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ABSTRACT / EXTENDED ABSTRACT

Context and methods

The Walloon Water Company (SWDE), a public operator, is the main supplier of drinking water in the Walloon Region of Belgium. As such, it manages a distribution pipe network 27,000 km long and invests more than 100 million euros each year to maintain, renew and improve it. The National Research Institute for Agriculture, Food and the Environment (INRAE) is a French public research organization, which, within its 'Environment, Territories in Transition, Infrastructures, Societies' Unit (ETTIS), conducts targeted research in the field of water infrastructures asset management (WIAM). These two organizations decided to join forces from 2020 to 2023 to carry out the applied research project entitled 'multi-scale asset management of drinking water networks' (GePaME).

This scientific program is based on a service-performance driven WIAM, mainly in terms of preservation of drinking water resources (control of water losses), continuity of service (control of network failures), quality of water, and service pressure. It adopts a multi-scale approach, which considers service performance from the local level (pipe segment) to the territorial level (District Metered Area (DMA), entire system) and from the short term (annual work programing) to the long term (investment strategy for the next decades). This requires being able to assess user vulnerabilities and knowing what elements of the network environment are affected by poor service performance. Furthermore, the methods and tools developed must take into account the operational organization and governance of the SWDE.

The GePaME project is structured around three interrelated subjects that are addressed through an interdisciplinary approach involving the methods listed in Table 1.

Table 1: Scientific fields and methods of the GePaME project

Topics	Scientific fields	Methods
Transversal tasks	Data science	Statistical and spatial processing of SWDE data
	Sociology	Bibliography and interviews to analyse decision-making factors and governance
	Computer science	Implementation of methods in the SWDE' information system
Leak process and effectiveness of leak detection	Water network engineering	Multilinear modelling of DMAs' minimum night flows according to their characteristics
	Sociology	Interviews and participative observations with leak detection teams
	Statistics	Modelling of the leakage likelihood according to pipeline and DMA characteristics
Multi-objective and constraint selection of renewal works	Water network engineering	Pipe failure prediction and multi-criteria analysis of their impacts on service performance
	Environmental economics	Survey to assess user vulnerability to water droughts and their consequences in terms of water supply
	Statistics	Coupled modelling of the risks of breakage and detectable leak according to pipes characteristics
Long-term simulation of WIAM strategies	Water network engineering	Tuning of long-term performance indicators
	Statistics	Development of a long-term risk-driven probabilistic algorithm integrating the different causes of renewal (constraint, opportunity, choice)

An operational monitoring committee, bringing together INRAE engineers and researchers and SWDE experts, coordinates and adapts the Research and Development work through the framework of monthly working meetings.

Results

The main scientific results of the GePaME project are the followings:

- Data processing and missing data completion methods and algorithms to feed the models
- Statistical models making it possible to jointly predict networks breaks and detectable leaks, to simulate in the long term the probabilities of a pipe section to be renewed and to estimate the minimum night flow of a DMA according to its characteristics
- A sociological analysis of the relationships between people / tools / decisions / actions at SWDE scale and from the particular angle of the implementation of the leak detection activity
- An econometric analysis of users' willingness-to-pay for measures aimed at mitigating the effects of droughts on the water supply service

The operational exploitation of these scientific advances by SWDE concerns:

- Improving the interoperability of databases feeding the information system, rationalizing the recording of network failures and detected pipe leaks and the automation of data processing methods for asset management purposes
- Improving the organization of leak detection (prioritization of DMAs, choice of types of action, information management)
- The implementation of a new multi-criteria decision support tool for pipes renewal, making it possible to rank all the pipes in the network and taking into account the reliability of data and the vulnerability of users.
- The experimentation of a simulation tool allowing to evaluate and compare the long-term performance of the system resulting from various investment scenarios

Conclusion

GePaME is a partnership, multi-scale and interdisciplinary applied research project.

Thanks to this partnership, INRAE had access to a large amount of structured data, benefited from the expertise of SWDE, and was thus able to renew its research questions in line with operational needs. At the same time, SWDE was able to engage in an improvement process by adjusting its practices to the project's innovations.

The multi-scale approach made it possible on the one hand to take into account the interactions between the organization, the territories and the infrastructures, and on the other hand, to reinforce the coherence between the short-term programming of pipes renewal and the long-term service performance strategy.

Finally, the joint mobilization of engineering sciences and social sciences, made it possible to take into account the human context (organization and internal practices of the SWDE, point of view of users) in the construction of the technical proposals.

The tools and methods developed within the framework of the project are a step towards a more integrated approach of WIAM practices and water loss control. After a necessary phase of appropriation and evaluation, they open up prospects to grasp a more global vision of the efficiency and performance of the service. This means, for example, taking into consideration disaster exposure, adaptation to climate change or the impacts of evolving technologies on skills needs and investment strategies.