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Assessing stakeholder impacts and adaptation to low water-levels: the Trent-Severn waterway

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Abstract The Trent-Severn Waterway in central Ontario, Canada, is a large inland water system. It is managed for a broad range of stakeholders with different needs and expectations, creating a complex management context. Although variations in water levels occur, extreme low water-level events may increase in the future due to climate change, challenging management practices, in addition to requiring adaptation to reduce impacts. A modified policy Delphi was used to generate and evaluate ideas related to historical and future water-level impacts and adaptations. The paper presents the perspectives of three groups—cottagers and homeowners (CH), government (G), and industry and business (IB)—on their experiences with historic low water-levels, as well as their perspectives on future impacts and adaptations using two water-level scenarios: a moderate decrease of 25 cm and a more severe 50 cm decline. Shared impacts and adaptations (individual and collective) were identified along with those that were unique to a group. The likelihood of and consensus on potential impacts and most adaptations increased with the severity of water-level reduction. All groups indicated a higher likelihood of using collective rather than individual adaptations with the severe scenario, and in some cases, their contacts for assistance with adaptation broadened. While the modified policy Delphi requires significant effort by the analyst and respondents, it

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provides a useful framework for generating and analyzing perceptions and preferences of diverse stakeholders.

1 Introduction

Stretching 386 km from the Bay of Quinte on Lake Ontario to Georgian Bay, the Trent-Severn Waterway (TSW) is made up of a series of lakes, rivers, and canals, some of which are managed by structures such as locks and dams. Originally designed in 1833 as a transportation link between Lakes Ontario and Huron, today it is a National Historical site. Parks Canada manages the system to meet the needs of diverse stakeholders, including cottagers, homeowners, recreational boaters, marina and resort operators, anglers, and government agencies (Parks Canada 2008). They have divergent expectations for water resources management including public safety, municipal water supply, flood control, tourism, recreation, hydro-electric power generation, and environmental conservation. This creates a complex, and potentially contentious, water management (WM) context (Parks Canada 2007; 2008).

Seasonal, inter-annual, and inter-decadal fluctuations in water-levels and changes in streamflow are a natural phenomenon in the Trent-Severn watershed (TSws) and define a hydrologic regime to which stakeholders and managers within the watershed are habituated. However, climate change (CC) has the potential to significantly alter this regime affecting water availability. Low-water situations are likely to increase in frequency and intensity, challenging water users' expectations and current WM practices (Bates et al. 2008).

Assessments of CC in the Great Lakes Basin have projected reductions in net basin water supplies (Mortsch et al. 2006; Angel and Kunkel 2010) with impacts on navigation, recreation, power generation, water quantity and quality, and aquatic ecosystem health (Mortsch et al. 2006; Schwartz et al. 2004; Trumpickas et al. 2009; Millerd 2011). Similar assessments of CC impacts on the TSws have demonstrated the potential for lower streamflow and lake-levels (Walker 1996, 2001; MacRitchie and Stainsby 2011; Chu 2011).

The article explores the potential impacts of water-level reductions on stakeholders of the TSW and the adaptations they are likely to undertake. A modified policy Delphi approach was used to generate information on impacts experienced by three groups (cottagers and homeowners (CH), government (G) and industry and business (IB)) under historic low water-level conditions and adaptations undertaken. Two synthetic water-level scenarios—decline of 25 cm (moderate) and 50 cm (severe)—were used to elicit perspectives on potential impacts and adaptation to future water-level reductions. Stakeholder groups were characterized as "agents of adaptation" by finding similarities and differences on the impacts and adaptations (individual or collective) identified; assessing whether the responses were different under historical conditions or two more severe scenarios; and gaining insights into how the process of adaptation may unfold with respect to WM.

2 Hydrology of the Trent Severn Waterway (TSW)

The TSW includes two watersheds: the Trent River watershed (TRws) which drains south into Lake Ontario, and the Severn River watershed which empties into Georgian Bay (Fig. 1). The waterway utilizes 44 locks, 160 dams, and 41 reservoir lakes to maintain water-levels for a diverse range of users (Parks Canada 2007; 2008). Other stakeholders, with diverse water-level

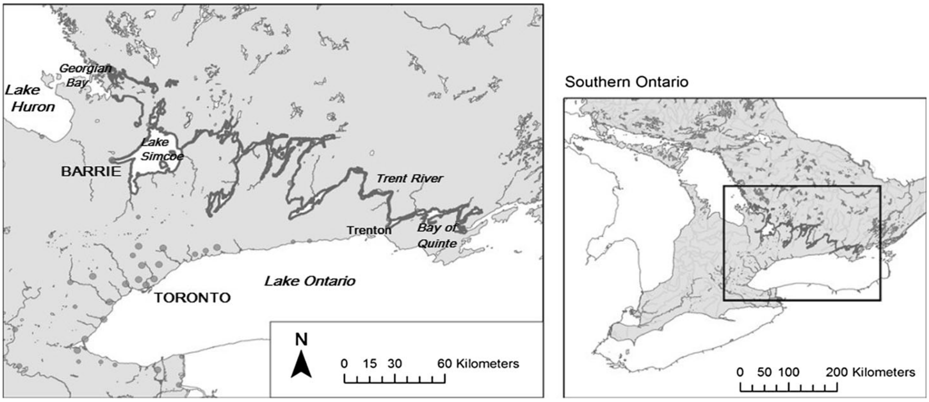

Fig. 1 Trent-Severn waterway map (Parks Canada 2008)

expectations and requirements, also rely on this system. This research focuses on the 12,200 km^2 TRws that stretches from Algonquin Park to Lake Ontario (Parks Canada 2011). The region's abundance of lakes and rivers in a natural setting, as well as its proximity to major urban centres in southern Ontario has resulted in the creation of a substantial water resources based industry crossing many sectors of the economy and multiple government jurisdictions. The water resources in this system are of importance to a variety of other stakeholders, who have varying, and sometimes contrasting, needs.

The hydrologic regime of the TRws is characterized by seasonal conditions: high levels and flows during the spring freshet with a progressive decline throughout summer and autumn to a minimum in winter. Water-levels and flows in the region are managed by removing or adding stop logs or opening dams when required; seasonal decisions to store or release water are based on rule curves. When establishing water-levels and flows, Parks Canada seeks to balance the collective needs and requirements of all water users. During the summer season, Parks Canada ensures that there is sufficient water for navigation and during the autumn and winter that water levels are low enough in lakes and reservoirs to provide storage for the spring snowmelt (Parks Canada 2007; 2008). Although water users have become habituated to this water level regime, CC could shift the timing of seasonal water availability and lower water-levels in the system. This could impact water users and may require adaptation—changes to current practices by all water users to reduce negative impacts.

3 Climate change impacts and adaptation

3.1 Hydrologic impacts

Increases in air temperature and decreases in precipitation are projected to change the hydrology of the TSW and reduce water-levels (Chu 2011; MacRitchie and Stainsby 2011). The foundation for this research stems from two CC impact assessments of the Bay of Quinte watershed (Walker 1996, 2001). An early hydrologic impact assessment developed a CC scenario from the Canadian Climate Centre (CCC) Global Climate Model (GCM) double carbon dioxide (2xCO_2) run, which projected decreases in precipitation and temperature increases, ranging from 1.6 to 9.6 °C (Walker 1996). Annual runoff into the Bay of Quinte decreased by 12% while runoff in the Trent River sub-watershed decreased by 9%. The hydrologic modelling also demonstrated the potential for major shifts in runoff during the hydrologic year. The winter runoff regime could change from low flow with snow stored on the ground followed by a spring snowmelt and freshet to a pattern where winter snowfall is partly replaced by rain resulting in more frequent winter runoff events, a reduction in snowpack and minor spring freshet. Summer and autumn low flows were projected to increase in frequency and duration. In a subsequent study, Walker (2001) developed CC scenarios from the Canadian Centre for Climate modelling and analysis (CCCma) Coupled Global Climate Model 2 (CGCM2) run (IS92a emission scenario) for the 2030s, 2050s, and 2090s. Annual flows declined and projected decreases were most severe for summertime flows due to reductions in summer rainfall, warmer air temperatures, and slightly higher potential evapotranspiration. For the 2050s scenario, annual and summer flows to the Bay of Quinte were reduced by 9 and 22%, respectively, and in the Trent River by 18 and 27% respectively. These climate-induced reductions in water supply suggest potential vulnerability amongst stakeholders as streamflow and lake-levels decline, particularly during the high use summer period.

3.2 Adaptation

Adaptation is necessary to reduce the impacts of CC since it is a process of adjustment to actual or expected climate and its effects (Noble et al. 2014). It needs to be “mainstreamed” into policy, planning and practice (Field et al. 2007), requiring the assessment of adaptation needs and building of adaptive capacity (Tompkins et al. 2010). The context for adaptation decision making is very complex: numerous human systems are affected across a range of spatial scales, requiring multiple stakeholders (e.g., individuals, business, government) to identify risks and vulnerabilities, and implement solutions across jurisdictions with varying levels of capacity (Berkhout 2005; Dovers and Hezri 2010; Tompkins et al. 2010).

Early assessments of CC impacts and responses used top-down approaches focused on determining changes in the climate system and how these translated to biophysical impacts and then cascaded to socio-economic implications (Dessai and Hulme 2004). A growing need to understand socio-economic responses to CC and the capacity to adapt lead to local or regional studies exploring the vulnerability of individuals and groups to current and future climate–a bottom-up approach (Jones et al. 2014). Combining the approaches can provide insight into opportunities and constraints for adaptation (Mastrandrea et al. 2010). Issues addressed include complex contextual effects (e.g., interrelated physical, institutional, legal, managerial, cultural), thresholds of exposure, identification and evaluation of adaptation needs, factors constraining the capacity to adapt and the implementation of adaptation options (Dessai et al. 2005; Birkmann et al. 2010). The process of engaging individuals, organizations, and governments has become central to adaptation decision making, as well as integrated WM (Lebel et al. 2010; Howe et al. 2013; Jenni et al. 2014; Noble et al. 2014).

Stakeholder engagement in CC assessment advances adaptation as it builds trust in and legitimacy of the process, integrates information from different perspectives, uncovers interactions and conflicts, encourages social learning and engenders adaptive capacity (Lebel et al. 2010). Stakeholders involved in the adaptation process have unique insights into the subtleties of the local context–the interplay between local and external conditions, actors and power, roles and responsibilities–that technical experts often lack (Birkmann et al. 2010; Howe et al. 2013). Linking local knowledge with expert knowledge can improve chances of successful adaptation as it increases relevance to individuals and communities.

Various scales of adaptation exist including individual and collective (de Loë et al. 2001). Individual cognition, perception, and interpretation play an important role in defining uncertainties, vulnerability, risks and adaptation needs. These influence individual decisions and are reflected in the actions stakeholders carry out on their own initiative relying on their adaptive capacity (e.g., knowledge and financial resources) (Berkhout et al. 2006; Boyer et al. 2012; Howe et al. 2013). However, decision making with respect CC can also occur collectively (Marx et al. 2007). How individual perspectives aggregate to collective adaptation needs and how adaptation options are deemed appropriate and legitimate for groups are important issues.

4 Methods

Various methodologies and decision-facilitation tools have been used to involve stakeholders in exploring: adaptation needs following from impacts identification and adaptation options through subjective assessments. Examples include: risk ranking (Howe et al. 2013), scenario planning (Peterson et al. 2003), interviews (Disch et al. 2012), workshops (van Slobbe et al. 2014), focus groups, multiple evaluative criteria (Lennox et al. 2011), and modified policy Delphi technique (de Loë et al. 2001; Lemieux and Scott 2011). This paper explores individual and collective adaptations to CC and water-level reduction in an inland water system. This approach provides new insights on stakeholder perceptions of impacts and adaptations, and the adaptation processes.

The policy Delphi technique is a group-oriented idea generating strategy (IGS) designed to produce, collect and identify both consensus and disagreement on issues. Using a multi-round surveying process, the technique is an iterative, interactive and anonymous way of polling people with different backgrounds, expertise and interests to assess options for an issue or explore values and opinions (Turoff 1975; Linstone and Turoff 2002; Gordon and Pease 2006; Franklin and Kart 2007). This method solves some of the limitations faced by traditional workshop processes including lack of time for reflection, participants' reluctance to speak or poor verbal communication skills, and dominance of the proceedings by one or more persons. The original policy Delphi technique proposed by Turoff (1975), which consisted of a six-stage process with rounds of surveys in each stage, was adjusted to reduce the duration of the process and analysis effort into five stages compressed in two-round surveys to generate and evaluate ideas relating to historical and future water-level impacts and adaptations (Appendix, Fig. 1). This would allow for the identification of commonalities and areas of potential conflict, and a further understanding of the adaptation process.

A policy Delphi approach has been used in some studies, proving that this method is a popular tool for identifying and prioritizing issues for better decision-making. For instance, de Loë (1995) investigated stakeholders' responses to CC impacts on water resources in the Grand River Basin, Ontario, and demonstrated the appropriateness of the technique for assessing impacts and adaptations. Lemieux and Scott (2011) evaluated the positions, priorities and challenges of adapting to CC for agencies responsible for managing natural protected areas. Taylor and Ryder (2003) use this method to determine fisheries' water and lake-level requirements in an interstate basin, and pointed out the advantages of this technique to assess expert opinion and generate agreements. As any other method, it has benefits and limitations. Some of the benefits are: reducing the influence of dominant personalities, and avoiding face-to-face debates (de Loë 1995). An important limitation of this method is related to the importance of the questions asked on the first questionnaire, which influence the remaining questionnaires. In addition, this method is very demanding for both respondents and researchers.

4.1 Water-level conditions

The water-level scenarios used in this survey were based on CC assessments that projected lower flows in the TRws (Walker 1996, 2001). The first scenario (moderate) assumed a water-level drop of 25 cm below the mean water-level at any given location in the TRws for a 1-year period. The second scenario (severe) considered a water-level decline of 50 cm. For each scenario, respondents were asked to think about how they would be affected by a water-level reduction of this magnitude at their location. Potential impacts or benefits they might experience from each scenario were also recorded, and they had to identify what adaptation they would undertake to respond to impacts and whom they might contact (if anyone) for assistance to address them.

4.2 Stakeholder group selection

Potential stakeholder groups were drawn from a CC literature review, identifying those sectors that could be affected by low water-levels in the TSW. The needs of these stakeholders include the use of water for household consumption, recreation, wildlife preservation, hydroelectric power generation, irrigation, and aesthetic and cultural appreciation. The surveys were sent to the representatives of these organizations, including; cottagers, anglers, environmental organizations, marina and other private facility owners, and government agencies. Tourists to the region are transient, and not amenable to being incorporated in a two-round survey.

The original list of stakeholder groups was extensive (Table 1), but Turoff (1975) suggested that ten to fifty respondents were sufficient to gather information on differing positions on an

Table 1 Classification of stakeholder groups and number of respondents by round-survey

Combined stakeholder groups	Original stakeholder groups	Number of stakeholders surveyed	Number of responses round one	Number of responses round two
Cottagers and Homeowners (CH)	• Homeowners or Permanent Residents • Cottagers or Cottagers' Association	47 30	15	12
Government (G)	• Provincial Agencies • Conservation Authorities • Municipal Government • Federal Agencies (e.g., Parks Canada)	25 9 30 7	23	13
Industry and Business (IB)	• Resort and Tourist Operators • Marina Operators • Hydro-electric Company • Chamber of Commerce	16 43 8 3	20	15
Other groups	• Hunter and Angler Associations • Golf Course Operators and Summer Camps • Environmental Organizations • Native Organizations	16 9 12 7	2	0
	Total	262	60	40

issue. Therefore, to have the minimum required number of respondents, the original respondent groups were combined based on their similarities (e.g., water use priorities and water level preferences) into three broad groups: cottagers-homeowners (CH), government (G), and industry-business (IB).

4.3 Survey implementation and analysis

The flowchart in Fig. 2 outlines the stages of the modified policy Delphi process, as well as the organization, objectives, content of the questions, and analysis used in this study. The first-round surveys were sent to 262 respondents. One year later, the second-round surveys were sent out to the 60 respondents that returned a completed first-round survey (see Table 1 for response rates).

4.3.1 First-round survey: defining the main problem

The first-round survey utilized mostly open-ended questions to elicit impacts and adaptations to water-level reductions in the watershed based on historical experience (the past 10 years) and two future "what-if" water-level scenarios. Respondents rated 15 water concerns during the past 10 years (e.g., shoreline erosion, poor drinking water, navigation hazards, high and low water-levels, and floods) from very important (1), important (2), slightly important (3), and unimportant (4). Respondents were also asked about their location within the study area, and the time of year they use the watershed.

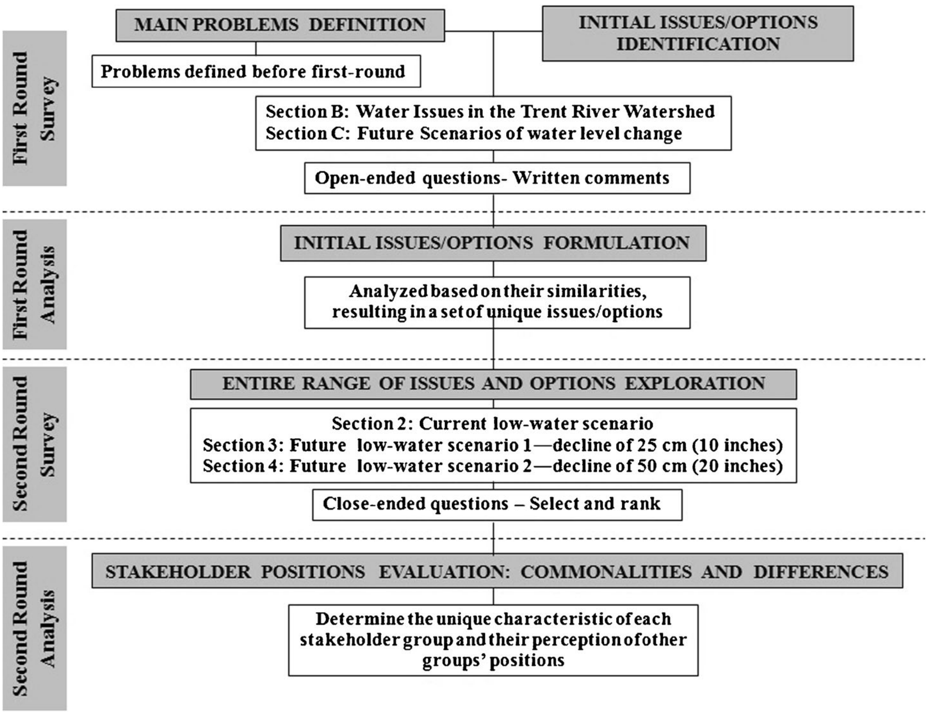

Fig. 2 Modified policy Delphi survey framework to assess low water-level impacts and adaptations in the TSW

4.3.2 First-round analysis: formulation of initial issues and options

In the analysis of the first-round survey, low-water levels emerged as the dominant concern in the watershed (62% of stakeholders). Respondents identified 49 impacts and 83 adaptations to historical low water-levels; 98 impacts and 61 adaptations for a future moderate water-level reduction of 25 cm; and 82 impacts and 32 adaptations for a future severe water-level reduction of 50 cm. These statements were grouped based on similarities into nine unique impact statements and 22 individual and 8 collective adaptation responses that were used to create close-ended questions for the second-round instrument. Responses to historical impacts and adaptations were not assessed using consensus, likelihood or polarity metrics, but the number of yes or no answers was counted. If more than 50% of the stakeholder group selected the impact as one that they had experienced, this impact was considered important; the same criteria was used for the adaptations. Only questions with a response rate higher than 50% in each group during the first-round survey were included in the second-round survey.

4.3.3 Second-round survey: exploring commonalities and differences

In the second-round survey, respondents were presented with a list of stakeholder-reported historical and future impacts and adaptations synthesized from the first-round instrument. Using the context of either a 1-year moderate (25 cm) or severe (50 cm) water-level drop, respondents had to determine which impacts they were likely to experience and the adaptation actions they might undertake. The impact areas included navigation and boating, docks and/or docking, tourism, aquatic species, recreational experience, water availability, the environment, economic, and power generation.

Adaptations were framed as individual or collective. Collective adaptation required that the respondent identify who they might contact, if anyone, for assistance in adapting to low water-level impacts. The contacts included: Parks Canada-TSW; friends, family, and neighbors; municipal government; government agencies other than Parks Canada; local environmental groups; industry or hydro; cottager groups; and no one. These impacts and adaptation options were ranked on a likelihood continuum ranging from very likely (VL), likely (L), unlikely (UL), and very unlikely (VU). The scale did not have a neutral option requiring respondents to make a clear decision.

4.3.4 Second-round analysis: evaluating commonalities and differences

In the second-round analysis, characterizations of the stakeholder groups were developed by combining individual likelihood rankings into a rating distribution using a method developed by de Loë (1995). Consensus, likelihood and polarity (differences) within the group were defined with respect to positions on an impact or adaptation to future water-level scenarios. The level of consensus was determined by the percentage of respondents in a group that accepted an impact or adaptation statement (e.g., L or UL). For high consensus, 70% of the ratings in a stakeholder group had to be in one category or attain 80% in two contiguous categories (e.g., VL–L or U–VU). In the medium and low consensus categories, 60% of ratings had to be in one category or 70% in two adjoining categories, and 50% in one category or 60% in two, respectively. Blank or non-responses (NA) were not included when calculating consensus. When consensus occurred, then likelihood was determined by the clustering of ratings. Likelihood categories included very likely (VL), very likely to likely (VL-L), likely

(L), unlikely (U), unlikely to very unlikely (U-VU), or very unlikely (VU). For example, if 80% of the responses to an impact or adaptation were very likely, then a likelihood of VL is achieved with a high level of consensus. Polarity occurred when there was no consensus on a question and there were opposing likelihood ratings.

5 Results

In the round-one survey, respondents identified their top water uses (Table 2). Recreational water use was common to all groups and reflects the dominant use of water in the region. CH and BI also shared boating/navigation and docking/marina operation as top uses. Marina and resort operator respondents dominated the IB group and the results reflect this. Therefore, maintaining streamflow for hydro-power generating, likely critical to the IB hydro-power members (1 of 8 responded) was not identified as a priority use. This situation may influence the reporting of adaptations as well. However, a threshold was established which required 50% or more of the respondents in a stakeholder group to select an impact or adaptation for it to be reported. For the G group, top uses were different and focused on resource management activities such as environmental preservation and both wildlife and water management.

5.1 Historical impacts and adaptations to low water-levels

Respondents estimated water-level declines experience at their location in the watershed during the past 10 years. The range reported was 10 to 80 cm, although the majority calculated a decrease between 10 and 20 cm. Based on their recent historical experience, respondents identified their impact areas and implemented adaptations from a list. Results by stakeholder group are summarized in the Appendix (Table 1). Shoreline impacts were common to all groups while power generation and economic impacts were not reported by any group.

CH identified the most impacts, which aligned with their top water uses. Yet, their adaptations were simple and focused on shoreline and water availability effects: individual actions such as moving docks into deeper water, lowering docks during the boating season, and moving water intake lines into deeper water. More costly measures such as building a new dock or dredging were not considered by CH.

The G group identified only three important impacts related to environmental management and did not include their other important uses (e.g., water supply and recreation). Their adaptations were collective; for example, they were likely to contact and work with other

Table 2 The top water uses identified by stakeholder group

Stakeholder group	Top water uses (ranked in order of importance)	
Cottagers-Homeowners (CH)	1. Recreation 2. Boating/Navigation 3. Docking/Marina Operation	4. Environmental Preservation 5. Water Consumption
Government (G)	1. Environmental Preservation 2. Wildlife/Environmental Management 3. Water-level Regulation	4. Recreation 5. Municipal Water Supply 6. Human Water Consumption
Industry-Business (IB)	1. Boating/Navigation 2. Recreation 3. Docking/Marina Operation	

government agencies (e.g., the Ontario Ministry of Natural Resources) to address aquatic species and environmental impacts. This group indicated that their adaptation options were likely to include informing the community about impacts but were not likely to include engaging with local environmental groups or CH organizations to address impacts.

IB reported the fewest impacts due to historical low water-levels. Key areas such as shoreline impacts and docking were identified but not impacts related to other top water uses such as boating and navigation. These stakeholders did not report economic impacts to low water-levels. Recent historic low water-levels may not have been severe enough to create economic issues or Parks Canada operation of the TSW may have successfully managed water levels to minimize impacts. Adaptation for this group was limited and the only option considered involved contacting Parks Canada for assistance.

5.2 Impacts and adaptation for scenarios of future water-level reductions

The impacts identified by stakeholder groups and adaptation responses they are likely to implement for a moderate and severe water-level scenario are summarized in the Appendix (Tables 2 and 3); these include details on levels of consensus, likelihood, and polarity.

5.2.1 Moderate water-level reduction (25 cm)

The moderate water-level scenario is similar to the water-level reduction reported for the historical assessment, but the list of impacts expanded from 2 to 7, and from 2 to 6 for G and IB, respectively. For CH the list of impacts decreased (Appendix, Table 2). CH identified navigation and boating, aquatic species, and environmental impacts as VL or L with a high level of consensus, and also included a new VL negative consequence on recreational experience but with low consensus. This group was equally likely to use individual (e.g., build a longer dock) or collective (e.g., contact Parks Canada) adaptations, but there was higher consensus for simple and not expensive individual actions (e.g., warn other boaters about hazards and reduce the number of fish caught). CH may use these options since they may not have the material, economic, or jurisdictional capabilities for more elaborate adaptations (e.g., getting permission to dredge). These stakeholders were most likely to contact Parks Canada for collaborative adaptation assistance, except for impacts on aquatic species where no cooperative responses were identified. For impacts on the environment and on docking, the group indicated that they would be likely to contact other cottagers or cottager associations.

For the moderate scenario, the G group expanded the list of VL-L impacts from the historical (shoreline, aquatic ecosystems, and the environment) to include tourism, recreation, water availability and economic impacts, but the level of consensus was medium or low. Overall, the G group was more likely to use collaborative adaptations and seek help from other government agencies with different jurisdictional authority and capacities than use individual adaptation. Many of their individual adaptations related to communication and serving the public good; for example, posting warnings or hazard notices to cope with navigation and boating impacts and advising the public about water supply and allocation problems.

Many IB stakeholders were resort or marina operators and they anticipated impacts on recreation and tourism. Many of the issues identified for the future scenario were the same as the historical assessment. IB indicated they were likely to tailor adaptation (individual or collective) to the impact. Water-based recreation and associated infrastructure are integral to their livelihoods; thus, IB stakeholders focused on individual adaptations for dock and navigation impacts that maintained business activity and revenues with minimal costs such as warning boaters about new hazards and re-arranging their docking system rather than building a new dock or removing docks earlier in the season. However, adaptations for recreation and tourism impacts were broader in scope and more costly, and included relocating/modifying recreational areas, dredging, starting an environmental awareness campaign, and increasing tourism marketing. This group was likely to contact only government agencies for assistance on adaptation, being the most frequent contact Parks Canada. They were unlikely to contact other IB stakeholders to initiate collective adaptation; perhaps they wanted to maintain a competitive advantage and protect their economic interests and business activities. There was some sensitivity toward environmental awareness campaigns since they might discourage visitors to the area and increase economic impacts.

5.2.2 Severe water-level reduction (50 cm)

Many of the impacts identified under the more severe scenario were similar to the moderate scenario. However, all stakeholder groups determined that there was greater likelihood of impacts with greater consensus within a group (Appendix, Table 2). IB and CH judged most impacts as VL while G stakeholders were more conservative in assigning likelihood. G and CH stakeholders each identified an additional VL impact area.

CH added docking as an impact area, and they had the strongest adaptation responses (lowest non-response rate) for navigation and boating and water availability impacts (Appendix, Table 3). A likely adaptation for navigation and boating impacts would be to warn boaters about new hazards in the lake, but respondents also indicated that they would change their behaviour (e.g., modifying where they boated). Some indicated they might stop boating entirely (polar response). CH expanded their contacts for assistance with adaptation. In the moderate scenario they relied on Parks Canada, but in the more severe scenario they would also seek help from friends, family and neighbors; cottagers associations; municipal and other government agencies, and local environmental groups.

Eight of nine impact areas excluding docking emerged with consensus for the G group (Appendix, Table 2). The majority of the adaptations identified as VL were collective, but individual actions for navigation and boating, aquatic species, water availability, and environmental impacts were also mentioned by respondents (Appendix, Table 3). Adaptations included: keeping the canal route navigable as long as possible by using water from upstream "reserve" lakes or re-evaluating operations; controlling dam output and maintaining water-levels to cope with aquatic species impacts; informing the population about water availability problems; and promoting environmental awareness campaigns. Under this severe scenario, government agencies continued the collaboration and communication amongst themselves, but they also were likely to interact with cottager associations and environmental groups to address environmental issues. They were polarized with respect to adaptations such as advertising and marketing for tourism impacts.

IB did not identify any additional impacts for the more severe scenario (Appendix, Table 2), but all impacts became VL with a high consensus. Under a severe water-level reduction, this group broadened the collective adaptations (more contacts with others for help to address the problem) but also increased the number of individual adaptations (Appendix, Table 3). New individual adaptations included reducing the number of fish caught for aquatic issues, or closing down their business; these responses were reported as VU under the moderate scenario. Other individual responses included warning boaters about new hazards for navigation and boating impacts; re-configuring their docking system; increasing tourism marketing, and taking legal action to address economic impacts (L-VL, medium consensus). However, "contact various agencies to express concerns" was a dominant collective adaption for all impacts for IB. Parks Canada was the most common contact for assisting with adaptation, although other groups (such as municipal and other government agencies) were identified as the dominant contact when the impacts related to their mandate (e.g., water availability issues). IB stakeholders were VU to collaborate with local environmental or cottagers groups on adaptation to address recreational impacts.

6 Discussion and conclusions

The modified policy Delphi method allowed for the subjective assessment by stakeholders of impacts and adaptations. The iterative process facilitates the collection and analysis of perceptions and preferences of diverse stakeholders. The patterns that emerge provide insights on key impacts and prevailing adaptations, as well as identify where there may be divergent or contentious adaptation options signaling potential conflicts or barriers. This information can facilitate the adaptation process and initiate thinking on how to accommodate stakeholders' divergent adaptation needs. The method, however, is time consuming and very demanding for both the researcher and the respondents. For researchers, implementing a multi-round survey involves several phases, including writing, editing, coding, and analyzing at least two-round surveys. For respondents, the process requires answering many open-ended and close-ended questions in multiple rounds. This may have led to respondent fatigue and the large number of non-responses. In addition, the survey design required that respondents choose an impact or adaptation and there was no neutral response (e.g., do not know or not applicable); this also may have contributed to the non-responses. In the future, instruments addressing impacts and adaptation issues would benefit from including "do not know" or "not applicable" options to clearly articulate the respondents' thinking.

In general, the key impacts identified by stakeholder groups matched with their top water uses. The likelihood and degree of consensus on impacts and adaptations increased from the moderate to the severe scenario. The CH and IB group were equally likely to use individual and collective adaptations under a moderate water-level decline, but the G group preferred collective adaptations. All stakeholder groups were more likely to use collective responses to deal with the severe water-level scenario. Under a moderate water-level decline, the adaptations selected by CH and IB suggested that they were relying on their adaptive capacity—their knowledge and financial resources with minimal interaction with others. Under the 50 cm water-level reduction, the severity of the water-level impacts may have been perceived by the respondents as reducing their capacity to adapt, and they realized they would need to contact others and use collaborative networks to address the issues more broadly. Government agencies were identified as the primary sources of assistance with adaptation for the IB and CH stakeholders. For CH, Parks Canada was the exclusive contact to address navigation, recreation, aquatic impacts and the primary one for environmental issues in the moderate scenario. With the more severe scenario, CH broadened their sphere of contacts to include friends and family, municipal government, and other government agencies. IB stakeholders also considered Parks Canada the primary agency for assistance in adaptation related to navigation, docking, recreation, tourism, and aquatic species impacts, but shifted to other government agencies for economic impacts. The G group did not identify Parks Canada as the primary contact for assistance but drew upon a broader range of organizations including municipalities, other government agencies, environmental groups, and cottage associations depending on the nature of the impact. Since Parks Canada was identified as the dominant, if not exclusive contact for much adaptation assistance by the IB and CH stakeholders, it signals their high expectations for Parks Canada in dealing with resource management issues related to future water-level impacts. Stakeholders ascribe a major role and many responsibilities for the agency with the potential to overwhelm its capacity. For Parks Canada, it may be beneficial to undertake some proactive adaptation planning, using low water scenarios, and consider how divergent stakeholder needs may be accommodated in the adaptation process. This may lead to a more informed, resilient community.

Changes in the viability/acceptability of an adaptation or a potential conflict within a stakeholder group on how to adapt (the likelihood of measures being used) can be signaled by changes in polarity. It also can highlight areas that may require facilitation to overcome an obstacle to adaptation. For example, dredging as an adaptation to low water-levels can be contentious. This study shows that the viability of dredging changes as the water-level scenario becomes more severe. For the CH group, in the moderate scenario there is polarization on use of the measure while for the severe scenario it becomes a L-VL consideration. In the moderate scenario, G stakeholders indicate they are VU (high consensus) to consider dredging as an adaptation, but with a severe water-level scenario the use of the measure is polarized. The IB group view dredging as an option in both water-level scenarios but changed from L-VL (low consensus) to VL (medium consensus). This shift in likelihood of an adaptation response and consensus illustrates that for each stakeholder group there may be different water-level thresholds where perception of the acceptability of an adaptation measure could change.

This research has contributed to our understanding of stakeholders who use the TRW and the types of impacts they perceive and are likely to experience when water levels are low, both currently and in the future, in addition to the different adaptations they are likely to use. The policy Delphi approach was a useful, albeit labour-intensive, methodology for generating new ideas on these topics, which can be used to characterize stakeholder preferences and positions, and inform planning on adaptation in the TSW.

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