EAU DE PARIS: PREVENTIVE MANAGEMENT OF WATER RESOURCES BY DEVELOPMENT OF DURABLE TERRITORIAL DYNAMICS

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KEYWORDS

Water resource protection, preventive approach, payments for ecosystem services, innovation, territorial dynamics, territorial solidarity, territorial development, organic farming, public water agency, nitrates, pesticides

ABBREVIATIONS

PES = payment for ecosystem services

ABSTRACT

Eau de Paris is the municipal agency responsible for management of the public water service for Paris, namely production, transport and distribution of drinking water. The supply of drinking water to Parisians is ensured by a broad diversity of resources, offering the advantage of a highly resilient, adaptable system. Over the past thirty years, Eau de Paris has granted increasing priority to a preventive approach for water purification with the aim of ensuring long term protection and safety of resources.

Actions to protect water resources on rural catchment basins aim at reducing leaks of pollutants to underground water. On these territories, the agency offers free technical and financial aid to farmers to help them change their farming system towards one that protects water (organic farming, low-input farming). It also promotes the development of local circuits and outlets (with Parisian school canteens for instance) to help secure financial resilience on farms and lends farmland to support organic conversions or safeguard prairies.

To ensure that the solutions deployed on the targeted territories are adapted to local challenges, Eau de Paris constantly seeks to innovate and to find new, well-suited ways of encouraging sustainable farming systems. Considering the urgency to further improve source water quality, the agency has built in 2019 a new aid scheme which will be more incentivizing for farmers and more efficient for water quality. Along with other levers used by Eau de Paris, one of its mains targets is to set the path to active territorial dynamics that will give more power to volunteer farmers to change their system.

The importance of a preventive approach to water protection before catchment marks a revised vision of water production. By protecting resources, the public agency contributes to the development of catchment territories, in a spirit of cooperation and territorial solidarity. And by using this approach, Eau de Paris amply illustrates the interest of being an integrated water operator from the source to the tap.

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INTRODUCTION

Eau de Paris amply illustrates the interest of being an integrated water operator from the source to the tap.On June 30, 2020, Martial Saddier, deputy of the French departement of Haute-Savoie, submitted a bill for the safeguard of water resources for future generations, which would reinforce existing regulations to protect water quality against pollution. This initiative coincided with a national debate on granting preemption rights on agricultural lands to local authorities with the aim of protecting water resources, and developing an approach of compensation for environmental services related to water. This focus on the challenge of prevention of pollution sheds light on the increasing urgency of protecting water resources prior to catchment. The Eau de Paris agency has employed this preventive approach for the past thirty years, in conjunction with purification, with the aim of ensuring long term protection and safety of resources.

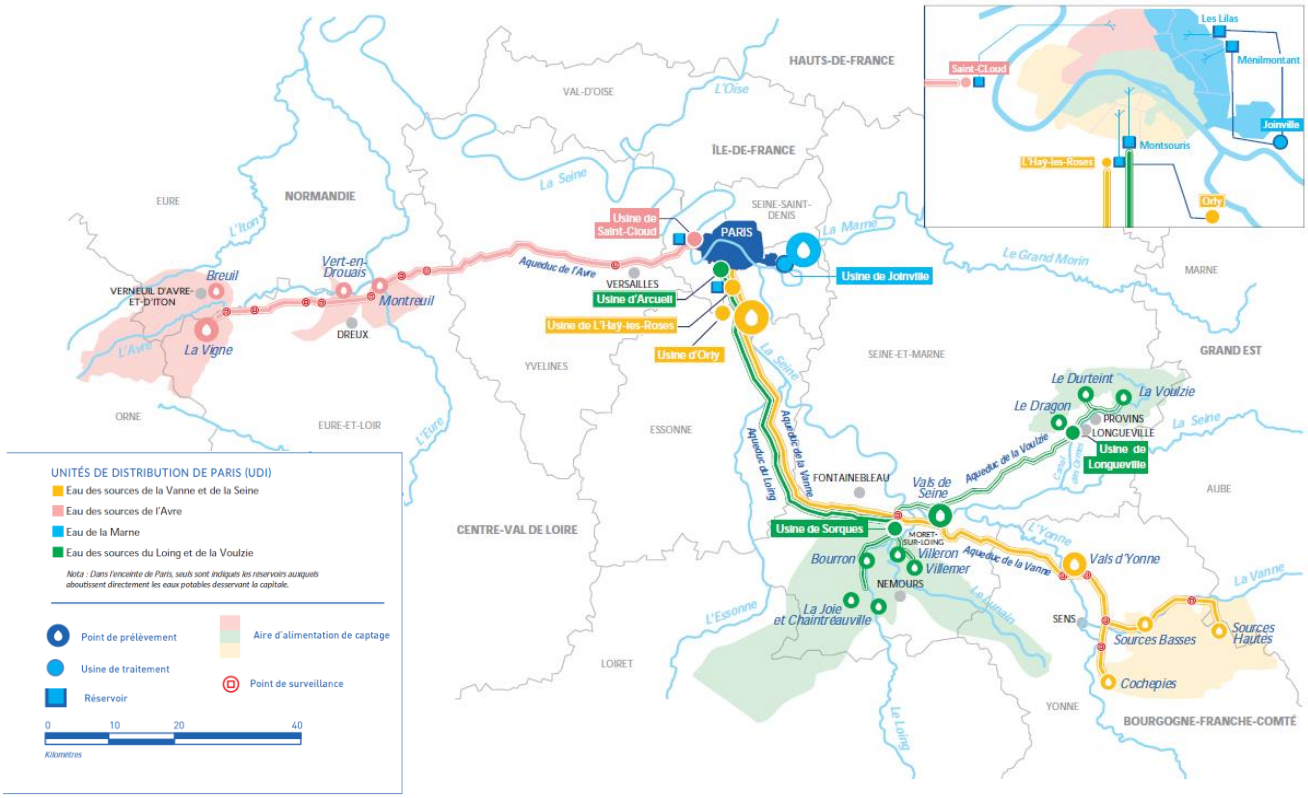
Eau de Paris is the municipal agency responsible for management of the public water service for Paris, namely production, transport and distribution of drinking water. The supply of drinking water to Parisians is ensured by a broad diversity of resources, offering the advantage of a highly resilient, adaptable system. Depending on geographic, hydrogeological and climatic variables, these resources are more or less vulnerable to the impact of human activities and the pollution they engender. Eau de Paris closely monitors the quality of resources and adapts production accordingly. Today, the importance of a preventive approach to water protection before catchment marks a revised vision of water production. By protecting resources, the collectivity contributes to the development of catchment territories, in a spirit of cooperation and territorial solidarity. Eau de Paris amply illustrates the interest of the model of a system integrated from the source to the faucet.

I. SUPPLYING WATER TO PARIS

The structure of the supply of drinking water to Paris is largely related to the history of the capital city and its public health and sanitation imperatives over the past two centuries, and to the aim of diversification of water supply to the city in the absence of adequate water resources within its administrative territory to supply its inhabitants. The current supply plan dates back to the 19th century, when the Prefect Haussmann, within the framework of his grand project of modernization of the capital, appointed the engineer Belgrand to construct a system that would bring sufficient quantities of safe water to Paris. To this end, a project of catchment of source water in the regions surrounding Paris was developed, with the construction of aqueducts to bring the water by gravity to the city. With the increased demand due to urbanization in the 20th century, technological progress made it possible to supplement the supply plan with three drinking-water treatment plants whilst also diversifying resources by the catchment of surface water in the Seine and Marne rivers.

Today, the sources of water supply to Paris are:

- **Half from water drawn from the Seine and Marne rivers, via two plants located in Orly and Joinville.**
- **The other half from underground water resources, located mainly in Seine et Marne, Aube, Yonne, Eure, Orne and Eure-et-Loir departments (around Sens, Dreux, Fontainebleau and Provins, in a radius of 100 to 150 km around the capital).**



With this structure, the grid is remarkably resilient today: the combination of different resources within four main vectors (in color on the map), along with current management and treatment arrangements, wholly satisfies the quantitative and qualitative needs of the capital. Catchment of underground resources draws on a hundred points located in five different regions (Île-de-France, Bourgogne-Franche-Comté, Normandie, Grand-Est and Centre-Val-de-Loire), primarily situated in rural zones. The water abstracted from sources comes from areas (or basins) that supply catchments (polygons represented on the map in attenuated colors) making a total of some 240,000 hectares, of which 160,000 hectares are agricultural land.

At the time when water was drawn from the first sources, the major quality concern was focused on bacteriological risks; the aim was to avoid the spread of epidemics in the population that was served. Today, control of this risk has improved, but other parameters drawn from human activity over the past decades may threaten the permanence of the water supply. Due to the geographic and socio-economic context of catchment points, pesticides and nitrates from agricultural sources are currently the major challenge to the quality of underground water.

Whilst effective treatment circuits and the complementarity of various resources ensure the distribution of high-quality water to the Parisian faucet, the degraded quality of certain raw resources (before treatment) should not be ignored. This was demonstrated by the assessment conducted for the elaboration of the SDAGE (Schéma Directeur d'Aménagement et de Gestion des Eaux [outline for the organization of the development and management of water resources]) 2016/2021 for the Seine-Normandie basin.

To permanently guarantee the quality of the water provided, the municipal agency mobilizes and combines the following tools: adapted treatment to safeguard current production, long

term actions to protect and restore the quality of resources, and reinforced monitoring of the quality of treated and untreated water, ensuring the vigilance indispensable to meet future challenges.

II. MONITORING WATER QUALITY AND START OF CURRENT QUALITATIVE CHALLENGES TO RESOURCES

Protection of the quality of underground water was a concern from the start of catchment. At that time, the primary focus was on preventing the spread of infectious disease, caused primarily by human domestic refuse. Broad perimeters of "close" protection were set up around the sources (total of 826 hectares of enclosed areas around 102 catchment points). These exclosure zones still today protect catchments from direct man-made pollution. Subsequently, and over several decades, priority was given to protecting sinkholes or sealing permeable beds of waterways in communication with underground water sources to limit rapid transfer of surface contaminants. Though these strategies are still in place today, the challenges of water protection have significantly evolved over time, particularly in connection with the introduction of various agricultural pollutants.

Management of the drinking water supply and, all the more so, protection of sources requires frequent monitoring of the quality of catchment water for adaptation of production according to the condition of various sources and evaluation of the effects of long-term protective actions. Eau de Paris adopted reinforced monitoring of its underground water catchment points to permit regular evaluation of the evolution of potentially problematical parameters such as nitrates and pesticides. The following account of monitoring over the years shows the timeline of certain pollutants.

The radical modification of agricultural practices, starting in the Sixties, led to a sharp degradation of the quality of underground sources. Monitoring of water quality, going back to the origin of catchment, highlights the impact of the growth of agricultural productivity (mechanization, chemical fertilizers, pesticides). This trend, illustrated below by the example of the Vicomté source (Seine-et-Marne), is verified overall on sources managed by Eau de Paris: first we observe a plateau, situated here at around 25 mg/l, reflecting agricultural practices up to the Fifties, then a very sharp increase, exceeding the quality limit in 1980.

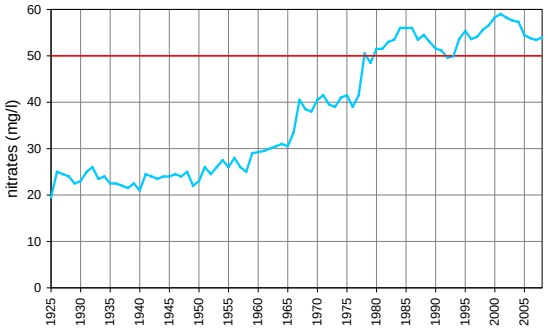


Chart 1: evolution of average annual concentrations of nitrates in the Vicomté source from 1925 to 2009

It is more difficult to detect the long-term evolution of pesticides in underground water because the search for these molecules is more recent. Atrazine was already identified in underground water in the early 1990s, in concentrations exceeding quality limits in some heavily agricultural sectors. Today, increasingly frequent and detailed analysis programs

highlight the presence of various pesticide molecules in the water. Substances of agricultural origin dominate, notably in periods when these products are spread (result of Eau de Paris monitoring search every 15 days for some 300 molecules). Identification of the presence of these products is closely tied to the quality of monitoring (frequency and molecules searched).

Between 2004 and 2009, 4 plants were built for the elimination of pesticides in underground water (active carbon filtration). Additionally, Eau de Paris quickly chose to reinforce its preventive approach and strictly minimize the recourse to new treatment circuits, while protecting the quality of resources for future generations. For example, still today, underground water is not treated for nitrates; the mixture of water in the major aqueducts produces water constantly in conformity for distribution.

III. START AND GROWTH OF PROTECTION OF THE RESOURCE: INNOVATION, INTEGRATION AND TERRITORIAL DEVELOPMENT

In the early 1990s, the increase in nitrate concentrations, followed by attention to the presence of pesticides in the water, motivated the first actions in partnership with farmers: engagement in nitrogen management practices (Ferti-Mieux) in the Voulzie source basin, substitution of atrazine in the Dragon source basin, financing fallow land along waterways in the Vigne source basin.

In the early 2000s, evaluation of these experiments highlighted the inadequacy of management practices programs to restore the quality of particularly vulnerable resources, leading Eau de Paris to refine its methodology of action. From 2005, actions for the protection of water quality evolved from advice on agricultural practices to global support of agricultural enterprises moving toward sustainable systems, better adapted to the measure of the challenge. This analysis was since confirmed by research indicating that, due to the nitrates parameter, the objective of satisfactory condition could not be met for the major aquifers of the basin without a radical change in the agricultural system (Viennot et al., 2009; Billen et al. 2011) ».

Given these objectives and outstanding structural challenges, Eau de Paris turned to a new approach, encouraging farmers to work gradually toward systems more respectful of water quality, and searching for a new technical and economic equilibrium based on the reduction of intrants and improved understanding of natural balance (integrated agriculture, organic agriculture). This approach includes a support system with the application of innovative, modernized engineering articulated around research (agronomy, hydro-systems), local experimentation, mobilization of specialists, and financial incentives through agro-environmental measures or aid for investment in adequate material.

By assuming responsibility for this project, Eau de Paris is in a position to make the connection between agronomical options and a concern for improvement of water quality. Particular attention is given to the definition, monitoring and evaluation of changes made, in order to certify in real conditions their effectiveness on water quality: suction samplers that measure the concentration of nitrates under farm plots, close study of axes of runoff and highly vulnerable sectors, monitoring agricultural practices for engaged farmers, identification of pesticides used in the fields, systematic search for these molecules in resources, etc.

An understanding of efforts, successes and failures noted over the course of the past three decades brought to light several principles essential to the pursuit of an approach aimed at continuous improvement and achieving the desired results on water resources:

- **Experimentation and evaluation: the agency offers ideas for experimentation with new cultivating techniques, crops, and monitoring, and applies them with volunteer farmers. Effects, successes, and failures are then evaluated to guide succeeding steps.**
- **Continuous innovation: reduction of pollution in underground water supposes a constant search for new ways of developing agricultural systems that durably protect water. It benefits from feedback on experimentation, and evaluation of results. Innovation is necessary for adaptation to evolving challenges of territories and water quality. In addition, it is possible to capitalize on the changes obtained and apply new tools for further changes.**
- **Appropriation of the approach by local actors: an exclusively top-down approach from the agency, even if necessary initially to promote actions, may quickly encounter the reticence of the target group. Durable change in agricultural systems must come from an active approach by farmers. The role of the public agency is to propose solutions, convince, and show that a certain type of project is feasible. The agency also gives technical tips, or outright financial incentive, so that the farmer will appropriate the change and personally ensure its durability.**
- **Propelling territorial dynamics: The experience of Eau de Paris has shown that working with one single tool was not enough to promote enduring change in practices having significant impact on water quality. Experimentation and innovation rest on a variety of complementary incentives for change at several levels: collective and individual technical support to initiate farmers to agricultural systems that protect water resources; financial help for changing systems or making investments; development of sustainable local circuits and outlets; acquisition of land to make available to farmers under rural environmental lease, etc. With these tools and the gradual involvement of farmers in these changes, it should be possible to propel territorial dynamics attractive to farmers (by testimonials of success from colleagues, technical and financial aid from Eau de Paris, etc.)**

In general, the adoption of a change or a novelty in a given field is initially followed by a small number of pioneers willing to experiment with practices that are still marginal. They subsequently bring along other actors (with the help of intermediaries, such as Eau de Paris for the protection of water) that give the new system greater visibility. The dynamics of commitment sometimes becomes autonomous, to the extent that a majority (or even 100%) of actors participate. The objectives of Eau de Paris in areas that supply catchment follow the same logic: help pioneers and those that follow their example, by giving them the technical and economic keys they need and, so doing, implant in the territory demonstrators that can inspire other farmers. This favors the appropriation of the approach by farmers, and the durability and fertility of the changes achieved.

The strategy of protection of resources employed across the territories is an iterative process of experimentation-innovation-evaluation that rests on proposed plans of action, support to help farmers apply them, and appropriation of their search for solutions. The aim is to obtain reciprocal top-down and bottom-up dynamics that favor the objectives of the public agency and territorial development.

IV. PROTECTION OF THE RESOURCE TODAY: TECHNICAL TOOLS IN THE SERVICE OF TERRITORIAL DYNAMICS

In addition to the principles and objectives described here, the strategy of resource protection rests, of course, on concrete technical tools that operate in complementarity with each other and truly activate the desired territorial dynamics.

A. **Technical motivation involves individual and collective support for farmers on territories that supply catchments. On four of its priority territories, Eau de Paris sent out four project managers, agronomical engineers bringing support for volunteer farmers in their conversion. The actions include trials, experimentations, demonstrations of new techniques of cultivation, weeding, surveillance of crops, new crops or cultivating systems, etc. Advice to farmers is free of charge and may take the form of individual diagnoses on the farm or collective workshops where they can share their experiences.**

B. **Financial support gives an economic boost to conversion. It contributes to coverage of the risk taken by farmers in changing their agricultural system. This is the case with agro-environmental and climatic measures and the national organic aid scheme, carried by Eau de Paris on the catchment areas since 2007. The first measure attracted commitments at interesting levels up to 2014, with certain territories like La Voulzie where they covered up to 40% of the agricultural surface, resulting in the first observed effects on water quality. However, most of the farmers eventually dropped out of the project, dissatisfied with the administrative red tape and the listed engagements, variable and inadequate, defined at the national level, without consideration for territorial specifics. Commitments to organic farming, on the contrary, continued to progress. In certain territories, the organic farming surfaces increased considerably: from 1% to 17% in the Vanne valley between 2008 and 2019; from 1% to 8% in the Lunain valley between 2015 and 2019. There is, however, a contrast between territories, some having very little organic farming so far (Voulzie-Durteint-Dragon, for example)**

C. **Development of cycles and outlets completes the preceding duo. We have suggested that, to be effective, agricultural actions of protection of the resource must adopt an integrated approach encompassing the full range of factors conditioning a broad transition of agricultural systems. Information and training, combined with a financial boost, help farmers make the leap. But the new agricultural system cannot be durable without adequate commercial outlets. Sometimes the circuits of new sustainable crops are not well enough developed locally to justify a change of system. The work of Eau de Paris is then to support the development of circuits of collection, sale, and distribution of low-input crops (hemp, buckwheat, alfalfa) or organic crops. This support may be through financing of facilities and machinery (organic silo, organic seed station, machinery for transformation of production for direct sales, etc.), technical and financial support for construction of a direct sales structure, etc. For example, Eau de Paris lent support in the Yonne department to a group of producers in the creation of a brand, elaboration of their products, and sales in short circuits of lentils, pasta, oils, chick peas to school canteen services in Paris.**

D. **Land purchases complete the tool kit of support for commitment to sustainable agricultural systems. Eau de Paris buys agricultural land, either because it is located in zones highly sensitive to transfer of pollutants, or because it presents a strategic interest for the conversion from conventional farming to organic agriculture, in which case it serves as a demonstration for the whole territory. The acquired lots are made available to farmers via a rural environmental lease between Eau de Paris and the farmer for a symbolic rental in exchange for maintaining prairies or converting them into prairies that are natural filters for water or converting them to organic farming. The**

low cost of the lease facilitates the conversion to organic farming or the installation of a young farmer.

The current strategy of protection of the resource grew out of a learning process that inspired the agency to go from the promotion of piecemeal modification of practices, to an integrated culture of protection of the resource with the aim of a global change of system on the scale of the farm, based on territorial cooperation. The latter took the form of setting up virtuous circuits beneficial to all: farmers that wish to change their system and protect the water, local food supply chains that benefit from healthy local products, local agencies exploiting their own water catchments and, of course, Eau de Paris. The implication of all of these actors promotes sustained solidarities, with the promise of achieving autonomous territorial dynamics of protection of the resource and the environment in general.

V. TOWARDS NEW INNOVATIONS

The objectives of the resource protection approach described above, integrated into a move for continuous improvement, leads to the constant and current search for new solutions, innovations to reinforce the commitment of farmers on resource territories to adopt systems that protect water resources, and perfection of the territorial dynamics of socio-economic development around environmental problematics. Still today, the Eau de Paris personnel constantly deploy new tools.

1. Agricultural aid and compensation for environmental services

Since 2014-2015, the agro-environmental measures of the Common Agricultural Policy of the EU, brought to its territories by Eau de Paris, saw massive disengagement by farmers for the reasons cited above. To ensure that gradual conversion of farms on the territory toward systems that protect water resources are pursued and definitively take root in the landscape, Eau de Paris must continue to support approaches that reduce intrants and encourage conversion to organic agriculture.

Since 2018, Eau de Paris has been working on a specific aid scheme based on the principle of payment for ecosystem services (=PES). This concept, which moves from the principle of polluter-payer to one of contributor-compensated, is a more positive approach that grants an incentive subsidy to farmers in exchange for applying practices that effectively protect the water. Eau de Paris organized its PES mechanism along the same principles as those that govern the global strategy of protection of the resource: using feedback on results of past actions and experimentation, and concertation with farmers and agricultural technical partners. The bill of specifications of measures proposed to volunteer farmers within this PES scheme were defined to have significant effects on water quality while being adapted to the agronomic and economic challenges of the concerned territories. Small concertation groups were gathered around partner farmers in each territory to discuss the project and ensure its viability for farmers while maintaining its purpose with regard to the resource. A commission of agricultural experts and partners was also formed and consulted to refine the mechanism.

The PES of Eau de Paris, finalized with the help of the Ministère de l'Agriculture et de l'Alimentation [ministry of food and agriculture], was notified to the European Commission as a state aid scheme, giving it a solid legal framework and permitting overrun of support ceilings imposed by the *de minimis aid scheme*, the only other PES mobilization tool available when the program was started. It includes three principle measures, targeting different types of farms: field crops measure, polyculture-livestock measure, organic agriculture measure (further

divided into two sub-measures, field crops and polyculture-livestock). This arrangement takes into account the diversity of agricultural systems and proposes several levels of objectives corresponding to progressive compensations. The overall mechanism of management, control, and disbursement of aid is handled by Eau de Paris, and co-financed with the Agence de l'Eau Seine-Normandie [Public basin water agency].

The obligations included in the measures are aimed at durable change of agricultural systems, not simple virtuous sectorial practices, and the exclusion of rapid backsliding when contracts expire. These contracts are of sufficiently long duration (6 or 7 years) to make a durable change. They include commitments to reduction (or, in the case of the organic measure, the prohibition) of agrochemical products, reduction of nitrogen fertilization to limit nitrate leaks, increase in surfaces in prairies, spring crops, pluri-annual crops, to install a long-lasting agronomical system. Other obligations are included: a diagnosis of transfers (of chemical inputs) on the farm, an economic study confirming the viability of the farm's commercial operation, and the active participation of the farmer in territorial dynamics. Exchanges and sharing experience among farms are encouraged with the aim of promoting autonomous territorial development.

This new mechanism, a first in France for a municipal agency that manages water, has a budget of 47 million euros and is, of course, integrated into the global approach of Eau de Paris in its catchment territories. Technical training and development of commercial circuits is also absolutely essential to the success of PES, because they provide the necessary prerequisites upstream of change and the outlets downstream of the cultivation practices essential to permanent conversion.

2. **<u>New paths of action</u>**

Beyond this highly important project, other new paths of action in favor of territorial development turned toward the future and resilience emerge:

- **<u>Light</u> <u>hydraulic works on agricultural plots</u>: drainage outlets or waterways are arranged to filter runoff water heavy with pollutants before they infiltrate in the direction of catchment resources. Targeting zones vulnerable to infiltrations, they facilitate the elimination of a significant proportion of nitrates and/or pesticides in the water through buffer zones planted with specific vegetation. Because they are pin-point arrangements, careful study of their configuration and implantation sites is necessary to optimize their efficiency on the resource. Though they cannot suffice to protect the resource on a territory, they are an interesting supplement to the application of sustainable cultivating practices. Eau de Paris currently conducts several projects with this type of installation.**
- **<u>Hedges and agroforestry</u>: the development of intensive agriculture since the 1960s-1970s and successive land consolidations led to the disappearance of hedges and trees on farmland. These green infrastructures favor the protection of water resources because they act as buffers, limiting runoff and infiltrations. Eau de Paris encourages the redevelopment of hedges and agroforestry on farmland as an agronomic advantage to create new sustainable productions and fight erosion and loss of soil nutriments, while purging nitrates and pesticides.**

Beyond the search for new technical solutions, these innovative actions are marked by the wish to harmonize the interests of the various concerned parties:

- **Respond to the expectations of farmers wanting to adopt a sustainable agricultural system that protects resources on their territory and produce healthy nourishment, sometimes in short supply chains**
- **Respond to imperatives of improvement of the condition of water resources exploited by Eau de Paris and guarantee quality for future generations**
- **Respond to consumer demand for healthy, local, organic foods**
- **Participate in the conservation and socio-economic development of catchment territories**

Based on these principles, protection of water resources contributes to shaping tomorrow's landscapes.

CONCLUSIONS

Eau de Paris opened the route to sustainable conservation of underground water resources through innovation, territorial development, and the initiation of autonomous local dynamics. New solutions remain to be discovered and deployed to consolidate this route and pave it with solid support to restore the quality of water resources for future generations. The approach of Eau de Paris, facilitated by its function as an operator integrated in the complete cycle from the protection of resources to the consumer, is based on its territorial anchorage. It begins upstream of catchment, where the resources emerge on catchment territories. It extends downstream, along all of the water circuits, by actions in favor of uses of water coherent with pressure on natural resources, and tomorrow's challenges with regard to quantity and quality of water. As a major actor in the realm of water, Eau de Paris also promotes sustainable water consumption and reduction of waste and the use of plastics, making itself active, one might say, from the territory to the pitcher.

The approach of Eau de Paris fits into the integrated methods recognized today as necessary to the conservation of the environment and natural resources used by man. The sectorial piecemeal vision of environmental problematics that prevailed until recently is becoming obsolete. The diversity of environmental pressures and the need for efficient protection of resources imposes awareness and action on environmental challenges as they become increasingly urgent. The concept of co-benefits now prevais in environmental policies and actions. In the face of this emergency, these policies and actions must now seek to combine positive effects on several environmental parameters (water quality, sustainability of agricultural systems, biodiversity, carbon stocking, etc.). This integrated approach can be a means of engaging more players in the same environmental project. Biodiversity and carbon stocking can become new paths to further protection of water resources.

These transversal ties also bring to light territorial solidarities. As an integrated operator, Eau de Paris disposes of tools and a position that allows it to act in several ways on the natural patrimony of territories where it is present. The agency has been protecting biodiversity for the past twenty years on source perimeters, aqueducts, treatment plants and reservoirs. Ecological management practices lie outside the realm of conventional attributions of Eau de Paris but present the interest of benefiting local flora and fauna, contributing in solidarity with their safeguard. These practices also participate in the spread of the culture of conservation of resources and virtuous environmental practices (hedges, reservoirs of biodiversity, ecological

networks and green infrastructure, prairies, etc.) and, perhaps, the reinforcement of ecological functionalities useful to water protection.

REFERENCES

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