water

MDPI

Article

Building a Foundation for Knowledge Co-Creation in Collaborative Water Governance: Dimensions of Stakeholder Networks Facilitated through Bridging Organizations

Wietske Medema [1,*], Jan Adamowski [1], Christopher Orr [1], Alison Furber [1], Arjen Wals [2] and Nicolas Milot [3]

1 Department of Bioresource Engineering, McGill University, 21 111 Lakeshore, Ste Anne de Bellevue, QC H9X 3V9, Canada; jan.adamowski@mcgill.ca (J.A.); christopher.orr@mail.mcgill.ca (C.O.); alison.furber@mail.mcgill.ca (A.F.)

2 Department of Social Sciences, Education and Competence Studies, Wageningen University, 6708 PB Wageningen, The Netherlands; arjen.wals@wur.nl

3 Institut des Sciences de l'Environnement, Université du Québec à Montréal, Montreal, QC H2L 2C4, Canada; nicolas.milot@gmail.com

* Correspondence: wietske.medema@mcgill.ca; Tel.: +1-514-398-7786

Academic Editor: Tim Smith

Received: 8 October 2016; Accepted: 12 January 2017; Published: 19 January 2017

Abstract: The sustainable governance of water resources relies on processes of multi-stakeholder collaborations and interactions that facilitate the sharing and integration of diverse sources and types of knowledge. In this context, it is essential to fully recognize the importance of fostering and enhancing critical connections within and between networks of relationships between different government and non-government agencies, as well as the dynamics that are in support of the development of new knowledge and practices. In Quebec, a network of watershed organizations (WOs) has been put in place to serve as bridging organizations (BOs) for stakeholder groups in their watershed territories. Using the WOs as a case study, this research aims to contribute to a greater understanding of how stakeholder groups can be effectively connected to support knowledge co-creation through networked relationships facilitated by BOs. In line with this overall research aim, the following research objectives are proposed: (1) to assess the quality of the knowledge that is developed and shared through the WOs and their stakeholder networks; (2) to determine the characteristics of stakeholders participating in the WOs' networks that either hinder or support collaborations and knowledge co-creation; (3) to describe the collaborative processes and mechanisms through which the WOs facilitate stakeholder interactions and knowledge co-creation; and (4) to assess the quality of the relationships and interactions between stakeholders participating in the WOs' collaborative networks. A comprehensive literature review is provided of collaborative network dimensions that are in support of knowledge co-creation that forms the foundation of a research framework to assess knowledge co-creation processes that are facilitated through BOs and their collaborative networks. Documented experiences have been gathered through face-to-face semi-structured interviews, as well as a Quebec-wide survey distributed to all WOs and their staff. A total of 41 interviews were conducted, of which nine interviews were with staff members of six selected WOs. Stakeholder perspectives were captured through 33 interviews with diverse stakeholders from three of the six selected WOs. Additionally, interviews were also conducted with five decision makers at the Quebec provincial government level. The findings of this study point to some key challenges and constraints for the effective facilitation of collaboration and knowledge co-creation through the Quebec WOs and their stakeholder networks. Through diverse collaborative mechanisms, most WOs have, to an extent, succeeded in creating opportunities for learning through a renewed sense making of different practices (and related identities) through the development of their

watershed master plans, as well as through the facilitation of new communicative connections and translation efforts between diverse stakeholder groups. Key challenges to their effectiveness have been relating to a limited capacity and resources, limited territory-wide impacts, as well as limited perceived legitimacy that hindered the WOs as BOs in their ability to facilitate effective knowledge co-creation. Areas for further research to overcome these challenges are in developing a greater understanding of how BOs can optimize resources and capacities available in their collaborative networks through, e.g., the development of boundary-crossing leaders and competences, as well as the use of Information Communication Technology (ICT).

Keywords: collaborative water governance; stakeholder collaborations; watershed organizations; bridging organizations; knowledge co-creation; network dimensions

1. Introduction

The governance of water resources relies on multiple knowledge sources and types that are often dispersed among local, regional, and national agencies and groups. This makes it challenging for any one group or agency to possess the full range of knowledge that is needed. Processes are required through which knowledge is continuously updated to reflect current understandings and needs [1–3]. To avoid knowledge gaps, sustainable water governance calls for inter-agency collaboration, ongoing learning and capacity building, as well as the emergence of partnerships between public, private and civil society stakeholders at different organizational levels [4–6]. The power of stakeholder networks is increasingly recognized in this context as a result of a move away from more top-down and hierarchical mechanisms to more collaborative forms of governance [7,8]. Collaborative water governance is meant to involve a diverse set of stakeholder groups at multiple levels and scales for the purpose of more sustainable water resources management [1,8,9]. Wheatley and Frieze [10] emphasize the importance of fostering and enhancing critical connections within and between these networks of relationships and argue that these dynamics support the development of new knowledge and practices.

Another feature that is increasingly recognized as key to collaborative water governance are bridging organizations (BOs) for their role as intermediaries between diverse stakeholder groups and networks in support of collaboration and the creation of new knowledge [1,2,11–14]. BOs can vary in form, degree of scope, stakeholder participation, and formalization. For this study, they are defined as distinct organizations established with the main purpose of facilitating the development of collaborative stakeholder networks that bring together multiple positions as well as knowledge types and sources, while providing a platform for knowledge co-creation [1,2,9,15,16]. Ideally, these collaborative networks become learning networks that allow for the continuous (co) creation of new knowledge, identity development, change of practices, and institutional development, involving boundary crossing and reframing [17]. Boundaries here are defined as socio-ecological and socio-cultural differences between diverse knowledge or professional domains and stakeholder groups leading to discontinuity in action or interaction [18]. Boundary crossing is defined here as a generative process that involves the effective integration of diverse knowledge forms while creating new knowledge through collaborative networks. Institutional arrangements created through BOs provide an environment for newly emerging collaborative networks that can stimulate boundary crossing and give rise to new social practices and interactions. However, there is a lack of understanding or agreement still about the ways and mechanisms through which BOs effectively facilitate knowledge co-creation [4,14,19,20].

The development of vertically and horizontally interlinked collaborative stakeholder networks is often recognized as a prerequisite for the success of BOs [8,15,21]. For this study, stakeholders are defined as those parties with the power to influence the outcome of resource management decisions; those affected by the decisions; and those who hold knowledge relevant to the decisions [22].

Collaborative networks are defined as dynamic configurations of stakeholder connections that can be used to explain the potential for knowledge co-creation [23]. Knowledge co-creation in turn can be described as the collaborative process that brings together a plurality of knowledge sources and types to address a defined problem and build a systems-oriented understanding of that problem [2]. There are many different types of knowledge (e.g., scientific, experiential, place based knowledge and knowledge generated at other scales than the scale of focus), and it is essential to find a way to combine these to support more sustainable water governance [1]. Network building investments have often created or funded BOs to support and maintain collaborative stakeholder networks and facilitate knowledge co-creation in a pluralistic context [24–26].

Both the Government of Quebec and the Government of Canada have recognized a watershed approach as a way to balance water demands from various sectors. In 2002, the Quebec Water Policy was launched with the aim to change the way water was being managed while proposing a reform in governance that would support the coordination of all government, local and regional actions through the use of effective policy tools and monitoring systems. In 2009, the Quebec Water Act was adopted to affirm the collective nature of water resources and provide for increased water resources protection [6]. A network of watershed organizations (WOs) has been put in place to serve as BOs for stakeholder groups in their watershed territories. The Quebec government provides funding to the WOs for administrative purposes as well as to create, monitor and facilitate the implementation of watershed master plans. Although the funding increased in 2009, a 2013 report by the Sustainable Development Commissioner emphasized that additional funding is still needed to support the realization of the watershed master plans [27]. The WOs have been established over the past 15 years and all WOs completed their first plans in 2014. These plans must be taken into consideration by government bodies functioning at different levels and scales [28]. In their role as BOs, the WOs are to ensure a balanced representation of both governmental as well as nongovernmental stakeholders [6,29,30]. The development and implementation of this watershed management approach relies on a voluntary participation of diverse stakeholders through collaborative networks facilitated through the WOs that encompass all of Southern Quebec [28].

Several authors [2–4,31,32] emphasize the importance of conducting more in-depth studies to develop a deeper insight into how collaborative structures and patterns of relations between stakeholders either enhance or hinder knowledge co-creation processes. Earlier research conducted by Olsson et al. [13] focused on developing a greater understanding of conditions that enable BOs to facilitate coordination among different stakeholders. Marín and Berkes [33] stress, however, that further research on how BOs contribute to the structure and functioning of collaborative networks is essential in support of sustainable water governance. Using the Quebec WOs as a case study, this research aims to contribute to a greater understanding of how stakeholder groups can be effectively connected to support knowledge co-creation through networked relationships facilitated by BOs. In line with this, the following research objectives are proposed for this study:

- Research objective 1: Assess the quality of the knowledge that is developed and shared through the WOs and their stakeholder networks.
- Research objective 2: Determine the characteristics of stakeholders participating in the WOs' networks that either hinder or support collaborations and knowledge co-creation.
- Research objective 3: Describe the collaborative processes and mechanisms through which the WOs facilitate stakeholder interactions and knowledge co-creation.
- Research objective 4: Assess the quality of the relationships and interactions between stakeholders participating in the WOs' collaborative networks.

The following section provides a literature review of collaborative network dimensions that are in support of knowledge co-creation. A research framework and methodology are proposed to conceptualize these network dimensions in more detail and assess knowledge co-creation processes that are facilitated through BOs and their stakeholder networks. Data and experiences from key

staff and stakeholders that are directly involved with the Quebec WOs have been gathered through face-to-face semi-structured interviews, as well as a Quebec-wide survey that has been distributed to all 40 Quebec WOs and their staff. The findings from the interviews and surveys serve as the beginning of an empirical foundation on which to conduct systematic analysis and comparison of knowledge co-creation processes across case studies and research sites in the future. This paper concludes with a discussion of the findings, important challenges and practical considerations, as well as an agenda for future research.

2. Network Dimensions for Knowledge Co-Creation

An earlier study of Quebec watershed territories was conducted through a network analysis of municipal water quality management networks to capture how BOs indirectly connect municipalities. Through this study, Rathwell and Peterson [16] found that municipalities do not collaborate directly with each other and are often connected via BOs spanning the water quality management networks. They also found that many agricultural municipalities are relatively isolated while at the same time being the primary producers of water quality problems. A key conclusion from this study is that a further strengthening of water management networks in Quebec requires a closer consideration of the social-ecological contexts of these networks to help explain their structures and reveal challenges and disconnects to the development of collaborative networks. The focus of this current study is unique in that it specifically looks at the Quebec WOs as BOs that are in charge of developing connections between a diverse representation of government and non-government stakeholder groups, as well as on the dimensions and features of stakeholder networks created through these WOs that either enhance or limit collaboration and knowledge co-creation between these network members.

When looking at knowledge co-creation through stakeholder networks as learning networks, it is also essential to look at the emerging literature of boundary-crossing in the learning sciences. As mentioned earlier, boundaries can be described as socio-cultural differences that lead to a discontinuity in action or interaction [17,18]. Akkerman and Bakker [18] provide a comprehensive literature review of this specific literature and offer an understanding of boundaries as dialogical phenomena involving four potential learning mechanisms that can take place at boundaries: (a) *identification*, which is about coming to know what the diverse practices are about in relation to one another; (b) *coordination*, which is about creating cooperative and routinized exchanges between practices; (c) *reflection*, which is about expanding one's perspectives on the practices; and (d) *transformation*, which is about collaboration and co-development of practice. The idea of "discontinuities" in this literature is that these can trigger learning in the form of collaborative re-framing—basically knowledge co-creation through the (re-)creation of identities and reshaping of relationships and practices. Kaufman and Smith [17] define "reframing" as an intervention tool through which one is seeking to change the way in which parties have initially framed issues.

In the context of sustainable land and water resources management, a number of scholars have specifically been studying required collaborative network conditions for effective knowledge co-creation processes over the past decade, e.g., [3,7,14,31,34–41]. A number of these previous studies have identified features of collaborative networks that are associated with effective knowledge co-creation in general [31,36,39,41–44]. Inkpen and Tsang [39], for example, divide these features into three dimensions: structural and relational (external) as well as cognitive (internal) dimensions. Their key argument is that the potential for knowledge co-creation is effectively facilitated through active stakeholder participations in collaborative networks and the resulting repeated and enduring exchange relationships. Other studies also confirm that knowledge co-creation is facilitated through intense social interactions between network members [41,45–47]. In addition, various scholars [31,36] emphasize the importance of a diverse stakeholder network to ensure more "socially robust" knowledge that is scientifically reliable while widely accepted in the social context in which it is being applied. Where some researchers specifically emphasize properties of stakeholder groups as an important

dimension [41,48], other researchers add to this dimension the properties of relationships between such groups [41,49], as well as the properties of knowledge [50] that enhance or limit knowledge co-creation.

The following subsections—that directly relate to the earlier mentioned research objectives—synthesize and provide details on a range of network dimensions and features identified from the above mentioned empirical studies that are in support of or may stand in the way of effective knowledge co-creation. At the end of each subsection, specific research questions are proposed.

2.1. Properties of Knowledge Outcomes (Research Objective 1)—Quality of Knowledge Developed and Shared

The properties of knowledge may have an effect on the rate at which certain knowledge is acquired, how much of this knowledge is retained and where, as well as how easily it diffuses within and between stakeholder groups in a collaborative network [40]. It is important to note that it is generally more difficult to transfer tacit knowledge that requires rich communication and interaction, than it is to exchange explicit knowledge [50,51]. In order for knowledge co-creation processes and outcomes to be considered credible, collaborative networks must deliver timely, tangible and useful outputs, including synthesis reports, briefings, while also providing access to useful data, models and expertise [34]. It is also crucial to develop a greater understanding of the levels of congruence or "fit" that exist between the different network dimensions, which determines the credibility, salience and legitimacy of knowledge outcomes and the success of knowledge co-creation efforts. Legitimacy refers to the extent to which knowledge co-creation efforts have respected the diverse values and beliefs of stakeholders involved [40]. It is important to take note of stakeholder perspectives on the credibility of knowledge outcomes, on the credibility of other stakeholders that are participating in the process, on the salience of the knowledge produced as well as on the perceived legitimacy of the knowledge co-creation process [52].

The following research questions are proposed, of which the first two question are explored in more detail in the results section, while the third question forms the basis for the discussion section:

(a) Have the WOs and their collaborative networks delivered timely, tangible, and useful outputs?
(b) How do the network dimensions impact the credibility, salience and legitimacy of knowledge outcomes and the success of knowledge co-creation efforts?
(c) What is the "fit" or level of congruence between the different network dimensions of the WOs' collaborative networks?

2.2. Properties of Stakeholders (Research Objective 2)—Characteristics of Stakeholders Participating in Networks

It is essential for successful knowledge co-creation that stakeholders are prepared to participate in such processes [35,36]. When it comes to enhancing knowledge co-creation processes, a diverse stakeholder network leads to more socially robust knowledge [53]. Lamers et al. [54] emphasize that in the process of identifying stakeholders, it is important to recognize that such stakeholders will only be prepared to participate if they expect the participation will result in "win-win" situations. These authors also point out that stakeholders will not always be willing to participate in every phase of the process, particularly if they consider themselves to be a "problem owner".

Bodin and Crona [7] look at how governance processes and outcomes differ significantly depending on structural differences of stakeholder networks, and find that the development of sub groups in such networks are inevitable (due to, e.g., geographical boundaries, specialization, and inherent limitations of stakeholders) and may pose challenges to joint knowledge development. Stakeholders and organizations that connect these sub groups must have the willingness, capacity and motivation to coordinate these sub-group activities within the larger network activities [7]. To successfully facilitate knowledge co-creation processes, it is also important to look at what stakeholders can do to optimize resources for knowledge development [14,36]. Literature on the

sociology of knowledge stresses the importance of "softer" resources in this context, and identifies three types of resources e.g., [38,55–58]: (a) boundary objects as a means to align different stakeholder perspectives and interests (e.g., site visits, reports, GIS maps, texts or computer tools); (b) facilities and forms of organizational embedding that stimulate the sharing of diverse forms of knowledge (e.g., administrative support, places to meet, computer networks, and organizational forms allowing creativity and innovation); and (c) specific competencies required for effective collaboration across different communities (e.g., in terms of negotiation, translation and mediation).

For the effective interfacing of knowledge across community borders, it is crucial not to only take into account expert or scientific knowledge (i.e., explicit knowledge), but also experiential or tacit knowledge dimensions that require more intimate and informal human interaction [38]. Some researchers emphasize the absorptive capacity of stakeholders as an important property for knowledge co-creation [40]. The "absorptive capacity" refers here to the stakeholder's capacity to understand diverse knowledge [40,59]. This ability to exploit external knowledge is an essential component of innovative capabilities, and is largely a function of the level of prior related knowledge that confers an ability to recognize the value of new information, assimilate it, and apply it to practical ends [48]. In other words, the premise of the notion of "absorptive capacity" is that the stakeholders need prior related knowledge to assimilate and use new knowledge.

The following research questions are proposed to address this second research objective:

(d) Do stakeholders have the willingness and motivation to participate in the WOs' collaborative networks and knowledge co-creation efforts?

(e) What resources are available with the WOs and their stakeholder networks to facilitate collaboration and knowledge co-creation?

2.3. Properties of Collaborative Process (Research Objective 3)—How Interactions Are Organized

There must be a deliberative quality to collaborative processes that enable a neutral space for open and iterative dialogue, allowing stakeholders to learn and express their interests [14,34,36,60]. In addition to following such principles of dialogue, there must also be clear "rules of the game" that guide interactions between stakeholders in a collaborative network [39,40]. Hegger et al. [36] point out that stakeholders must choose carefully which roles they wish to pursue, what responsibilities they are willing and able to take on, and to openly share their positions with other stakeholders. An understanding is required of incentives or reward structures that are in place to promote knowledge co-creation between stakeholders [7]. Ansell and Gash [41] discuss that incentives to participate are low when stakeholders are effectively able to achieve their goals unilaterally or through alternative means (e.g., if litigation or direct advocacy or staying silent would be more productive or a better use of resources).

Bodin and Crona [7] highlight how both qualitative studies [15,61] and quantitative studies [62,63] have demonstrated that by including crucial stakeholders, and by facilitating the development of strong connections between them, the chances for collaboration, joint action as well as collective development of knowledge significantly increase. Although the number of stakeholders that are included in collaborative networks needs to be somewhat limited in order to keep knowledge co-creation processes manageable [54], it is essential to develop a practical and strategic coalition of stakeholders that have a clear interest in and knowledge about the system under consideration [3,34,36]. Stakeholders that are not included from the beginning may eventually become sources of opposition, either out of self-interest or out of a resistance to not having been included earlier [52]. A close proximity between stakeholders (physically or psychologically) is also crucial in providing opportunities to build trusting relationships and enhance the sharing of knowledge [60], either through provision of physical space (e.g., meeting rooms), virtual space (e.g., computer networks and ICT tools), or mental space (e.g., common goals) [57,64]. Non-competitive and innovative discourse in addition to more formalized settings are essential, while formal environments are often limited in fostering interactions and learning, keeping stakeholders stuck in defending entrenched positions [3,60].

Ongoing reflection on effectiveness of knowledge creation process and its outcomes is another key condition and may be achieved through the facilitation of lessons learnt meetings and reflective workshops [34]. It is also important to develop a deeper understanding of how certain impacts and outcomes are affected by existing political, cultural and institutional factors [14,65]. Transformational leadership that elevates stakeholder interests, stimulates a culture with a shared vision, and encourages collaboration and learning are conditions in support of ongoing reflection [66]. This in turn requires emergent leaders and effective knowledge liaisons and brokers (i.e., agents of change) that are able to build critical connections for knowledge exchange and development between stakeholders in a region [15,67]. In this context, it is important to understand power asymmetries that may exist between stakeholder groups or individuals occupying different network positions [14]. Ansell and Gash [41] emphasize that power asymmetries not only need to be understood but adequately addressed through the collaborative process.

Finally, knowledge co-creation may be enhanced through the use of boundary objects as a means to align different stakeholder perspectives and interests [8,14,36]. Literature on learning sciences emphasizes that boundary crossing, and boundary people, organizations or objects carry learning potential. Boundary people or objects referring to individuals or artifacts—such as local leaders, the WOs as bridging organizations, and the WOs' watershed master plans—playing an essential bridging function in facilitating these crossings [18].

The following research questions are proposed to address this third research objective:

(f) Have crucial stakeholders been included effectively in the WOs collaborative and knowledge co-creation processes and efforts?

(g) Have the WOs been able to provide a space, processes and mechanisms for their networks to effectively interact and create new knowledge?

2.4. Properties of Relationships (Research Objective 4)—Quality of Relationships between Network Members

For effective knowledge co-creation, it is essential to facilitate collaborative processes that are characterized by informal and open discourse as well as repeated interactions that build trust between stakeholder groups within a collaborative network [6,60,68,69]. High levels of trust between members is a crucial condition for successful knowledge co-creation that provides more insight into the properties of relationships between different stakeholders within a collaborative network [39,60]. Strong network ties through repeated interactions that involve more personal and informal interactions allow stakeholders to get to know and trust one another [7,31,39]. Collaborative processes that are facilitated through BOs are still often embedded in a web of power dynamics and often constrained by limited capacity and resources [70,71]. Ansell and Gash [41] stress that trust building is a key aspect of collaborative processes that is often time consuming and requires a long-term commitment and boundary crossing leadership in order to effectively achieve collaborative and knowledge co-creation outcomes. These authors also emphasize how knowledge co-creation efforts are more likely to succeed through "small wins" and intermediate outcomes that are essential to building momentum as well as trust between network members.

When stakeholders are connected in a collaborative network, a major challenge is that of finding shared problem definitions and developing a shared vision and purpose [34,37,39,52,72]. The enhancing of knowledge co-creation processes requires that stakeholders deliberate on the nature of policy problems and the types of outcomes to be expected [36]. Mutual goals represent the degree to which network members share a common understanding and approach to the achievement of network tasks and outcomes. In this context, bridging organizations may have a strong influence on the development of a shared culture that becomes part of the collaborative networks over time [39]. A shared culture refers to the degree to which institutionalized rules and norms of behavior govern relationships, spelled out in formal contracts, or understandings that evolve within the network [39,73]. Incentives to participate in knowledge co-creation processes increase when stakeholders consider the achievement of their goals to be dependent on the on the input and collaboration of other stakeholders

in the network whose interests are often opposing. Stakeholders must therefore develop a shared understanding of what they can achieve together or of the relevant knowledge that is required to address a collective problem [41].

The following research questions are proposed to address this fourth research objective:

(h) Are the WOs' collaborative networks characterized by strong network ties and mutual trust between stakeholders?

(i) Have the WOs been able to facilitate the development of a shared culture, purpose and goals within their networks?

3. Research Methodology

The central focus of this study is first on the extent to which knowledge co-creation occurred within the WOs' collaborative networks. Subsequently, it examines how, and under what circumstances, the WOs engaged in knowledge co-creation with their stakeholders. By starting with the dependent variable (properties of knowledge) and then positing a series of rival and/or intersecting explanations, a stronger basis for making broader, more generalizable claims about the theoretical relationships observed in this study is provided. The following research framework is proposed that synthesizes the key findings from the review in Section 2 on network dimensions for knowledge co-creation (see Figure 1). Additionally, this framework also includes a component that depicts pre-existing conditions (i.e., asymmetries between stakeholder groups of power, resources or knowledge; incentives for and constraints on participation; and prehistory of cooperation or conflict), as well as external context factors (i.e., existing regulatory frameworks; availability of funding and support instruments; level of political support and buy-in; and environmental events including floods and spills) that either provide new opportunities or hinder the success of the WOs and their collaborative stakeholder networks [6,41].

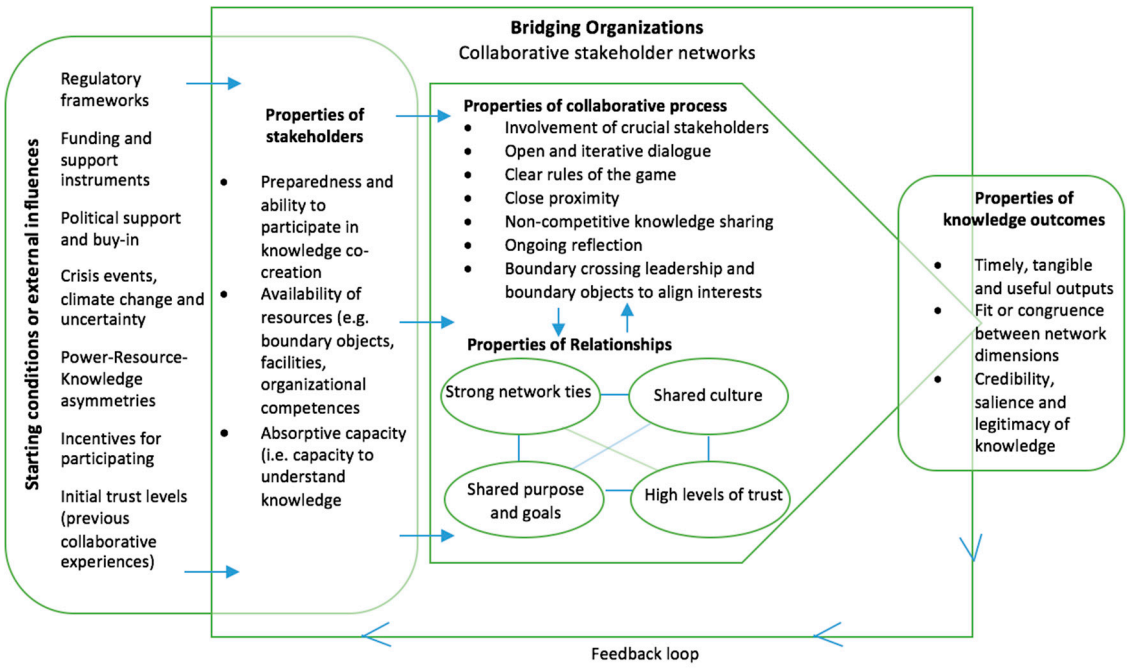

Figure 1. Framework to assess network dimensions and their impact on knowledge co-creation.

A case study approach is followed to assess the dynamics, processes and structures of knowledge co-creation as this is facilitated through the WOs and their stakeholder networks. The case study types that are being followed for this study are mostly of a descriptive as well as exploratory nature;

presenting a description of a phenomenon within its context and presenting data that explain how events occurred [74]. A case study approach can be designed to consider a single case, or multiple cases. Multiple cases are used when studying a phenomenon in different situations, or from different perspectives [75]. The case study that is being used for this study has been chosen because it provides the opportunity to investigate or assess the same phenomenon (i.e., knowledge co-creation processes) through multiple perspectives (i.e., that of the different WOs and their stakeholder groups). The assessment takes into account perspectives of WOs through semi-structured interviews with 9 staff members of 6 selected WOs. These WOs were selected to include diverse water issues, geographic sizes, and durations of existence (see Table 1), within practical limitations and based on their willingness to collaborate in this research: Agence Bassin Verssant des Sept (ABV des 7); Société de Conservation et d'aménagement du Bassin de la Riviere Chateauguay (SCABRIC); Conseil des bassins versants des Mille-Îles (COBAMIL); Conseil Du Bassin Versant De La Region De Vaudreuil-Soulanges (COBAVER-VS); Conseil de gouvernance de l'eau des bassins versants de la rivière Saint-François (COGESAF); and Organisme des bassins versants de la Capitale (OBV de la Capitale) (see Figure 2).

Table 1. WOs and their characteristics [28].

Watershed Organizations	ABV Des 7	SCABRIC	COBAMIL	COBAVER-VS	COGESAF	OBV de la Capitale
Territory	Des Sept	Châteauguay	Mille-Les	Vaudreuil-Soulanges	Saint-François	Capitale
Area (km^2)	40,254	2543	1053	8132	10,228	711
Population	320,000	297,000	435,401	100,666	348,800	517,921
Population density (km^2)	8	117	414	124	34	728
Municipalities	50	39	25	19	95	11
Regional County Municipality (RCM)	9	5	4	1	12	1
Year of creation	2004	2002	2010	2009	2003	2002

Figure 2. Quebec watershed management territories [28].

Stakeholder perspectives were captured through interviews with 33 stakeholders from three of the six selected WOs (ABV des 7, COBAMIL and SCABRIC). These stakeholders were identified with the support of the three selected WOs staff and recruited by the researchers based on their current or past participation as stakeholders in the WOs stakeholder networks. Due to practical limitations, it was not

possible to conduct interviews with stakeholders in all six selected WOs, or with WOs that are located far from the Montreal area. Additionally, interviews were also conducted with five decision makers at the Quebec provincial government level. A total of 41 interviews were conducted from November 2014 until April 2015 (see Table 2). These semi-structured interviews investigate themes of network dimensions and conditions for effective knowledge co-creation as identified in the literature review and proposed research framework. Interviews were conducted in person, recorded and transcribed with consent of the interviewees, and responses coded and analyzed using an inductive and thematic analysis approach. Thomas [76] defines an inductive (thematic) approach as a systematic procedure for analyzing qualitative data where the analysis is guided by specific research questions. In the case of this study, the research questions have determined the design of the data collection methods as well as the analysis of data collected. The concepts in the research framework proposed earlier in this paper have been used as themes and codes to guide the analysis.

Table 2. Overview of interview participants of each stakeholder group or respondent type.

Group	ABV Des 7	SCABRIC	COBAMIL	Other WOs	Quebec	Total
Organization Staff	1	2	3	3	0	9
Economic	1	0	3	0	0	4
Social	3	2	1	0	0	6
Local Government	5	6	2	0	0	13
Regional Government	1	1	2	0	0	4
Provincial Government	0	0	0	0	5	5
Total	11	11	11	3	5	41

A Quebec wide online survey was also sent out to managing staff of all 40 WOs with the help of the Regroupement des Organismes de Bassins Versants du Québec (ROBVQ), an overarching organization in charge of facilitating communications across the WOs and between the WOs and the provincial government of Quebec, to see if findings from the interviews held true across Quebec. Survey questions related to which stakeholders are involved in their stakeholder networks, how strong or weak their involvement is, how network interactions are organized through the WOs, and what mechanisms and tools are used to facilitate such interactions. From the 40 WOs, 19 managing WO staff members completed this survey. Survey questions included Likert-style questions as well as short written response questions to address concerns for precision as well as depth of answers respectively. The written responses were coded for key themes following a similar inductive (thematic) approach as that used for the analysis of the interview data.

4. Results

This section provides an analysis of the results and findings from the Quebec-wide survey and case study interviews while providing details concerning the research objectives and subsequent questions proposed in Section 2 of this paper.

4.1. Properties of Knowledge (Research Objective 1)—Quality of Knowledge Developed and Shared

All interviewees recognized that the effective development of watershed master plans require the integration of a wide variety of knowledge sources and types that allow to address a wide range of complex water issues. In the case of the Quebec WOs and their watershed master plans, the approach to their development is quite static in that they are five-year plans that offer a lot of data and information in one place. Often this information was perceived as far too lengthy to be enticing for specific stakeholder groups to read and use. This was shared during the interviews with stakeholder groups who claimed to not having sufficient time to go through the entire document, or not finding the plans appealing enough to use directly for their own work. One interviewee highlighted an overall agreement amongst stakeholders that "*the length of the plans makes it unappealing and time consuming*

to go through". All interviewees emphasized the importance of changing the current format of the watershed master plans as more self-contained documents to more personalized tools that address and are relevant to specific needs for data and information with different stakeholder groups in their watershed territories.

Subsequently, half of the WOs' staff interviewed expressed overwhelm at the task of developing the watershed master plans. Study results indicate that the WOs were often limited in the development of their watershed master plans due to a lack of available scientific data. A number of regional and provincial stakeholders expressed concerns that decisions made by the WOs regarding their plans and prioritization were not sufficiently informed by scientific data or a complete understanding of the issues. To overcome this challenge, all WOs studied for this research indicated initiating and delivering services for water quality monitoring as a means to gather additional data required to inform their plans. As one WO staff member explained, "*WOs often apply for additional funding to be able to produce more reliable data, such as on water quality, to help inform better decisions*". The studied WOs agreed that these additional services not only addressed issues of funding and data availability, but also, more importantly, showed their utility as organizations while improving their (perceived) legitimacy and credibility with stakeholder groups in their watershed territories. All interviewed stakeholders emphasized that for the WOs to increase credibility and recognition with stakeholder groups, it is essential to achieve more on-the-ground results and have a larger impact in their watershed territories beyond the development of the master plans.

Study results also show that an opportunity in support of more effective knowledge co-creation that has not been taken up by a large majority of the WOs Quebec wide is relating to data access and sharing within and across stakeholder networks. This pertains to data ranging from biophysical data on surface and groundwater resources to social and economic data that should set key criteria for selecting the best development options. One interviewee explained that: "*There is often difficult access to or limited availability of reliable, comparable and relevant data across the province, which remains a key constraint to the development of the plans*". All WO staff that were interviewed for this study agreed with this statement while emphasizing it is often time consuming and difficult to get access to or develop required types of data and information for the development of their plans. All studied WOs offer where possible their knowledge and information via an organizational website (e.g., watershed plans, reports). One of the challenges highlighted by the WOs that were interviewed is, however, in keeping these websites up-to-date. One WO addressed this issue by programming their watershed plan in html allowing for immediate online updates while progressing with their plan. Although survey results do indicate that stakeholders have to an extent been involved in joint fact-finding activities to support the development of the watershed plans, the WOs have so far not been able to achieve more advanced management of knowledge and information (involving, e.g., open and shared information sources).

4.2. Properties of Stakeholders (Research Objective 2)—Characteristics of Stakeholders Participating in Networks

When it comes to enhancing knowledge co-creation processes, it is important that stakeholders are prepared to participate in such processes. In the context of Quebec water governance, all WOs highlighted that they are mandated to facilitate the voluntary participation of the public and local experts in the development and implementation of their watershed master plans. All provincial level interviewees agreed that as voluntary participatory organizations, the WOs form the Quebec government's key mechanism to improving water governance. In that light, the WOs are required to ensure a balanced representation of stakeholders from sectors, such as the government, First Nations, municipal, economic, environmental, agriculture and community sectors. The interview results indicate that all interviewees agreed on the important role the WOs play in in connecting government and non-government stakeholders across different levels and scales. The large majority of these interviewees, however, also expressed a genuine concern regarding the voluntary participation of relevant stakeholders, especially concerning the voluntary involvement in the implementation of the

watershed master plans. An interviewee from the municipal sector emphasized, for example, that "*there is no obligation for stakeholders to be involved in their [the WOs] process*", and another interviewee explained that "*stakeholders will have an interest in proposed changes if it is beneficial to their work, this becomes much harder if this benefit is not clear to them*".

All interviewees agreed that the willingness of stakeholders to participate often depends on their awareness or interest in a specific water issue, as well as their perceived legitimacy of the WOs and what they do. Although governance arrangements in Quebec appear most strongly connected to the municipal sector (i.e., due to their capacity and mandate to make decisions), all interviewees from this sector expressed that they often do not look at water issues from a watershed scale, which they consider lying outside the normal "scope" and boundaries of their work. Most WOs also expressed facing challenges in engaging economic sectors (e.g., commercial business, forestry) because of limited incentives for their participation. This has been much less the case with the agricultural sector particularly in more agricultural watershed territories. In agricultural regions, many of the WOs were able to slowly establish cooperation with the agricultural producer unions (UPA) through farmers that were open and supportive of what the WOs are trying to achieve. Three of the six WOs that were interviewed were able to leverage existing networks and develop collaboration with the Agricultural Producers Unions (UPA) through farmers that were open and supportive of what the WOs are trying to achieve. One WO staff explained how "*they [farmers] are quite well networked, so going through those networks works to reach other farmers*". Only seven out of the 19 surveyed WOs specified their interactions with the UPA and farmers.

The inclusion of citizen groups has also proven challenging, especially in the case of larger scale watershed territories. All the WOs that were interviewed have not directly included First Nations in their collaborative networks, the reason for this is likely that First Nations now primarily interact with the Federal government, as well as the fact that First Nations communities are often overwhelmed by requests to participate in different activities, councils and research projects. Their councils are often small and do not have the capacity to consult on all requests. Survey results confirm the very limited involvement of First Nations. When survey respondents were asked to list key stakeholders in their watershed territories, only one WO out of the 19 WOs made specific mention of First Nations as a key stakeholder. The respondents were asked to provide a list of local, regional and provincial level stakeholders they interact with, and although the WOs identified ministries, Regional County Municipalities (RCMs), and municipalities as stakeholders they interact with, there was a lesser mention of interactions with economic, environmental, agriculture and community sectors. For example, only seven out of the 19 surveyed WOs specified their interactions with the UPA and farmers. When asked to indicate to what degree local stakeholders support the WOs through participation, 33% of respondents answered "*sometimes*", 53% of respondents "*often*", and 13% of the respondents "*always*". These answers differed slightly for the same question regarding the participation of regional and provincial level actors: 7% answered "*rarely*", 33% "*sometimes*", and 60% "*often*". While the WOs function on a voluntary basis, they invite participants for their interests and capacities, depending on their willingness to participate. These results indicate that those involved with the WOs are prepared to participate, although this group may not include a representation of all key actors and stakeholders.

The Quebec government provides funding to the WOs for administrative purposes as well as to create, monitor and facilitate implementation of their watershed master plans. Although the funding towards the WOs increased in 2009, all WOs interviewed expressed a strong need for additional funds to support the actual implementation and realization of the plans. All interviewees agreed that there is a lack of capacity at all levels of government. As a result, the WOs receive insufficient technical support, vision and precise orientations from the regional and government level stakeholders. This limited support from the regional and provincial levels forms not only a limitation to the success of the WOs, as both WO staff and stakeholders interviewed agreed, but "*it forms a major challenge to the establishment of vertical integrated cooperation structures while regional level stakeholders communicate*

issues on watershed levels up to the provincial level", as one interviewee explained. Survey respondents were asked to what degree key stakeholder groups possess finances to implement actions proposed, and 39% of the respondents answered "*very little*", 50% of the WOs answered "*somewhat*", and 11% said "*mostly*". The same question was asked regarding the availability of finances within the WOs, and 17% responded "*not at all*", 22% of the WOs stated "*very little*", 56% responded "*somewhat*", and 5% answered "*mostly*". The interview results strongly confirm these survey results, highlighting limiting capacities and resources of the WOs as well as key stakeholders for the implementation of the watershed plans, which may form a threat to the durability of knowledge co-creation processes that are facilitated through the WOs.

Although it is difficult to determine the absorptive capacity of actors and stakeholders based on interview and survey data, all interviewees highlighted that the WO staff often have more experience and expertise relating to technical and biophysical aspects of water resources management than to the collaborative side, which may cause real issues for the effective facilitation of knowledge co-creation processes. This is, however, not only the case for the WOs but also for most of the key stakeholders, who often are, as several interviewees explained "*not used to a systems thinking approach*". In this context, it is possible that much more emphasis is given to knowledge as a more static asset (in this case in the form of five-yearly watershed master plans) than to the perspective of knowledge co-creation as an ongoing and dynamic learning process.

4.3. Properties of Collaborative Process (Research Objective 3)—How Interactions Are Organized

The voluntary basis on which stakeholders participate in the WOs means that some stakeholder groups choose not to be involved, and, as discussed earlier, results show that the WOs have achieved mixed success in engaging diverse stakeholders. The involvement of crucial stakeholders is essential to socially robust knowledge creation. Interview responses indicated that some of the WOs have been more successful in bringing together different stakeholders than others by using diverse approaches for facilitating interactions. These mechanisms focused mostly on the participatory development of shared visions, goals, strategies and decisions on priorities and actions in the watershed master plans. Ideally, such interactions should be ongoing while extending from the highest political to local levels, as well as cutting across horizontally to bring together different sectors and disciplines, although all interviewees agreed this is not yet the case for Quebec water governance. All interviewees also expressed that the collaborative process facilitated by the WOs represents a small fraction of their watershed territory populations, and it is often a major challenge for the WOs to reach wider groups of stakeholders due to time and financial constraints.

The mechanism for interaction between the WOs and stakeholder groups include consultation tables and technical or scientific committees through which stakeholders interact with each other. Individuals participating are selected in terms of representativeness of key stakeholder groups and their willingness to participate. All the WO staff interviewees recognized the importance of identifying local leaders, as such individuals may take on an essential role in advocating on behalf of the WOs and their work to their respective organizations in order to find support in the development and implementation of the watershed master plans. As one interviewee explained, "*these people are key players that become crucial for the success of the WOs and the implementation of the watershed master plans*". In this light, the WO staff was asked through the survey whether or not they have identified local leadership. Only two of the 19 WOs that participated in the survey responded with "*no*", and the remaining WOs all indicated that these local leaders were invited to participate on their round tables and technical committees while forming important resource persons and knowledge brokers. The degree to which the WOs engaged stakeholders in formal processes varied greatly. One younger WO (formed in 2009), for example, was exceptional in that its technical committee was not meeting in person due to time constraints and it had created no other committees or regular venues to engage stakeholders.

Interviewees from all other WOs described conducting regular meetings and other interactive fora. Another equally young WO facing similar time constraints had been successful in conducting

regular committee meetings, as well as several rounds of public consultations to gather input on their plan. Staff from five of the six WOs reported tailoring meetings and activities of WOs to local issues, context, and the needs of relevant groups and individuals. The young WO that had been successful in engaging stakeholders, for example, shared their plans to further expand their engagement to include six local committees to involve stakeholders through issue- and sector-specific groups. Likewise, one of the older WOs divided their territory into 24 sub-watersheds creating an informal committee of local stakeholders in each. Strategies included having meeting locations throughout a territory, creating multiple local committees, or both. These strategies reduced travel time and costs, while increasing relevance for participants, making the process accessible to a greater diversity and number of individuals. One WO coordinator noted the success of these smaller meetings: "*People were talking more and really arguing sometimes. It was smaller, so they were more interested. When you are 30 around the table you can avoid participating, but when it's smaller, they have to talk and give their opinions and be involved*". This type of strategy improved inclusion and participation of specific interest groups and actors, while addressing challenges related to diverse contexts and issues.

Interviewees from all six WOs expressed to have developed and implemented projects in partnership with existing stakeholder groups. Since they possessed limited funding and other resources, WOs attempted to demonstrate what could be done and how by partnering on these small projects with stakeholders to share resources and expertise. For example, one WO coordinated an ongoing revitalization project in a community creek with numerous government and NGO partners, while several other WOs partnered with agricultural unions on projects funded by the Ministry of Agriculture to educate and engage farmers in mitigating agricultural impacts on water. These partnerships enabled watershed organization staff to reach larger numbers of stakeholders. With these projects and partnerships, the WOs hoped to demonstrate effective actions to encourage other organizations to do the same. This approach is considered especially important for younger WOs, as one interviewee described "*If they [stakeholders] see that they can do simple actions, they will be more willing, and at the end of the next 5 years we have to be able to show the result if we want people to continue to work with us*". In other words, these more experiential means were followed by the WOs to demonstrate substantive results and potential actions, as well as to change stakeholder perceptions of and relationships to water.

All interviewees reported using some strategy to inform and educate stakeholders and the public. Several WOs described conducting public awareness campaigns to educate specific groups or the general public on issues such as ways to prevent spread of invasive species or to reduce domestic pollution of waterways. Additionally, almost all WOs developed educational resources, such as online mapping tools to better communicate water issues and inform the public. While staff of younger organizations cited other priorities such as establishing their organizations and producing their first watershed plans, interviewees in older organizations recognized the importance of these larger means of reaching and engaging diverse citizens to ensure they established and maintained broad public support. For instance, the oldest WO had organized community engagement events with more than 100 participants, while another WO had engaged diverse stakeholders through academic partnerships, including a regular international conference. Meanwhile, staff of one younger organization had begun small-scale engagement at local markets and other community venues, although staff of the younger organizations reported no other such initiatives.

All studied WOs acknowledged the importance of ongoing reflection and monitoring of the collaborative process, as well as the objectives, actions and outcomes that are a result of such processes facilitated through the WOs. As one WO staff stated "*by identifying and transferring lessons learnt within and between jurisdictions, the WOs may play a key role in the development of new knowledge and understanding about issues in their territories*". When asked whether there has been monitoring and evaluation of actions undertaken through the WOs, 25% of survey respondents answered this is done "*a fair amount*", 40% answered only "*sometimes*", 25% stated this happens "*a little*", and 25% answered "*none*". Interview results confirm these findings and highlight that there is often very little time for

collaborative monitoring of processes and outcomes. Survey respondents were also asked how often they facilitate dialogue to discuss lessons learnt with relevant stakeholders, only 11% answered "*often*", 44% responded "*sometimes*", 39% responded "*rarely*", and 6% answered "*never*". All interviewees agreed that limited resources and capacities are the main hindering factors for this very limited ongoing reflection. A unified framework for monitoring the implementation of the watershed plans as well as engagement processes was not in place until mid 2015.

4.4. Properties of Relationships (Research Objective 4)—Quality of Relationships between Network Members

In addition to in-person meetings as described above, all survey and interview respondents expressed that stakeholder interactions take place through phone calls, emails, and social media. When the WOs were asked through the survey how frequent their collaboration with key stakeholders is through the above-mentioned means, the responses varied from 2 to 10 times per year, with 85% collaborating less than six times per year. The interview and survey results emphasize how the collaborative processes facilitated through the WOs are often embedded in a web of power dynamics while also being constrained by limited capacity and resources, both within the WOs as well as their stakeholder groups. While municipalities and RCMs hold a majority of responsibilities for managing water, all WOs expressed the importance of closely involving these stakeholders in the development of the watershed plans, for both input as well as recognition and support. In almost all watersheds, interviewed WOs described the challenge of finding sufficient support and recognition from these local and regional municipal stakeholders often as a result of interpersonal issues or misconceptions of the WOs and their plans, as well as limited time and resources.

Effectively, the mandate of the WOs is to create and motivate new stakeholder networks, or mobilize existing networks in new ways. The majority of interviewees highlighted that physical distance and geographical spread of diverse stakeholder groups form a major challenge for the WOs to connect key stakeholder groups in their watershed territories. Especially the WOs with larger watershed territories described the major challenge to operate at a larger scale and reach a wider group of stakeholders in a way that enhances knowledge co-creation processes and efforts. As one interviewee explained, "*distances and geographical spread form a challenge for connecting with all key stakeholders in the watershed territories*". Although all research participants agreed that the WOs play a crucial role in bringing together stakeholders through collaborative networks not existing prior to their development, at the same time, the frequency of interactions facilitated through the WOs between diverse stakeholder groups is still often low. A central concern pointed out by all the WO staff is that the processes facilitated through the WOs are justified in the eyes of stakeholders and supported in practice. One WO staff explained that "*one of the most important measures of our organization's success is whether stakeholders within the watershed perceive that we are doing good things.*"

Interviewees expressed that processes facilitated through the WOs have enabled positive interactions between stakeholders not collaborating prior, and there was an overall agreement that WO leadership is important to build strong stakeholder networks. As one interviewee explained, "*personalities of people running the WOs have a strong impact on how they work together with and relate to stakeholders*". Results indicated that WO leadership has a large impact on the development of a shared culture, vision and goals by stakeholder networks over time. A shared culture refers to the degree to which norms of behavior govern relationships and interactions, often spelled out in formal contracts, or through shared understandings that evolve within collaborative networks. While the WOs work on a voluntary basis, they generally form no contracts with stakeholders regarding the implementation of aspects of the watershed master plans. Since each of the key stakeholders working with the WOs have distinctly different cultures, collaborative networks are formed through the WOS on the basis of some sort of cultural compromise between participants concerned.

Most interviewees agreed that limits to inclusion and interaction frequency emphasize the importance of complementing voluntary initiatives with measures such as regulation and incentives to provide an institutional environment that enables the WOs to facilitate the development and

implementation of their plans. All the interviewed WO staff recognized the importance of identifying local leaders, which may take on an essential role in advocating on behalf of the WOs to their respective organizations and networks. One WO staff emphasized that "*these people are key players that become crucial for the success of the WOs and the strengthening of their stakeholder networks*". Survey results indicate that 17 of the surveyed WOs take steps to identify such local leaders and invite them to participate in their round tables or technical committees. In this way, one of the younger WOs leadership in particular made substantial progress in gaining recognition and support of stakeholders over a short period of time. This WO also attributed reasons for its success to the hiring of staff with skills in community engagement and participatory processes, as well as the ability to maintain a clear and readily shared vision that enabled ideas to be shared and transmitted more effectively.

All WOs considered educating the public through partnerships with schools and other formal institutions as part of their primary mandate, although they possess limited capacities and no formal mandate to do this. The WOs prioritized water education as a way of reaching a much wider audience. For example, the interviewed WO with the largest watershed territory had provided education training on water issues to the regional school board, and its staffers were also delivering water education workshops in several schools in the territory. Another WO was coordinating the regional Adopt-A-River program, engaging students in experiential water education. A third WO was more involved in higher education, while a fourth collaborated closely with a non-profit water education center. The importance WO staff placed on education related to water issues is likely shared across Quebec. This claim is supported by the fact that the ROBVQ claimed that at least one staff member in more than 25% of WOs have received formal training to provide water education. As one WO coordinator affirmed, "*our job is to wake up people and make them realize they have to change their behavior, their thinking*." Another WO staff articulated that "*if you want to work with people, you have to first inform them because if they don't know what you want to do they won't want to work with you. And after that, you have to involve them more and more in decisions. Gradually, so at the end they will agree to take action*". Although offering a way to overcome limitations of capacity, it should be noted that education conveys a one-way communication strategy, which is indicative of another issue, that of the depth of engagement. This may in turn influence the likelihood of effective knowledge co-creation.

Finally, building trust between stakeholders was also considered crucial for the effective facilitation of knowledge co-creation processes and efforts. When survey respondents were asked about existing trust between stakeholders, results indicated that 11% answered "*very little*", 44% answered "*some*" and the remaining 45% responded "*a lot*". WOs were also asked to what degree conflicting views are common, and only 5% responded "*none*", 21% answered "*few*", 42% choose "*some*", and 32% responded "*common*". These conflicting views occurred mostly between the municipal sector (e.g., municipalities), economic sector (e.g., farmers), environmental groups and citizens. The survey data do not, however, indicate whether these conflicts were productive or unproductive, or how these situations were dealt with over time. These findings do, however, indicate that despite existing conflicting views or conflicts between some stakeholder groups, the WOs are often able to facilitate collaborative processes that facilitate the development of trust between participants.

5. Discussion and Conclusions

In this section, each of the research framework components will be discussed, while also exploring the relationships and dynamics among the content, the agents, and the outcomes of this model. An important component of the model consists of the "starting conditions or external influences" to knowledge co-creation processes and efforts. Ansell and Gash [41] explain how these starting conditions or external influences that are present at the beginning and throughout knowledge co-creation processes may either hinder or support these efforts. These conditions can relate to very diverse factors such as an imbalance in resources, knowledge or power between different stakeholder groups in a network, existing or newly proposed changes in regulatory frameworks, funding and

support instruments, political support and buy-in, as well as large environmental events (e.g., floods, and spilling).

In Quebec, there has been a strong move towards more decentralized water governance, with responsibilities increasingly devolving to lower levels of governance [77]. Although a reform of local governance processes has been taking place in Quebec over the past decade, there has been a lack of reform of the provincial-level government, which continues to take a more fragmented approach towards water resources management [27]. The Quebec WOs form an example of this reform of local governance processes, and represent diverse histories, leadership styles, local contexts, issues and stakeholders that make each of them quite different and unique. Many of the older WOs originated from pre-existing environmental organizations, whereas others were institutional experiments previously set up or supported by the Quebec government. In 2002, the Quebec Water Policy as a result of a public outcry of water issues, formed a key driver to the official formation of the WOs [6]. Subsequently, a blue-green algae crisis in 2007 led to a myriad of public meetings and governmental actions, and eventually to the 2009 Quebec Water Act that was proposed and adopted to affirm the collective nature of water resources and provide for increased water resources protection [30]. At this time, a revision took place of the watershed territories, increasing the number of WOs from 33 to 40 while also increasing the annual funding available for these organizations.

Despite the apparent commitment through the Quebec Water Policy and Act to move towards more collaborative forms of water governance, all research participants agreed that the Quebec government has placed significant emphasis on the development of the watershed master plans, and much less on the actual realization of these plans. Many interviewees noted that because of this the transfer of responsibilities and accountability through decentralized governance failed to devolve the requisite knowledge, power and resources to provide for the building of required capacities with the WOs and their stakeholder networks. Research participants also pointed to a resistance to the proposed paradigmatic changes from existing institutions and powerful interests involved. It should be noted that although the formation of the WOs has been supported through the Quebec Water Policy and Act, separate legislative provisions are lacking to further support and push this approach. Study results also indicate clearly that this has negatively impacted the credibility of the WOs in the eyes of stakeholders. It has also made it more challenging for the WOs to find their niche in the existing water governance structure, and to receive the commitment of other stakeholders for the implementation of the watershed master plans. The relatively limited on-the-ground impact of the WOs in their watershed territories so far, further affects their credibility. Any further knowledge co-creation efforts and outcomes coming from the WOs, as well as stakeholder experiences of the collaborative processes facilitated through the WOs, will greatly determine their long term success (or lack of).

Findings from this study overall point to one key challenge that hinders the WOs in their ability to facilitate effective knowledge co-creation through their stakeholder networks: a limited power, knowledge and capacity due to insufficient provincial-level government support (i.e., funding, and legislative provisions). This challenge exhibits itself in different ways, for example: (a) by limiting the WOs territory wide impacts; and (b) a limited perceived credibility resulting in limited support from stakeholders for the implementation of the watershed master plans—a reality that may continue to restrict available funding for the WOs. Although the WOs have succeeded in creating collaborative mechanisms to facilitate communication and interactions between stakeholder groups in their watershed territories, all research participants emphasized the importance to increase the frequency as well as the scale of these interactions while also facilitating processes for ongoing reflection and learning. The participants highlighted how limited resources and capacities often stand in the way of achieving this. Findings from this study indicate clear relationships between the different network dimensions and conditions. One example is the influence of WO leadership on creating a shared culture, vision and goals within their networks. Another example is how the lack of resources is directly related to a low frequency of communication and interactions with stakeholders. This in

turn prevents the WOs from optimizing resources with key stakeholders through close collaborations and strong ties.

It is important, therefore, to investigate in more detail how the WOs, as BOs, can optimize resources available within their collaborative networks for more effective knowledge co-creation as well as for an increased impact within their watershed territories. It is also crucial that the WOs, as BOs, find innovative ways to form new knowledge partnerships and extend the stakeholder networks throughout their watershed territories. For the WOs and their collaborative networks to have a wider and more sustained impact in their watershed territories, the majority of interviewees acknowledged that it is crucial for the WOs to develop a more embedded and persistent leadership across different levels and scales through their stakeholder networks. These findings are in line with findings from earlier studies on BOs and their role in knowledge co-creation [10,52,64,78]. For BOs to truly enable and be in support of knowledge co-creation, their collaborative networks must be self-organizing and decentralized, with many hubs, shared leadership, and multiple platforms for connections and communications [78]. Evidence from this study indicates how leadership has played a large part in the success of the WOs in facilitating stakeholder collaborations and developing stakeholder networks. Olsson et al. [37] refer to this as "transformational" leadership that involves the ability and capacity of leaders to recognize opportunities, to identify and transform constraints and barriers, and to span and link key stakeholder groups operating across different levels and scales.

When looking at knowledge co-creation through stakeholder networks as learning networks, the emerging literature of boundary-crossing in the learning sciences discern four mechanisms that constitute the learning potential of boundary crossing [18]. As highlighted earlier in this paper, these mechanisms involve: (a) *identification*, which is about coming to know what the diverse practices are about in relation to one another; (b) *coordination*, which is about creating cooperative and routinized exchanges between practices; (c) *reflection*, which is about expanding one's perspectives on the practices; and (d) *transformation*, which is about collaboration and co-development of (new) practice. Through their diverse collaborative mechanisms, most of the Quebec WOs have been able to facilitate a renewed sense making of different practices and related identities (i.e., identification) through the development of their watershed master plans. Results showed that the majority of stakeholders before the start of their participation in the WOs collaborative networks were not used to a watershed systems thinking approach. Their involvement with the WOs and other stakeholder groups often allowed them to see their role and function in a larger perspective. To a certain extent, the WOs were also able to facilitate new communicative connections and coordinate efforts of translation between diverse stakeholder groups (i.e., coordination). Due to the various constraints and challenges discussed in this paper, the WOs' ability to facilitate "reflection" and "transformation" was, however, hindered.

An important opportunity for further research that has not been explored sufficiently and that may allow the WO to overcome some of their major challenges is the use of ICT to provide ways of easing communications and interactions, while supporting the collective development and sharing of new knowledge [79]. While distances and a geographical spread form a challenge to connect with all key stakeholder groups, more extensive use of ICT provides the WOs and their networks new avenues to share, integrate and develop new knowledge that is informed by diverse knowledge sources and types. Additionally, the use of such innovative tools in support of the development of diverse knowledge "objects" and "spaces" provides also an opportunity to increase the legitimacy of BOs in general and their future work. By including more diverse ways of sharing and creating new knowledge on a more ongoing and frequent basis, in addition to the development of their more "static" five-yearly watershed master plans, the WOs and their collaborative networks can begin to give more emphasis to the perspective of knowledge co-creation as an ongoing and dynamic learning process. Although ICT is still often considered more effective for capturing and integrating explicit knowledge [80], in alleviating some of the practical challenges raised in this study, it may be worthwhile to research in more depth how such tools and technology may support BOs and their collaborative networks in

facilitating more effectively the sharing and development of new knowledge to inform sustainable decisions on a watershed scale.

Acknowledgments: This study was funded by a Social Sciences and Humanities Research Council of Canada (SSHRC) Partnership Development Grant held by Jan Adamowski and contributed to by Nguyen from the McGill University Brace Centre for Water Resources Management.

Author Contributions: Wietske Medema, Jan Adamowski and Christopher Orr conceived and designed the experiments; Christopher Orr and Wietske Medema analyzed the data; and Wietske Medema, Alison Furber, Arjen Wals and Nicolas Milot wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Berkes, F. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. *J. Environ. Manag.* **2009**, *90*, 1692–1702. [CrossRef] [PubMed]
2. Armitage, D.R.; Berkes, F.; Dale, A.; Kocho-Schellenberg, E.; Patton, E. Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Glob. Environ. Chang.* **2011**, *21*, 995–1004. [CrossRef]
3. Edelenbos, J.; Van Buuren, A.; Van Schie, N. Co-producing knowledge: Joint knowledge production between experts, bureaucrats and stakeholders in dutch water management projects. *Environ. Sci. Policy* **2011**, *14*, 675–684. [CrossRef]
4. McDowell, G. The Role of Bridging Organizations in Facilitating Socio-Ecological Transformation: A Case Study of the Great Northern Landscape Conservation Cooperative. Master's Thesis, Environmental Change and Management, University of Oxford, Oxford, UK, 2012.
5. Scott, P.; Arjen, E.J.W. Learning and knowing in pursuit of sustainability: Concepts and tools for trans-disciplinary environmental research. In *Trading Zones in Environmental Education: Creating Transdisciplinary Dialogue*; Krasny, M.E., Dillon, J., Eds.; Peter Lang: New York, NY, USA, 2013; pp. 79–104.
6. Medema, W.; Adamowski, J.; Orr, C.; Wals, A.; Milot, N. Transforming water governance regimes to collaborative adaptive systems: Assessing the capacity for multi-loop social learning in Québec watershed organizations. *Can. Water Resour. J.* **2015**, *40*, 373–391. [CrossRef]
7. Bodin, O.; Crona, B.I. The role of social networks in natural resource governance: What relational patterns make a difference? *Glob. Environ. Chang.* **2009**, *19*, 366–374. [CrossRef]
8. Folke, C.; Hahn, T.; Olsson, P.; Norberg, J. Adaptive governance of social–ecological systems. *Annu. Rev. Environ. Resour.* **2005**, *30*, 441–473. [CrossRef]
9. Allen, C.A.; Fontaine, J.J.; Pope, K.L.; Garmestani, A.S. Adaptive management for turbulent future. *J. Environ. Manag.* **2011**, *92*, 1339–1345. [CrossRef] [PubMed]
10. Wheatley, M.; Frieze, D. *Lifecycle of Emergence: Using Emergence to take Social Innovation to Scale; Feature 1: How Life Creates Radical Change*; Kosmos: Stuttgart, Germany, 2015.
11. Carr, A.; Wilkinson, R. Beyond participation: Boundary organizations as a new space for farmers and scientists to interact. *Nat. Resour.* **2005**, *18*, 255–265. [CrossRef]
12. Schultz, L.; Folke, C.; Olsson, P. Enhancing ecosystem management through social-ecological inventories: Lessons from Kristianstads Vattenrike, Sweden. *Environ. Conserv.* **2007**, *34*, 35–43. [CrossRef]
13. Olsson, P.; Folke, C.; Galaz, V.; Hahn, T.; Schultz, L. Enhancing the fit through adaptive co-management: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike biosphere reserve, Sweden. *Ecol. Soc.* **2007**, *12*, 181–194. [CrossRef]
14. Crona, B.I.; Parker, J.N. Learning in support of governance: Theories, methods, and a framework to assess how bridging organizations contribute to adaptive resource governance. *Ecol. Soc.* **2012**, *17*, 293–303. [CrossRef]
15. Hahn, T.; Olsson, P.; Folke, C.; Johansson, K. Trust-building, knowledge generation and organizational innovations: The role of a bridging organization for adaptive comanagement of a wetland landscape around Kristianstad, Sweden. *Hum. Ecol.* **2006**, *34*, 573–592. [CrossRef]
16. Rathwell, K.J.; Peterson, G.D. Connecting social networks with ecosystem services for watershed governance: A social-ecological network perspective highlights the critical role of bridging organizations. *Ecol. Soc.* **2012**, *17*, 1915–1933. [CrossRef]

17. Kaufman, S.; Smith, J. Framing and reframing in land use change conflicts. *J. Archit. Plan. Res. Theme Issue Collab. Confl. Manag. Des. Plan.* **1999**, *16*, 164–180.
18. Akkerman, S.F.; Bakker, A. Boundary crossing and boundary objects. *Rev. Educ. Res.* **2011**, *81*, 132–169. [CrossRef]
19. Crona, B.I.; Parker, J.N. Network determinants of knowledge utilization: Preliminary lessons from a boundary organization. *Sci. Commun.* **2011**, *34*, 448–471. [CrossRef]
20. Plummer, R.; Armitage, D.R.; de Loë, R.C. Adaptive comanagement and its relationship to environmental governance. *Ecol. Soc.* **2013**, *18*, 21. [CrossRef]
21. Walker, B.H.; Abel, N.; Anderies, J.M.; Ryan, R. Resilience, adaptability, and transformability in the goulburn-broken catchment, Australia. *Ecol. Soc.* **2009**, *14*, 1698–1707. [CrossRef]
22. Regeer, B.J.; Bunders, F.G. *Knowledge Co-Creation: Interaction between Science and Society, a Transdisciplinary Approach to Complex Societal Issues*; VU University Amsterdam: Hague, The Netherlands, 2008.
23. Nonaka, I.; Toyama, R. The knowledge-creating theory revisited: Knowledge creation as a synthesising process. *Knowl. Manag. Res. Pract.* **2003**, *1*, 2–10. [CrossRef]
24. Imperial, M.T. Using collaboration as a governance strategy: Lessons from six watershed management programs. *Adm. Soc.* **2005**, *37*, 281–320. [CrossRef]
25. Lubell, M.; Fulton, A. Local policy networks and agricultural watershed management. *J. Public Adm. Res. Theory* **2008**, *18*, 673–696. [CrossRef]
26. Pahl-Wostl, C.; Kranz, N. Water governance in times of change. *Environ. Sci. Policy* **2010**, *13*, 567–570. [CrossRef]
27. MDDEFP. *Chapitre 3: Interventions Gouvernementales: Gouvernance de L'eau*; Ministère du Développement Durable, de l'Environnement, de la Faune et des Parcs: Ville de Québec, QC, Canada, 2013; pp. 1–24.
28. ROBVQ. *Le Reseau des Organismes de Bassin Verssant du Québec*; Antoine Verville, A.D., Ed.; ROBVQ: Ville de Québec, QC, Canada, 2014.
29. Robins, L. Nation-wide decentralized governance arrangements and capacities for integrated watershed management: Issues and insights from Canada. *Environ. J.* **2007**, *35*, 1–47.
30. Orr, C.J.; Adamowski, J.F.; Medema, W.; Milot, N. A multi-level perspective on the legitimacy of collaborative water governance in Québec. *Can. Water Resour. J.* **2015**, *41*, 353–371. [CrossRef]
31. Weichselgartner, J.; Kasperson, R. Barriers in the science–policy–practice interface: Toward a knowledge-actionsystem in global environmental change research. *Glob. Environ. Chang.* **2010**, *20*, 266–277. [CrossRef]
32. Armitage, D.R.; Plummer, R.; Berkes, F.; Arthur, R.I.; Charles, A.T.; Davidson-Hunt, I.J.; Diduck, A.P.; Doubleday, N.C.; Johnson, D.S.; Marschke, M.; et al. Adaptive co-management for social–ecological complexity. Adaptive co-management for social–ecological complexity. *Front. Ecol. Environ.* **2009**, *7*, 95–102. [CrossRef]
33. Marín, A.; Berkes, F. Network approach for understanding small-scale fisheries governance. The case of the Chilean coastal co-management system. *Mar. Policy* **2010**, *34*, 851–858. [CrossRef]
34. Reed, M.S.; Stringer, L.C.; Fazey, I.; Evely, A.C.; Kruijsen, J.H.J. Five principles for the practice of knowledge exchange in environment management. *J. Environ. Manag.* **2014**, *146*, 337–345. [CrossRef] [PubMed]
35. Sol, J.; Beers, P.J.; Wals, A.E.J. Social learning in regional innovation networks: Trust, commitment and reframing as emergent properties of interaction. *J. Clean. Prod.* **2012**, *49*, 35–43. [CrossRef]
36. Hegger, D.; Lamers, M.; Van Zeijl-Rozema, A.; Dieperink, C. Conceptualising joint knowledge production in regional climate change adaptation projects: Success conditions and levers for action. *Environ. Sci. Policy* **2012**, *18*, 52–65. [CrossRef]
37. Olsson, P.; Gunderson, L.H.; Carpenter, S.R.; Ryan, P.; Lebel, L.; Folke, C.; Holling, C.S. Shooting the rapids: Navigating transitions to adaptive governance of social–ecological systems. *Ecol. Soc.* **2006**, *11*, 18. [CrossRef]
38. Roux, D.J.; Rogers, K.H.; Biggs, H.C.; Ashton, P.J.; Sergeant, A. Bridging the science-management divide: Moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecol. Soc.* **2006**, *11*, 4–23. [CrossRef]
39. Inkpen, A.C.; Tsang, E.W.K. Social capital, networks, and knowledge transfer. *Acad. Manag. Rev.* **2005**, *30*, 146–165. [CrossRef]
40. Argote, L.; McEvily, B.; Reagans, R. Managing knowledge in organizations: An integrative framework and review of emerging themes. *Manag. Sci.* **2003**, *49*, 571–583. [CrossRef]

41. Ansell, C.; Gash, A. Collaborative governance in theory and practice. *J. Public Adm. Res. Theory* **2007**, *18*, 543–571. [CrossRef]
42. Baum, J.A.C.; Calabrese, T.; Silverman, B.S. Don't go it alone: Alliance network composition and startups' performance in Canadian biotechnology. *Strateg. Manag. J.* **2000**, *21*, 267–294. [CrossRef]
43. Dyer, J.H.; Nobeoka, K. Creating and managing a high-performance knowledge-sharing network: The toyota case. *Strateg. Manag. J.* **2000**, *21*, 345–367. [CrossRef]
44. Gupta, A.K.; Govindarajan, V. Knowledge flows within multinational corporations. *Strateg. Manag. J.* **2000**, *21*, 473–496. [CrossRef]
45. Lane, P.J.; Lubatkin, M. Relative absorptive capacity and interorganizational learning. *Strateg. Manag. J.* **1998**, *19*, 461–477. [CrossRef]
46. Yli-Renko, H.; Autio, E.; Sapienza, H.J. Social capital, knowledge acquisition, and knowledge exploitation in young technology-based firms. *Strateg. Manag. J.* **2001**, *22*, 587–613. [CrossRef]
47. Zahra, S.A.; Ireland, R.D.; Hitt, M.A. International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance. *Acad. Manag. J.* **2000**, *43*, 925–950. [CrossRef]
48. Cohen, W.M.; Levinthal, D. Absorptive capacity: A new perspective on learning and innovation. *Adm. Sci. Q.* **1990**, *35*, 128–152. [CrossRef]
49. Reagans, R.; McEvily, B. Network structure and knowledge transfer: The effects of cohesion and range. *Adm. Sci. Q.* **2003**, *48*, 240–267. [CrossRef]
50. Nonaka, I.; Konno, N. The concept of 'ba': Building a foundation for knowledge creation. *Calif. Manag. Rev.* **1998**, *40*, 1–15. [CrossRef]
51. Nadler, J.; Thompson, L.; Van Boven, L. Learning negotiation skills: Four models of knowledge creation and transfer. *Manag. Sci.* **2003**, *49*, 529–540. [CrossRef]
52. Hegger, D.; Lamers, M.; van Zeijl-Rozema, A.; Dieperink, C. Knowledge co-production in climate change adaptation projects: What are the levers for action? In Proceedings of the Colorado Conference on Earth System Governance, Fort Collins, CO, USA, 17–20 May 2011.
53. Nowotny, H. Democratising expertise and socially robust knowledge. *Sci. Public Policy* **2003**, *30*, 151–156. [CrossRef]
54. Lamers, M.; Ottow, B.; Francois, G.; Korff, Y.V. Beyond dry feet? Experiences from a participatory water-management planning case in the Netherlands. *Ecol. Soc.* **2010**, *15*, 14. [CrossRef]
55. Steyaert, P.; Jiggins, J. Governance of complex environmental situations through social learning: A synthesis of slim's lessons for research, policy and practice. *Environ. Sci. Policy* **2007**, *10*, 575–586. [CrossRef]
56. Van den Hove, S. A rationale for science–policy interfaces. *Futures* **2007**, *39*, 807–826. [CrossRef]
57. Nonaka, I.; Toyama, R.; Konno, N. SECI, ba and leadership: Unified model of dynamic knowledge creation. *Long Range Plan.* **2000**, *33*, 5–34. [CrossRef]
58. Nonaka, I.; Takeuchi, H. *The Knowledge—Creating Company: How Japanese Companies Create the Dynamics of Innovation*; Oxford University Press: New York, NY, USA, 1995.
59. Hisschemöller, M.; Hoppe, R. Coping with intractable controversies, the case for problem structuring in policy design and analysis. In *Knowledge, Power and Participation in Environmental polIcy Analysis and Risk Assessment*; Hisschemöller, M., Hoppe, R., Dunn, W.N., Ravetz, J.R., Eds.; Transaction Publishers: New Brunswick, NJ, USA, 2001.
60. Medema, W.; Wals, A.; Adamowski, J. Multi-loop social learning for sustainable land and water governance: Towards a research agenda on the potential of virtual learning platforms. *Wagening. J. Life Sci.* **2014**, *69*, 23–38. [CrossRef]
61. Olsson, P.; Folke, C.; Hahn, T. Social-ecological transformation for ecosystem management: The development of adaptive co-management of a wetland landscape in Southern Sweden. *Ecol. Soc.* **2004**, *9*, 2. [CrossRef]
62. Sandström, A.; Carlsson, L. The performance of policy networks: The relation between network structure and network performance. *Policy Stud. J.* **2008**, *36*, 497–524. [CrossRef]
63. King, A. *Managing Without Institutions: The Role of Communication Networks in Governing Resource Access and Control*; University of Warwick: Coventry, UK, 2000.
64. Nonaka, I.; Von Krogh, G. Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory. *Organ. Sci.* **2009**, *20*, 635–652. [CrossRef]

65. Fernandez-Gimenez, M.E.; Ballard, H.L.; Sturtevant, V.E. Adaptive management and social learning in collaborative and community-based monitoring: A study of five community-based forestry organizations in the western USA. *Ecol. Soc.* **2008**, *13*, 4. [CrossRef]
66. Bierly, P.E.; Kessler, E.H.; Christensen, E.W. Organizational learning, knowledge and wisdom. *J. Organ. Chang. Manag.* **2000**, *13*, 595–618. [CrossRef]
67. Straith, D.; Adamowski, J.; Reilly, K. Exploring the behavioral attributes, strategies and contextual knowledge of champions of change in the Canadian water sector. *J. Can. Water Resour. Assoc.* **2014**, *39*, 255–269. [CrossRef]
68. Dyball, R.; Brown, V.; Keen, M. Towards sustainability: Five strands of social learning. In *Social Learning towards a Sustainable World*; Wals, A.E.J., Ed.; Principles, Perspectives, and Praxis; Wageningen Academic Publishers: Wageningen, The Netherlands, 2007; pp. 181–195.
69. Keen, M.; Bruck, T.; Dyball, R. Social learning: A new approach to environmental management. In *Social Learning in Environmental Management: Towards a Sustainable Future*; Keen, M., Brown, V., Dyball, R., Eds.; Earthscan: London, UK, 2005; pp. 3–21.
70. Avelino, F.; Rotmans, J. A dynamic conceptualization of power for sustainability research. *J. Clean. Prod.* **2011**, *19*, 796–804. [CrossRef]
71. Barnaud, C.; van Paassen, A. Equity, power games and legitimacy: Dilemmas of participatory learning processes. In Proceedings of the 9th European International Farming Systems Association (IFSA) Symposium, Vienna, Austria, 4–7 July 2010; University of Natural Resources and Applied Life Sciences: Vienna, Austria, 2010.
72. Huitema, D.; Mostert, E.; Egas, W.; Moellenkamp, S.; Pahl-Wostl, C.; Yalcin, R. Adaptive water governance: Assessing the institutional prescriptions of adaptive (co-) management from a governance perspective and defining a research agenda. *Ecol. Soc.* **2009**, *14*, 1698–1707. [CrossRef]
73. Gulati, R.; Nohria, N.; Zaheer, A. Strategic networks. *Strateg. Manag. J.* **2000**, *21*, 203–215. [CrossRef]
74. Yin, R.K. *Case Study Research: Design and Methods*; Sage: Newbury Park, CA, USA, 1994.
75. Jacelon, C.S.; O'Dell, K.K. Demystifying nursing research: Case and grounded theory as qualitative research methods. *Urol. Nurs.* **2005**, *25*, 49–52. [PubMed]
76. Thomas, D.R. *A General Inductive Approach for Qualitative Analysis*; University of Auckland: Auckland, New Zealand, 2003.
77. Bakker, K. Governing Canada's water wisely. In *Eau Canada: The Future of Canada's Water*; Bakker, K., Ed.; UBC Press: Vancouver, BC, Canada, 2007; pp. 359–368.
78. Grant, H. *Transformer: How to Build a Network to Change a System: A Case Study of the Re-Amp Energy Network*; Monitor Institute: San Francisco, CA, USA, 2010.
79. Karpouzoglou, T.; Zulkafli, Z.; Grainger, S.; Dewulf, A.; Buytaert, W.; Hannah, D.M. Environmental virtual observatories (EVOs): Prospects for knowledge co-creation and resilience in the information age. *Curr. Opin. Environ. Sustain.* **2016**, *18*, 40–48. [CrossRef]
80. Van der Wal, M.M.; de Kraker, J.; Kroeze, C.; Kirschner, P.A.; Valkering, P. Can computer models be used for social learning? A serious game in water management. *Environ. Model. Softw.* **2016**, *75*, 119–132. [CrossRef]