Scientific Program

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CentrEau
Centre québécois de recherche sur l'eau
Quebec Water Research Centre

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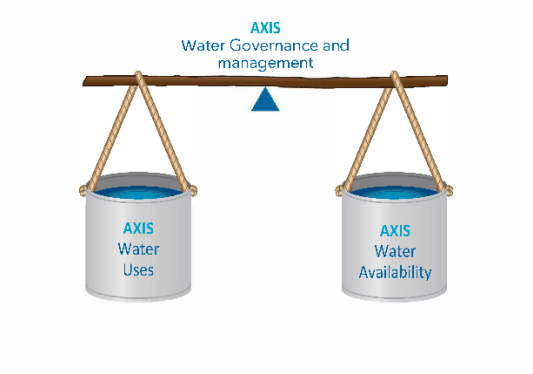
CENTREAU'S SCIENTIFIC PROGRAM



CentrEau's approach is to strengthen water governance by studying the interactions between uses and the availability of the resource. Water is used for multiple purposes and its quality and/or availability are modified accordingly. These two facets of the water governance problem are often linked, but rarely integrated into overall planning. In the context of climate change and increased urbanization, a sufficient supply of good quality water is not always assured. Water availability and quality depend on multiple interrelated factors that need to be studied together to design sustainable solutions for water governance. Thus, the governance tools that will be developed under the leadership of CentrEau will increase the resilience and water security of communities. CentrEau' scientific programming, ambitious but long-term, is based on the two fundamental axes of usage and availability that are crossed by the transversal axis of governance. Each axis has three themes.

Governance and water management Axis

This axis is interdisciplinary and transversal since it federates the other axes around a common vision of sound water governance. Since water is present at all levels of ecosystems and involved in key sectors of societies, its governance must be well planned. The Intergovernmental Panel on Climate Change (IPCC) recently concluded that current water governance systems are not able to cope with the challenges of climate change. In addition, water is at the heart of important social changes (demographics, public policies, urbanization, etc.) to which communities are exposed. Focusing on the notions of water use, availability, vulnerability, uncertainty and resilience, this axis feeds the reflection on the rules, public policies and practices surrounding decision making in a context of interdependence by pooling the results and complementary scientific expertise of the cluster.

Research area G.1 : Understanding the interactions between uses and availability

More effective water management requires a good understanding not only of the interactions between uses and availability (which are found at the interfaces between water, food, energy and natural environments), but also of the socio-economic contexts and regional disparities in terms of availability, adaptation to sudden and gradual changes, and possible inter-regional transfers. There is no single optimal allocation method that can accommodate all possible changes. The prevention of water scarcity and contamination must be planned according to the ecological, economic and social particularities of the regions in question and must be based on a holistic view of the watershed. In the face of climatic hazards (e.g., drought and floods), water analysts will rethink the interactions between uses and availability, e.g., with regard to hydropower or food production,

keeping in mind the UN Sustainable Development Goals (SDGs), e.g., SDG 2 (zero hunger) and SDG 6 (clean water and sanitation).

Research area G.2 Understanding risks and key governance disruptors at different scales

The links between water, global change and human vulnerability are very strong. Water availability and quality depend on multiple factors with uncertainties that need to be studied simultaneously in order to design sustainable solutions for water governance. In terms of availability, the three main stressors are environmental pollution, water scarcity and flooding. In turn, factors that can compromise water quality include climate hazards related to global warming, intensification of economic activities, accelerated urbanization, and weak or non-existent institutions. This research area therefore aims to better understand these uncertainties and vulnerabilities at different scales in order to better understand their impacts on the resource and better manage them.

Research area G.3 Identify governance venues and models to reduce risks and vulnerabilities

Since water is present in all environments (natural, urban, industrial, agricultural, etc.) and concerns all institutional levels and a wide range of actors, its governance involves multi-level models. The diversity of its uses and territories, the risks of conflicts and the inherent complexity of the hydrological cycle pose governance challenges. This research area aims at a better understanding of the governance spaces and tools likely to reduce the risks and vulnerabilities of communities and ecosystems. Adaptive and participatory governance is emphasized as it promotes equitable management, shared responsibility and preservation of water resources. The analysis of governance models at work will highlight the framework and limitations of public policies in terms of multi-level coordination and equitable distribution of a resource that is sometimes scarce and subject to diffuse risks.

Water Uses

This axis places the quality of collective life at the centre of research on water management. Water has an essential use, both for humans and for the natural environment. Cities, villages and remote communities use water for various purposes, but on different scales. On the other hand, the primary and secondary economic sectors need water to produce and satisfy the needs of society and ensure economic development in line with sustainable development and a blue economy. All these uses modify the quality and availability of our water resources. In order to promote the integrated and comprehensive management of this essential resource, the main objective of this axis is to develop an observatory on the uses of water and examine their impacts. In this way, strategies will be identified and evaluated in order to promote the improvement of the quality of the resource and the reduction of water consumption. This will be done in a circular economy perspective, in a context of climate change, in line with the *Quebec Water Strategy 2018-2030* and aiming at achieving the SDGs, in particular SDG 6 (access to water and sanitation), but also SDGs 1 (poverty), 2 (zero hunger), 3 (health) and 11 (cities), 14 (aquatic life) and 15 (terrestrial life).

Research area U.1 : Qualify, quantify and optimize the water needs and uses of cities and small communities

Cities face significant challenges in managing their water resources. Key issues include: ensuring safe drinking water and efficient sanitation, reducing the risk of and adapting to major climatic events, upgrading aging water supply and sanitation infrastructure, and improving green infrastructure by harmonizing it with urban development. It will therefore be essential to focus on the protection of

water sources in relation to land use, the production and distribution of drinking water (quantity, quality), the management of wastewater and stormwater (green infrastructure, sanitation, resource recovery), access to water for the population (awareness, enhancement and citizen participation, recreation and tourism activities) and the establishment of "smart communities" i.e., resilient and aquaresponsible cities, villages and communities. Through the acquisition of new data, modelling and the development of decision support tools, this research area aims to qualify and quantify the needs and uses of water in cities and small communities, including those of First Nations and developing countries. It also seeks to identify sustainable solutions so that these needs satisfy an optimal cost/benefit ratio.

Research area U.2 : Quantifying and optimizing water uses for primary production, taking into account the ecological services offered in various sectors

This theme aims to improve knowledge of water use in various sectors such as agriculture, mining, forestry, fish farming and energy production. Agricultural activities are in constant competition with cities for the use of freshwater and consume about 70% of this resource on a global scale (in Quebec, the proportion is lower since hydroelectricity accounts for about 50% of water demand). Moreover, these activities still represent major sources of pollution for surface and groundwater. Smart agriculture with optimal management of irrigation, runoff, and fertilizer and pesticide use is essential for sound rural water governance. Mining and freshwater fish farming, which are growing economic sectors in Quebec, Canada and elsewhere, also bring their own set of issues related to the quality of water resources. Hydroelectric production and forestry operations also raise concerns about the amount of water used, but also about the impact on environmental quality. All of these primary production sectors can disrupt the ecological services provided by natural environments. The main objective of this theme is to improve knowledge of the impact of primary production practices on the quality and quantity of water resources, and to identify strategies and means to reconcile these uses with the capacities of natural environments.

Research area U.3 Quantify and optimize water use in secondary production

The secondary economic sector (agri-food, chemical, pharmaceutical and manufacturing industries) requires a significant amount of water for the production or transformation of raw materials. The sector's activities almost inevitably generate effluents loaded with so-called conventional pollutants (organic matter, nutrients, toxic metals, etc.), as well as new types of contaminants resulting from industrial production processes (endocrine disruptors, refractory chemical compounds, micro- and nano-plastics, nanoparticles, etc.). This research area aims to improve our understanding of the impact of this sector on the quality of receiving environments and to optimize the use of water and reduce pollution risks by developing new processes and treatment systems. The development of new strategies for source reduction, recycling or (internal) reuse of treated industrial effluents will also be studied. The anticipated technological developments are aimed at physical, chemical, electrochemical, thermal and biological processes.

Water Availability

Before looking at the various uses of water, whether anthropogenic or ecosystemic, it is essential to know the volumes available locally. These volumes depend on complex interactions between the climate, the biophysical characteristics of the territory and its occupation. The available volumes of water evolve over the days, seasons and years, given the climatic instability and the anthropic

pressure that is increasing. They vary from one watershed to another and even locally within the same watershed. The precise characterization of the water resource requires an thorough understanding of the processes involved and their modelling. This research area, which is part of SDG 13 (fight against climate change), aims to improve our knowledge of water flow and to develop hydrological and hydrometeorological tools to predict its availability in the short and long term to support water governance.

Research area A.1: Quantifying the spatiotemporal variability of hydrological flows and states

The observation of water flow in natural and managed environments is performed at several temporal and spatial scales. The measurement of various flows (precipitation, evapotranspiration, infiltration, runoff, groundwater flow) and hydrological states (soil water content, snow cover, aquifers) allows us not only to improve our fundamental understanding of the processes, but also to compare our models of water flow with the reality on the field. Once validated, these models allow us to estimate the quantity and quality of water in a given territory according to given hydroclimatic conditions, thus making possible a large number of interventions related to water resources, such as the design of hydraulic structures, the planning of agricultural irrigation, and the simulation of the propagation of contaminants in groundwater.

Research area A.2: Predicting the long-term hydrometeorological regime and the necessary adaptations to water governance

Meteorological hazards represent a major challenge in hydrology for both the design of structures and various public safety issues. It is therefore essential to develop approaches to better assess the risks and probabilities of occurrence of these hazards in a context of climate change. The objective of this research area is to develop projections of hydrometeorological regimes, as well as to propose and analyze various adaptation responses that will allow for sustainable governance of the water resource. The latest climate simulations and meteorological reanalyses will be used for hydrological modeling at the spatial and temporal scales required for water resource management. This work will be used to identify and analyze the most appropriate adaptation responses to ensure optimal water governance in a non-steady climate.

Research area A.3 : Predicting short-term flows and water levels using a chain of models combining the atmosphere, the watershed and the river

In recent decades, Quebec has experienced major floods as well as notable summer droughts that have brought to the forefront the importance of short-term hydrological forecasts. Indeed, in a context of crisis management and development of intervention plans, it is essential to be able to anticipate the inflow of water to the river system. This research area intends to address this concern through the coupling of various models combining weather forecasts, hydrological simulations of watersheds, and hydraulics of networks and water structures. Ultimately, these tools will make it possible to predict the flows and water levels of rivers and water bodies in the short term in a context of real-time management of the floodplain, watersheds and hydraulic structures such as dams. Various approaches to quantify uncertainties, such as probabilistic data assimilation, will also be implemented.