The Castor Project of Quebec's Water Strategy – An Agri-environmental living laboratory

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Abstract.

This article outlines a project focused on enhancing water quality in a Montérégie watershed near the Quebec-Vermont border, while sustaining local farm economies. Supported and funded by the Government of Quebec, this project relies on effective collaboration among stakeholders and government levels. The Castor Team, comprising representatives from farming, research, and integrated watershed management sectors, leads the initiative. The farming and research communities involve 25 enterprises and six universities, with the Quebec Association of Watershed Organizations (ROBVQ) representing integrated watershed management. The project's objectives include improving soil health, optimizing nutrient management, and encouraging cover crop and riparian buffer adoption, all while ensuring the farming community's economic viability. Since its inception in 2019, this project has redefined conventional watershed initiatives and is expected to continue until 2030. This collaborative effort provides a promising model for addressing environmental and economic challenges in agriculture, offering sustainable practices applicable to similar regions globally.

Keywords. Water quality; collective project; agriculture; adoption; integrated management; bottom-up approach

1 Introduction

In recent years, numerous initiatives have been undertaken to ameliorate the conditions of watercourses within agricultural settings at a watershed scale. However, it is evident that these collective endeavors often fall short of yielding substantial improvements in the quality of agricultural waterways.
A comprehensive analysis of these collective projects, funded by the Ministry of Environment, the Fight against Climate Change, Wildlife, and Parks of Québec (MELCCFP) since 2005 in 67 watersheds, has uncovered several prominent challenges. Primarily, there exists a noticeable lack of active engagement among local stakeholders, primarily attributed to insufficient involvement of producers and their advisors within the project dynamic. Additionally, a comprehensive assessment of the targeted agricultural area, encompassing an evaluation of farming practices affecting aquatic environments and the identification of priority intervention areas, is conspicuously absent. This shortfall is exacerbated by an absence of coordinated scientific expertise within these initiatives. Furthermore, a limited portion of land undergoes agro-environmental actions due to inadequate mobilization, coupled with a lack of financial, technical, and professional support. The selection of actions at times proves suboptimal in terms of environmental efficacy. Inconsistencies in project coordination over the years, largely stemming from insufficient financial, technical, and professional support for project coordinators, result in high turnover. Finally, the challenge of an excessively large number of agricultural producers within the project's scope arises, a consequence of intervention areas being overly extensive.
Drawing from these past experiences, the MELCCFP introduced a pilot project that adopts a multidisciplinary and collaborative scientific approach as part of the Québec water Strategy 2019-2030. This approach endeavors to demonstrate the advantages of enhancing agricultural and agro-environmental practices while implementing riverbed improvements, ultimately enhancing the aquatic ecosystem quality of a watershed. What distinguishes this approach from prior collective projects are its main characteristics:(i) the project's development adheres to a collaborative approach, with producers, agro-environmental advisors, agricultural producer representatives, and other stakeholders at the forefront of the decision-making process; (ii) scientific support is a foundational component of the project, established through a consortium of researchers following specific mandates developed collaboratively; (iii) a substantial budget allocation ensures the project's objectives are met, encompassing costs associated with comprehensive scientific, professional, and technical support for their execution; (iv) the selection of the watershed is a collaborative effort, involving potential project stakeholders. This includes the choice of a watershed facing significant agricultural pollution issues, with a reduced size (tens of square kilometers), and where agronomic expertise and environmental leadership are evident; (v) effective coordination among local stakeholders is guaranteed by the Regroupement des organismes de bassins versants du Québec (ROBVQ); (vi) the project is set for a minimum timeline of eleven years for implementation and monitoring (2019-2030).
In this context, the objective is to establish an agro-environmental program that enhances water quality and provides irrefutable scientific evidence of agro-environmental improvement. This endeavor outlines predetermined intervention strategies, guided by the natural upstream-downstream logic inherent in integrated watershed management. Projects are categorized based on spatial considerations, addressing the field level, the field-watercourse interface, and the watercourse itself.
The first axis is aimed at maintaining soil health, reducing soil erosion, and minimizing nutrient and contaminant losses. This is to be achieved through the implementation of cover crops, precise fertilizer and pesticide management, and various soil conservation techniques. The second axis is dedicated to preventing direct water and sediment linkages between the land and water bodies. The third axis focuses on the management and restoration of watercourses within an agricultural context. These axes operate within an economic research framework, seeking ways to support farmers and local authorities in adopting these beneficial practices while assessing their impact on local economies, including those of agricultural enterprises, while the social background inherent to that of a living lab must document and favor the identification of obstacles and levers associated with implementing behavioral and practices change among all stakeholders. To achieve the overarching goal of demonstrating agro-environmental improvement throughout the program's duration, diverse monitoring programs will be established to track changes in land use, water quality, habitats, and the overall environment. The complexity of this comprehensive setting justifies the research-oriented nature of the program, which can be viewed as a constituent part of the MELCCFP Climate Change Action Plan 2020-2030 (PACC 2020-2030).
Within this broader context, the Castor project has been initiated, presenting an intriguing paradox central to this article. How can an agro-environmental project be developed as a living laboratory within the framework of a government initiative with predefined objectives? How can project stakeholders transition from a relatively conventional top-down approach to an innovative bottom-up approach? What will be the impact on project governance, and what key parameters will emerge to ensure the success of this pilot project? This article aims to address these questions, using the classical Method-Results and discussion-Conclusion sequence, drawing upon the first three years of the Castor Project, showcasing the achievement of success and providing insights for the redefinition of collective projects within the Quebec and Canadian agro-environmental landscape.
The reader can note that this paper is mostly extracted from confidential reports in French, that’s why no references are provided here.

2 Methodology

2.1 Study region

In late 2019, following extensive consultations with watershed Organizations (Organismes de bassins versants or OBV), a collaborative effort between the ROBVQ and the three ministries of Agriculture, Environment, Forests, and Parks of Quebec (MAPAQ, MELCC, and MFFP, respectively), guided by the Maison de l'Innovation Sociale, culminated in the establishment of a living laboratory settings The selected study site was the Castor Creek, a tributary of the Aux Brochets River, ultimately flowing into Missisquoi Bay.

The Missisquoi Bay and its watersheds have been subjects of study for nearly three decades due to issues related to cyanobacteria and diffuse pollution. This region provides a wealth of valuable data, information, and potential collaborations with local stakeholders, enabling the development of ongoing improvement projects involving research-action on water and soil management and protection.

However, defining the precise study territory, while it may appear to be a basic step when undertaken in 2020, presented numerous intriguing challenges, especially within the context of establishing an agro-environmental living laboratory. The complexity stems from the diverse array of stakeholders involved, including farmers, residents, legislative and regulatory bodies, the research community, and various levels of government at the local, regional, and provincial levels. Consequently, the process of delineating the study area generated multiple definitions and practices, almost as diverse as the number of stakeholders. This section delves into the questions that arose during the definition of the study area.

One of the central concerns revolved around aligning the project's objectives with the definition of a study watershed to ensure that all agro-environmental measures studied and implemented have a meaningful impact on a single, coherent watercourse. From a legal perspective, a critical question arises concerning the formal definition of a watercourse. Does it solely encompass the entire delineated hydrographic network? At what point does a farm ditch, which may convey water either continuously or intermittently, qualify as a watercourse? What are the established practices within municipal and provincial water management authorities in the region?

From the standpoint of local residents, the issue of their connection to the watershed, the historical consideration of farmer collectives, and the operation of farms across multiple hydrological watersheds further complicate the initial definition. Even from a scientific standpoint, the matter is far from straightforward. Should hydrological, hydrographic, and underground watersheds all be considered, or only specific ones? How should farm ditches be categorized when they distribute water into a watershed while originating from neighboring territory? How do we account for unlisted culverts that significantly alter surface flow dynamics?

These questions may initially seem relatively straightforward to resolve. However, it is crucial to emphasize that, as the foundation of project implementation, this definition plays a pivotal role in specifying program participation, eligibility for associated compensation, the bodies of water subject to evaluation, and the geographical extent over which agro-environmental practices will be assessed. Hence, this issue holds paramount significance.

Addressing these challenges necessitated nearly six months of collaborative effort involving various stakeholders. The resolution process was guided by a clear and systematic scientific methodology, supplemented by numerous field visits that served to elucidate contentious issues as they arose.

The final map of the intervention area is presented in Figure 1. The study area is centered around Stanbridge Station. It covers a total of 1526 hectares, 90% of it being used for agriculture.

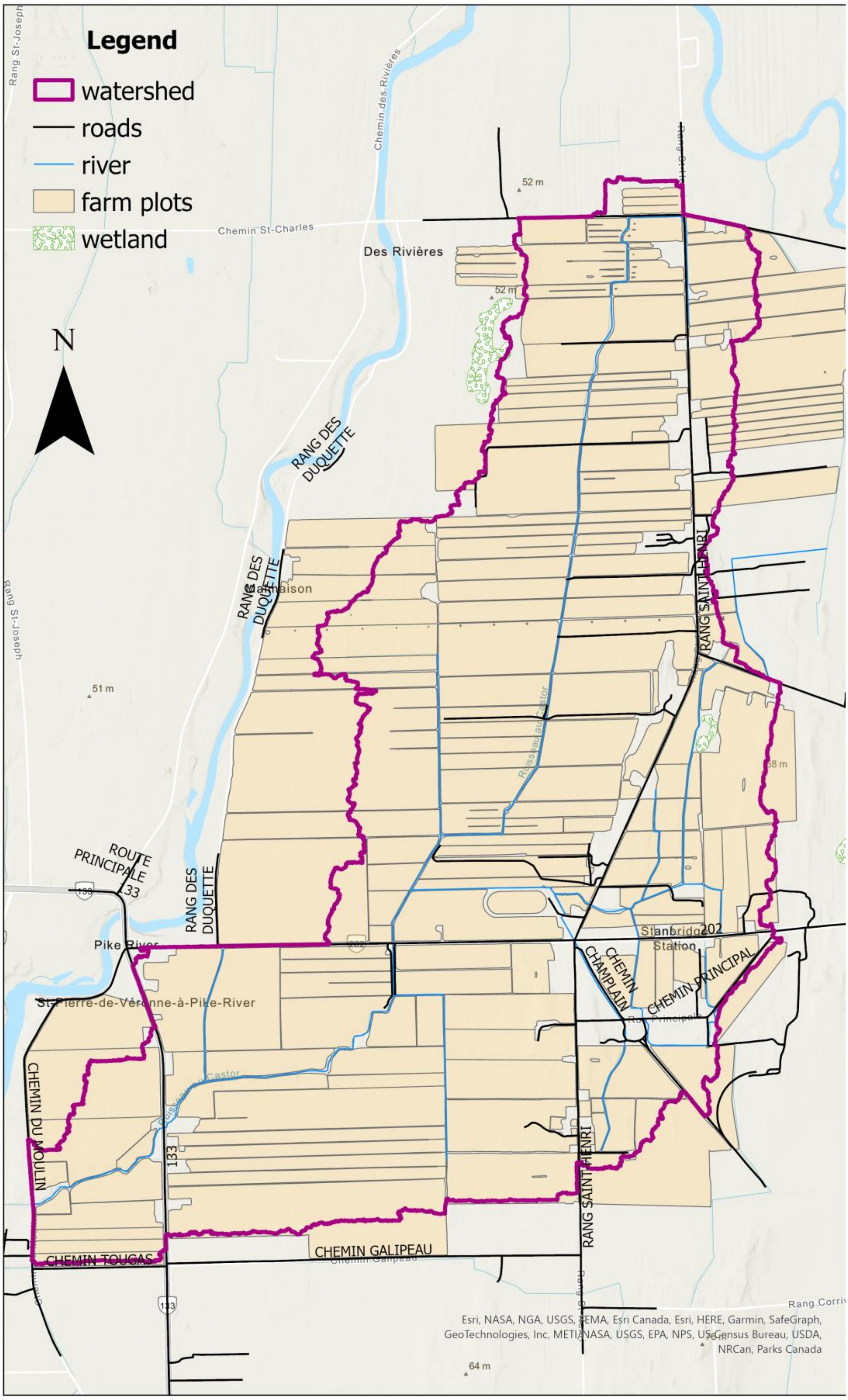

Figure 1: Map of the study area and waterhsed

2.2 Project selection

Expertise requirements

In the early stages of the SQE pilot project, the collaborating ministries distilled a core set of expertise areas crucial for the project's success. These expertise domains included agronomic sciences, rural engineering, fluvial hydrogeomorphology, surface water contamination processes, agricultural systems hydrology, environmental sociology, and agro-environmental economics. Additionally, the specific needs of the ministries (since grouped into two entities) were identified in conjunction with the project's scientific coordination, managed by INRS since early 2020. A detailed breakdown of these extensive requirements is provided in Table 1, reaffirming the historically top-down approach adopted by the ministries while demonstrating the need for “translation” between Ministries- research – farmers.

Table 1: Summary of the needs identified by ministries. BMP stands for Beneficial Management Practice

MELCC	• microeconomic analysis and profitability of different BMP • macroeconomic aspects, including pollution/detoxification costs and remuneration for environmental goods and services (BSE). • examine the landscape of agricultural taxation and explore incentives to enhance the sustainability of BMP and associated BSE.
MAPAQ	• Identify effective BMP to reduce nutrient losses (N and P), pesticides, and suspended solids while maintaining profitable agriculture. • Determine the extent of BMP implementation, whether systematic or targeted in high-contribution areas, to achieve desired outcomes. • Investigate specific areas within fields for enhanced measures (e.g., extensive forage production, eco-grazing, or crop removal). • Assess constraints, technical, economic, and social impacts, and barriers to BMP implementation. • Evaluate the combined *in situ* effectiveness of BMP, considering environmental performance and the time required for water and ecosystem quality improvement. • Identify the need for services and support for agricultural enterprises. • Examine the economic self-sustainability of BMP and propose reimbursement models if necessary. • Explore collective agro-environmental services for BMP implementation and sustainability. • Establish a reimbursement framework to support changes in practices or land use.
MFFP	• Restore riparian zones with diverse vegetation strata to create wildlife habitats and enhance aquatic habitat quality through shade. • Establish windbreak hedges in areas where they complement other BMP to create wildlife habitats and improve habitat connectivity. • For extensive forage production, schedule the first hay cut no earlier than mid-July, considering ground-nesting species, with appropriate mowing patterns to minimize harm to amphibians and turtles.

Bridging the Gap: Farmer Engagement

To better understand the perspectives of the agricultural community and foster collaboration, a dedicated brainstorming day-session was conducted with farmers, unaware of the ministries' specific needs. The primary concerns expressed by farmers centered around water management in their fields, with a particular emphasis on rapid water drainage. The second key area of interest pertained to crop management practices.

The Need for Cross-Disciplinary Collaboration

Recognizing the necessity of expert guidance within the agricultural sector to bridge the gap between government needs and farmers areas of interest, the project architects sought to integrate professionals and subject matter experts into the initiative. Leveraging a functional framework for assessing watershed health, as presented in Figure 2, and aligning this with the ministries' requirements and the preliminary list generated during the brainstorming session, a collaborative method was developed to select projects that bridge the gap between these disparate domains.

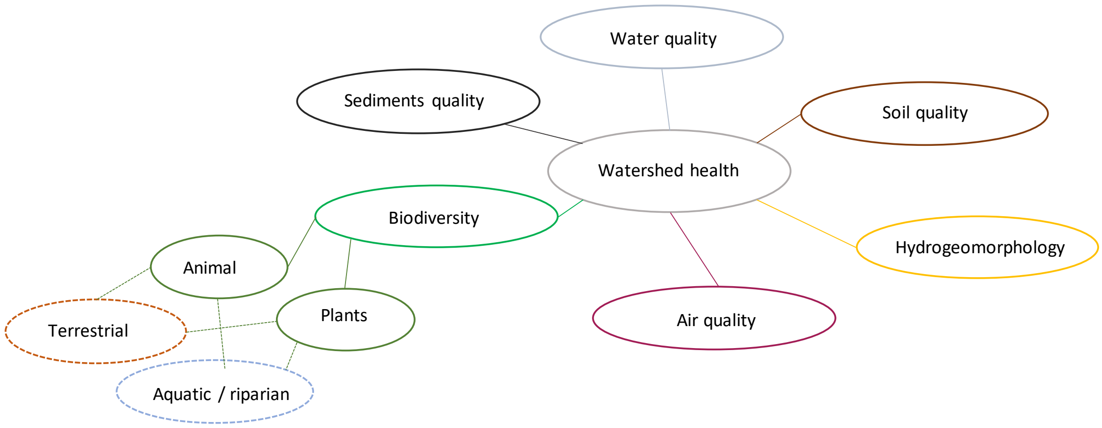

Figure 2: Schematics of the different components of watershed health

Multidisciplinary workshop-based methodology for project selection

The distinctive methodology crafted for the selection of interdisciplinary projects has been systematically employed since 2021. This method comprises six distinct phases, meticulously designed to foster collaboration among stakeholders. Initially, a preselected expert or specialist showcases their expertise and elucidates its potential contributions to the project. Subsequently, an on-site discussion ensues, evaluating the suitability of the expertise in addressing local requirements vis-à-vis research, technical, and legislative interests. During this phase, the professional formulates a preliminary project proposal in the form of a concise document (One-pager), outlining key objectives, methodology, and tangible benefits for farmers. This pivotal step facilitates an adjustment phase, wherein any gaps between the experts and farmers' needs are addressed to align all parties and ensure the project fulfills its applied purpose. Ultimately, formal agreements, encompassing funding agreements and participation commitments with farmers, are executed, signifying the commencement of the project. Typically, this entire process spans approximately one month and is reiterated for each new project.

Prior to project initiation, all project requisites are defined through thematic workshops, organized in accordance with the living lab methodology. These workshops cover three principal themes embedded within farmers' areas of interest and the ministries' requirements, specifically: (1) socioeconomic aspects, (2) water management, and (3) soil health and fertilization. Each workshop convenes three independent farmers, selected based on their independence from the specific issues under consideration, alongside one external professional and one lead researcher. The participation of farms varies depending on the subject matter and the envisioned project's specific needs.

The reader can note that as per the wheel of continuous development, the designed 3-tiered structured approach is evolutive. In 2023-2024, following the pilot project’s first phase 2020-2023, thematic workshops now include (1) the development of farmland to promote biodiversity; (2) systematic incorporation of social innovation processes; and (3) development and use of physico-chemical, economic, and social targets for short-, medium-, and long-term monitoring of project impacts.

2.3 Scalable project governance

As of March 1, 2023, an entire consortium of research partners (R), as well as collaborating organizations and companies (P), was coordinated by the Castor Team. This coordination represents a tripartite collaboration among the local agricultural community team within the watershed, INRS for scientific coordination, and ROBVQ. The research partners include: R1: Pascale Biron from Concordia University; R2 & R3: Simon Ricard (formerly part of Aubert Michaud's team) and Caroline Côté from IRDA (Institut de recherche et de développement en agroenvironnement); R4, R5, R6, R7, and R8: Silvio Gumiere, Thiago Gumiere, Monique Poulin, Jean-François Bissonnette, and Lota Dabio Tamini from Laval University; R9: Jérome Dupras from the University of Quebec in Outaouais; R10: Julie Ruiz from the University of Quebec in Trois-Rivières; R11 and R12: Alain N. Rousseau and Richard Villemur from INRS. The collaborating organizations and companies include: P1: Agrinova; P2: Agrocentre Farnham; P3: Regional branch of MAPAQ (Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du

Québec); P4: Dura-club; P5: Forest-Lavoie Inc; P6: Municipalité Régionale de Comté Brome Missisquoi; P7: Organisme de Bassin Versant de la Baie Missisquoi; P8: Pleine Terre, Synagri; P9: Union des Producteurs Agricoles; P10: Xeos Imagerie Inc.

The aggregation of all these stakeholders, given their diversity, naturally entails the creation of numerous contracts and agreements of various types. These encompass grants, research contracts, service agreements, bilateral agreements, financing conventions, confidentiality agreements, and copyright assignments. Each of these contracts may involve legal entities, non-profit organizations (NPOs), corporate entities, or individuals, whether legal or natural persons.

In this complex context, the Castor team has chosen to implement the RACI framework to create an evolving project manual that represents a shared vision. This manual outlines the structure of the pilot project, specifying the roles and responsibilities of participants during different phases, including coordination, research, and field activities. The RACI framework, widely used in project management and organizational contexts, defines roles through a matrix: "R" for "Responsible" for task execution, "A" for "Accountable" for decision-making, "C" for "Consulted" for providing expertise, and "I" for "Informed" for those needing updates. This matrix enhances transparency and accountability, promoting effective task execution.

3 Results and discussion

This section will present the outcomes stemming from the implementation of the Castor project spanning from early 2020 to March 2023. As elucidated in the introduction, the project's novelty emerged from an analysis of collective projects funded by the MELCC since 2005, aimed at overcoming critical issues that had been identified as contributing to the partial failure of such endeavors. Consequently, we emphasize the initiatives that illustrate the current success of the collective watershed project for the Castor Creek.

3.1 2020-2023 activities

The comprehensive array of actions implemented encompasses plot-level trials conducted under real-world conditions, field trial protocols, large-scale initiatives, and support and monitoring activities. This classification logic is rooted in the diversity of stakeholders involved in the pilot project.

Plot-level trials, conducted on relatively small areas, facilitate research in uncontrolled real-world conditions, with the aim of testing, refining, or enhancing innovative beneficial management practices. These plots are made available by farmers and are accessible to research teams for initial periods ranging from 3 to 5 years. These projects are at the forefront of current global research and have already been featured in 5 scientific conferences, comprising a total of at least 11 presentations and posters.

Field trial protocols are instrumental in concretizing and documenting crop and input management trials conducted by farmers themselves, as well as professional stakeholders such as agronomists or their associations. These activities run concurrently with the research plots.

Large-scale initiatives, on the other hand, enable the implementation of recognized agro-environmental practices for willing farmers that have not been widely adopted. To achieve this, financial assistance, including yield insurance, and technical guidance are provided to volunteers in exchange for the measurement of resulting agricultural and socio-economic performance.

Lastly, as the name suggests, support and monitoring activities facilitate knowledge dissemination within the agricultural community, whether through training workshops, on-farm demonstrations, or successful practice testimonials from neighboring watersheds. A comprehensive documentation of these actions is presented in Table 2. However, detailed commentary is beyond the scope of this article, which primarily focuses on demonstrating the successful implementation of the project, leaving precise content details to be found in forthcoming scientific articles from various teams or in communication documents disseminated at the watershed level or through partner websites.

Table 2: 2020-2023 summary of activities

Type of activity	topics
Plot-level trials	• Design of optimized riparian filter strips through distributed hydrological modeling. • Coordinated development of downstream riparian space. • Research and implementation of alternative agricultural drainage practices (upstream sector). • Alternative crop systems, soil health, and water quality. • Rotations and soil health.
Field trial protocols	• Reduction of nitrogen doses in grain corn. • Reduction of starter phosphorus doses. • Laser grading to enhance field drainage and mitigate erosion.
Large scale initiatives	• Inclusion of a cereal (fall and spring) in the corn-soybean rotation. • Cover crops. • Workshops on calculating opportunity costs, maintenance, and incentives associated with BMPs.
Support and monitoring activities	• Personalized on-farm diagnosis of manure and slurry management. • Ongoing agronomic support service. • Thematic technical workshops • Local project journal.

Table 2 provides a non-exhaustive list of activities conducted within the Castor Creek watershed between 2020 and 2023. While the detailed specifics of each activity are not elaborated upon in this article, attention is drawn to the adopted nomenclature and, notably, the inherent long-term vision. From the inception of these activities, the objective has been unequivocal: to ensure the sustainability of the outcomes. This aspect addresses one of the drawbacks associated with government incentive programs. When these programs conclude, the incentives diminish or vanish, leading to a decline or discontinuation of BMPs implementation. The agricultural community raised this pivotal concern at the project's inception. There was even discussion about farmers in the watershed not participating if the government could not guarantee the project's existence for a duration exceeding the usual three-year term. This critical point will be expounded upon in the third results section.

All activities, on the other hand, adhere to a sustainability rationale. Plot-level trials are initiated at the experimental plot level, with the goal of demonstrating the benefits or conditions necessary for the successful implementation of a specific BMP over a 3 to 6-year cycle. Once this demonstration is achieved, the experimental practice is proposed for watershed-wide adoption on a large scale. For instance, in the summer of 2023, a map suggesting variable-width riparian buffer implementation based on topography and soil types was presented to farmers. This approach guides them towards achieving consistent effectiveness in riparian buffers, rather than applying a fixed width that may not always ensure sufficient pollutant filtration and retention.

Field trial protocols enable direct farmer participation in vital agricultural trials for the adaptability of cultural practices. This element aims to multiply change drivers by encouraging the agricultural community to continue existing initiatives under facilitated conditions (technical and financial support provided by the project). This aligns with the theory of change, suggesting that approximately 1/3 of individuals are change drivers, 1/3 are ready to take action, while the remaining 1/3 is not yet willing to change. Social theories of change suggest that about five phases assess a person's readiness for change, with transitions between phases taking 5 to 10 years. Within the project framework, the objective is to reduce this transition time to 2 or 3 years to promote innovation in the watershed. Consequently, large-scale initiatives are expected to facilitate the adoption of recognized BMPs by the majority of the watershed since they allow for the implementation of "risk-free" practices, with no opportunity cost, driven by positive peer pressure. This change management approach is further invigorated by support, monitoring, and educational activities.

Finally, to ensure the tangible impact of the pilot project on its initial goal of improving water quality and watershed health, a comprehensive monitoring program has been established, with over 90 measurement instruments deployed. These instruments include cameras, surface collectors, piezometers, lysimeters, automatic samplers, manual water and soil sampling points, an echo doppler probe, and a multi-parameter probe, among others. Agreements of at least 5 years are planned for each measurement point.

3.2 Effective participation

The responsibility of demonstrating the impact of BMP implementation on water quality and watershed health as a whole rests squarely on the project's shoulders. One of the necessary conditions for achieving this primary goal is, of course, the active participation of farmers and the implementation of practices over a substantial area within the watershed. Table 3 provides the 2022 breakdown of the areas allocated to each activity, based on the typology presented in Table 2.

Table 3: 2022 Breakdown of the areas allocated to each type of activity.

Type of activity	topics
Plot-level trials	• 0.4 ha (3650 m^2)
Field trial protocols	• 9 producers adopted 21 practices, including 9 entirely new ones, (total area 26 ha)
Large scale initiatives	• 176.9 ha Inclusion of a cereal (fall and spring) in the corn-soybean rotation. • 104 ha Cover crops.
Support and monitoring activities	• 4 activities 13 producers, 10 agronomists • 355 h of agronomic services provided

Table 3, as presented, offers a comprehensive view of the spatial dimension of the project's efforts. It illustrates the commitment of resources and land areas to various activities. These areas serve as the canvas upon which the project's impact is painted. As the data shows, substantial portions of the watershed have been actively engaged in BMP adoption and testing, reflecting a concerted effort to drive meaningful change demonstrating the success of the project in its second year of implementation, namely in the year 2022-2023. The year 2020-2021 marked the overall project setup, while 2021-2022 served as the startup year. It is worth noting the dynamics in the evolution of the numbers. For instance, 0.4 hectares were dedicated to research. This area does not include access roads or intermittently sampled fields but solely the areas exclusively allocated to research protocols. Phase 2 of the pilot project anticipates a tripling of these areas. While in 2020-2021, four BMPs were implemented by producers, three of which were entirely new to their farming practices, these numbers increased to nine producers, implementing 16 BMPs, including five entirely new ones, in 2021-2022. In 2022-2023, nine producers adopted 21 practices, nine of which were entirely new, covering a total area of 26 hectares, clearly demonstrating the success of the field trials. In 2022-2023, 177 hectares were dedicated to introducing either fall or spring cereals into the soybean-corn rotation, while 104 hectares saw the implementation of cover crops that were not previously used. This represents over 10% of effective impact solely related to the total agricultural area of the watershed. Such an evolution is undoubtedly a notable success, given the watershed's historical context. In the fall of 2020, no agricultural businesses in the watershed were members of a club council, and very few producers availed themselves of the services offered by the agriconseils network. Furthermore, MAPAQ agronomists were scarcely present in the area. During the winter of 2020-2021, the soil health and fertilizer workgroup identified three major areas of intervention, with a fourth being added later: improving crop rotations by adding a cereal; covering soils with cover crops or fall cereals; reducing inputs; manure and slurry management.

For most producers, these changes represented significant departures from their usual farming practices. The presence of qualified agronomic advisors who could support the adoption of BMPs was therefore a significant factor for the project's success. It was also essential to ensure that producers would use these services. Since 2021, agronomic services for the following activities have been paid for by the project: Technical support for cereal or cover crop cultivation; technical support for implementing trial plots aimed at better input management; technical support for all activities aimed at improving soil health. For the 2022-2023 period, the Castor project offered 355 hours of agronomic services to agricultural producers. The presence of quality agronomic services means that each year, new producers try new actions, and the number of BMPs tried also increases.

Participation in support and monitoring activities is also an indicator of long-term commitment by farmers and professionals in the field. In 2002, four activities were organized, involving 13 different producers (representing more than 50% of the watershed) and ten agronomic advisors (accounting for more than 50% of the watershed's agronomists). The participation of agronomic advisors in these two meetings was excellent. These group discussions also help to identify and validate issues and challenges for the Castor project related to agronomic support.

The elements contributing to the success demonstrated by the previous numbers include local representation through a committee consisting of three farmers representative of the 25 agricultural businesses in the watershed. This representation, in a way, allows for the creation of a champion or local role model, enabling mobilization through positive peer influence. In the same fashion, the ripple effect or peer pressure should not be underestimated, as evidenced by the evolution of the numbers from 2020 to 2023. Finally, a crucial element present in all aspects of the project is the construction of a relationship of trust among stakeholders at all levels. Historically, there was some fear of the presence of ministry professionals in the watershed, stemming from concerns about potential reporting or the discovery of practices, some of which might be less than legal, leading to unexpected inspections that would not have occurred without the pilot project. From this historical perspective, we now see a systematic invitation of ministry representatives to all events in the watershed. Moreover, they are no longer ostracized but physically part of the group and engaged in discussions rather than being seated separately and excluded from conversations among farmers. Along the same lines, research programs put in place are systematically validated by farmers, including details regarding the actual location of certain phenomena, such as the presence of preferential flow paths. While scientifically speaking, the exact location of these paths is unnecessary, as only their quantification is required, ensuring an accurate representation of these localized phenomena at the plot scale has allowed for the construction of trust and direct exchange between the research and agricultural worlds, ensuring a win-win project and the possibility of information transfer between the two realms in a collegial manner.

3.3 An evolving project governance

The implementation of the RACI exercise and the description of the roles and responsibilities of each stakeholder in each task of the pilot project is one of the tangible elements allowing us to measure the evolution of project governance. Although the project manual itself cannot be disclosed due to its confidential and evolving nature, the following key elements will help the reader understand its significance. Initially, the pilot project stemmed from a government initiative proposing a relatively top-down approach, but the multiplication of partners, types of contracts, and the desire to make this pilot project a living laboratory focusing on farmers' needs justified the implementation of the RACI matrix. The initial exercise was carried out jointly by the "leading" bodies of the project, resembling the top-down approach. Farmers initially saw their role limited to "Informed" or "Consulted" in the RACI matrix, whereas an approach centered on their needs should have given them a more prominent role as "Responsible" or even "Accountable". The current version of the project manual, the result of the third complete collaborative revision, includes 16 tasks associated with deliverables in the project. The local team representing the farmers has the role of "Responsible" (R) six times, "Consulted" (C) six times, and “Informed” (I) twice. This division of tasks reflects the central role of farmers.

This central role is also recognized in the funding agreements, which must now include a reference to the MOP as a contractual document stemming from the project's governance evolution and guaranteeing compliance with the governance's evolution as the project matures. The value of such a document, which can be described as supra-project, lies in its ability to sustain responsibilities beyond the duration of the agreements. Indeed, the duration of government programs, divided into phases of a maximum of 3 to 5 years, is one of the challenges identified by all parties as a potential obstacle. This substantial hurdle, which nearly prevented the project from starting, led to a major evolution in project financing. Through a funding agreement that had to be approved by the ministerial cabinet and endorsed by the Treasury Board, the creation of a budget reserve for 2023-2030 was allowed to ensure the project's continuity beyond Phase 1 of the pilot project from 2020-2023. This advancement demonstrates government investment and its willingness to concretely evolve the implementation of agricultural projects in Quebec. This openness is necessary, and the project's long-term commitment facilitates it. Along the same lines, the signing of research agreements between universities and ministries, or the ROBVQ, must sees the parameters of their drafting evolve. The local team and farmers must have and demand a recognized role in agreements traditionally signed between institutions, without mentioning private individuals or unregulated entities. Changing these practices, while logical and in line with the living lab trend, is not without challenges, as it indirectly mobilizes administrative teams of entities with significant inertia and legal and legislative worlds that perceive these changes as risks sometimes deemed unacceptable at first glance.

Last but certainly not least, the current project team envisions an overarching pilot project in which each action is inherently linked to a set of performance indicators. These performance indicators are aligned with the project's initial objective but must resonate with all stakeholders. They are designed to reflect a three-tiered vision, encompassing legislative, research, and agricultural perspectives, and should enable the temporal and spatial summarization of project progression. This exercise, deemed crucial for the advancement of collective projects in Quebec by the project's stakeholders, is currently underway. It will culminate in an interactive project dashboard, akin to a speedometer and odometer in a car, allowing for real-time monitoring of the project's health. In a closer analogy, similar to water quality indicators, these metrics will serve to identify both weaknesses and strengths in the program's implementation, facilitating remediation in its successive phases.

4 Conclusion and future work

In conclusion, the Castor Project exemplifies a holistic approach that combines agri-environmental research, socioeconomics, policy development, beneficial field practices, and overall education and awareness development within the framework of a living laboratory. This multifaceted initiative emerged as a pilot project under the Quebec Water Strategy 2018-2023, drawing on insights gained from collective projects funded by MELCC since 2005. This article has highlighted crucial factors contributing to the project's initial success in its establishment and refinement during the planned 10-year period.

One pivotal aspect was the meticulous definition of the project's agro-environmental territory, involving the reconciliation of legislative, stakeholder, and scientific perspectives. By harmonizing these viewpoints with input from diverse stakeholders, the project ensures a comprehensive and equitable assessment of agro-environmental practices across the selected territory. The project's evolution from an initially top-down approach, characterized by clear governmental objectives and expectations, underwent a process of structuring and interpretation. This process allowed all stakeholders to find their place within the project while emphasizing the centrality of farmers in a participatory initiative for the integrated management of an agricultural watershed. Key success factors contributing to the project's achievements to date include active listening to various stakeholders and the cultivation of a trust-based relationship over a sufficiently extended timeframe to avoid undue pressure for immediate results.

While this paper offers a quantitative overview of the project's footprint within the watershed, substantial area dedicated to the project and farmers participation to name but a few, its qualitative impact on water quality and watershed health is of paramount importance and will be documented for the seven years to come. This outcome is the result of collaborative efforts involving farmers, researchers, and diverse stakeholders. The ongoing success story of the Castor Project will continue to provide valuable lessons and guidance for future initiatives aimed at preserving and enhancing the health of our critical watersheds.

5 Acknowledgment

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