' participation. On the one hand, the role of the demand side of water services and more specifically the private sector (Danone) is emphasized. Steering committees of the new local governance arrangements are mainly composed of representatives of the demand side (Danone, public authorities). If we take the example of CEPIV steering committee, Volvic and Danone have three representatives each while the three other communes have one representative each.

Besides, interviewees also suggested that in practice, Danone holds significant decision power in devising strategies for watershed protection. Decision power is derived from the significant financial resources Danone holds and is willing to spend locally. It is also explained by the fact that letting Danone take the lead is a conscious strategy motivated by the fact that there are converging public and private interests and that public resources are limited and should be spent in areas where there is no private investment and where environmental issues are more severe. Public authorities monitor both Danone's actions by participating in local arrangements and the supply water services to make ensure compliance with the law. Indeed, the only lever public authorities have to influence Danone's decision is actually the enforcement of the legal framework.

Finally, opportunity for farmers to participate and influence decision-making processes is reportedly insufficient Farmers are at best represented indirectly in new local governance arrangements, despite being amongst the main suppliers of water services. For example, two members of the CEPIV committee are both mayors of one upstream commune and farmers. However, among the two mayor-farmers, one of them is not very active because his commune has little land on the *impluvium* and, as stated earlier, both of them have little relative power to influence decisions. Besides, farmers reported that they are consulted very late in the design phase of CEPIV interventions: they rather play the role as recipients of actions initiated by these different arrangements. Earlier consultation would, from their point of view, improve the design of interventions. For example, one farmer argued that if they had been better consulted during the design phase of the biodigester, the process would have been much faster and some pitfalls could have been avoided. What is important to note is that in general, procedural justice seems to matter to them and that the perception of not being involved in CEPIV decision processes might negatively influence their willingness to participate in CEPIV's initiatives.

4 Discussion

4.1 Business case and water risks

Our case study suggests that a necessary condition for the involvement of private companies in collaborative watershed management is becoming aware of "water risks" to their businesses. In the case of Volvic, they are twofold. The business case is reputational. Indeed, in a context of shrinking market for bottle water and the emergence of ecological concerns among consumers, Danone chose to develop Volvic brand image on the high level of protection of surrounding natural environment. Investing in watershed management is thus a way for Danone to align its actions with its marketing strategy. The business case is also regulatory. Investing in watershed management is a way to ensure water quality and thus to strengthen and maintain its licenses to operate in the various countries where Danone sells Volvic water. Overall, Danone's watershed approach can be considered as being

the result of a risk management strategy which objective is to make business stronger and more resilient.

The United Nations' CEO water mandate suggests that awareness about the business case for watershed protection water services is growing, particularly among multinational corporations and that it originates from a diversity of water risks, beyond those identified in the case on Volvic. It would be interesting to document whether other types of risks and conditions can lead to the emergence of collaborative watershed management. This question is relevant because evidence show that other bottling companies that identified a clear business case for watershed management do not necessarily opt for collaborative management. For example, Nestlé, in the emblematic case of Vittel, primarily based its strategy on large-scale land acquisition.

It is also worth noting that although water risk concern most drinking industries, only some of them make significant investment in watershed protection. This is particularly striking in the mineral water sector in France where just a few brands owned by Danone and Nestlé do take action to protect their watershed beyond the very proximate catchment area. We hypothesize that it is linked to the size of the mother company, as it is a factor correlated to its public exposure and thus the importance of brand image and because the financial resources it is able to allocate for such type of action is larger. It is also linked to the particular profitability of the brand and the business horizon, as consequences of today's pollution would only be measurable after several decades. It finally depends on local watershed conditions, as water risks are highly local in nature. Compared to other mineral watersheds in France, land-uses and hydrogeological conditions are such that Volvic is relatively more prone to human-borne pollutions than other mineral water sites in France (deeper origin, less human activities). Overall, the characteristics of local conditions that enhance business case for watershed protection should be further studies.

4.2 Incentive-based mechanisms and effectiveness

In Volvic, the preferred approach for interventions targeting the agricultural sector is based on economic incentives. CEPIV's subsidies shares common characteristics with the concept of payments for ecosystem services (PES). Indeed, CEPIV's incentives are direct transfers of financial resources between representatives of water service demand (Danone and Volvic municipality) and service providers (farmers). Participation of service providers is also voluntary. The provision of incentives is conditional to changes in agricultural practices. The ecosystem service is rather well defined: past research has contributed to considerably reduce uncertainties regarding water services provisions and accumulated significant knowledge on current risks associated with land-uses and subsequent technical solutions.

PES has often been presented as an efficient approach to solve problems of environmental degradation, but only under certain enabling conditions (it is not a silver bullet). These conditions are partially fulfilled in the case of Volvic. We indeed identified what could be considered as a market failure, i.e. the fact that the provision of ES is not fully compensated for – we noted a gap in public subsidies targeting water services. The situation is also characterized by an institutional failure, i.e. the absence of regulations for land-uses that prevents the use the command-and-control approach to strengthen the provision of water services. Liability rights – a necessary precondition for direct bargaining- are also clearly defined - water distributors are by-law designated as liable for the quality

and the quantity of water. Finally, the characteristics of the SES are such that transaction costs are rather low. In particular, the resource is small with clear boundaries and the number of actors is limited and easily identified.

PES has also often been presented as a suitable solution in situations where service providers are poor because it would be more socially acceptable than tools based on traditional polluter-pay principle (this is why it is a popular tool in developing countries). In this regard, the use of economic incentives in the case of Volvic could thus be justified by the fact that the local agricultural sector is currently facing a significant crisis and farmers are on the edge of pauperization.

However, the perception of fairness or justice has been often documented as an important factor of success of such tools because it supports high levels of participation and compliance. In this regard, we question Danone's current strategy to prefer a technical approach based on significant knowledge development to a wider participative approach in order to make decision regarding local interventions. Indeed, this approach leads to significant gaps in knowledge about the underlying mechanisms and motivations that drive the adoption of pro-environmental practices and the maintenance of agriculture in the Volvic *impluvium*, particularly those linked with the livestock crisis. Further research is needed to assess motivational aspects of response to such environmental instruments and more specifically how they influence the willingness to engage in pro-environmental practice change.

4.3 Public-private partnerships and adaptive management

The Volvic case is also characterized by the emergence of new partnerships and governance arrangements between local stakeholders, which results in local collaborative planning of interventions and the organization of local funding mechanisms. Our results suggest that the emergence and the probable success of local collaborative governance of water services are linked to a number of structural characteristics that provides the conditions for adaptive management.

Although Danone operated a paradigm shift towards decentralized collaborative management of water resources, the dominant approach that is currently being implemented is based on the quantification of risk and the reduction of uncertainties, which generally characterize "predictive and control regimes" (Pahl-Wostl et al. 2010). Together with the literature on adaptive management, we suggest that participative risk assessment - or risk dialogue- would probably lead to better results in terms of identification of risk and development of adapted response. In the same line of thought, we showed that the governance structure is such that it enhances the leading role Danone and limits the active participation of farmers in local decision-making processes. While the importance of leadership is emphasized in the literature as an important source of innovation, the literature on adaptive management shows that lack of broad stakeholder participation can hamper collective management initiatives. Overall, we argue that greater participation from farmers would probably allow CEPIV to better tailor its intervention, increase social acceptance and improve participation of farmers.

Integration with different administrative levels and across sectors of public planning is undoubtedly a strong point of the Volvic case. Linkages with public policies and planning are strengthened by converging public and private interests, particularly the fact that Volvic aquifer is considered as a

strategic resource for public drinking water provision by public authorities, but also by the active participation of state representatives in local arrangements. Besides, the fact that public planning is based on principles such as decentralization, broad stakeholder participation and cross-sectoral integration facilitates vertical and sectoral integration because it is clearly consistent with Danone's strategy to implement a decentralized collaborative management and a holistic approach targeting all sources of risks in this *impluvium*, regardless of the sector.

It is also worth noting that a key factor of success for this case study is the fact that collaborative governance and more specifically the participation of Danone allowed raising sufficient financial resources to cover both transaction and opportunity costs associated with the additional provision of water services. It also allowed diversifying and coordinating public and private subsidies so that they complement each other. Several interventions, such as the biodigester plant, are indeed cofounded.

Finally, we show that the development and the wide diffusion of knowledge on ES provision and the functioning of the resource system have probably contributed to change local actors' attitudes and strategies because it reduced uncertainties and raised awareness about the link between land-use and water services. We also suggest that by supporting the development of a common understanding of the situation, the diffusion of such information contributed to the convergence of interests and the emergence of cooperative behaviors, not only on the demand side but also amongst farmers. However, the way knowledge is produced is imperfect. Indeed, we show that it is mainly focused on technical aspects, which provides a good understanding of agronomic and hydrogeological aspects of SES but falls short in supporting a fine understanding of social processes at stake.

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