Environmental Governance Indicators in Theory and Practice: Applying the OECD's Water Governance Indicators in the Great Lakes Region

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Abstract:
Environmental indicators have been used for decades by scholars and practitioners to deepen our understanding of how well policy regimes achieve their goals. Some of these indicators are general 'state of the environment' indicators and others are issue specific. In the past decade there has been a growth in the development of water governance indicators to address what is considered a current or pending water governance crisis in many water systems. This article presents findings from research that applies the OECD's water governance indicators to the complex, transboundary, environment and water policy regime in the North American Great Lakes region. The article concludes with reflections on the insights that can be gained from using water governance indicators but also the theoretical and methodological challenges of moving forward with policy research that uses environment and water governance indicators.

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Introduction

> *"If one were to gaze intently into water resource research, much of the universe of public policy studies would be found reflected there"* (Godwin, Ingram and Mann 1985, 349)

This quote still holds true today. Policy scholars and interdisciplinary scholars from several fields have long recognized the unique complexities and uncertainties associated with water policy research. After decades of policy development, implementation and regime maturity, there is growing interest in research related to improving policy outcomes and regime effectiveness. From this body of work has emerged a growing concern in both developed and developing countries that policy regimes at the interface of climate change, water, and ecosystem studies involving human and social-ecological systems are not producing outcomes or adapting fast enough to address complex governance challenges.

Related to these concerns, scholarship on water policy has grappled with issues of scale and the transboundary, multi-level, and multi-sectoral dimensions of policy systems. It has long been recognized that water and ecological systems do not align with political jurisdictions or policy-focused sectors. In the past decade there has been a move to embrace uncertainty and complexity in environment and water policy research, and this is evident in both theory and methods being used to study water governance. At the same time there has been a move to try and grapple with complexity through a focus on theory and methods associated with environment and governance indicators. What is interesting and challenging in this context is the paradox between embracing complexity in policy research while at the same time looking to governance indicators to try and assess progress, diagnose policy challenges and improve policy outcomes.

Many scholars and practitioners are trying to assess whether current policy regimes are adapting to cope with future challenges, and trying to understand how assessment of existing policy regimes can produce better outcomes in the future than have been achieved in the past 50 years. With growing global concern about the environment and water governance, particularly related to climate change, international organizations such as the United Nations (UN) through its Millennium Development Goals (MDGs), and the Organization for Economic Cooperation and Development (OECD) through its water governance programme, have been keenly interested in assessing and promoting better governance. Governance is now considered one of the most significant obstacles for the sustainable management of water as "water crises are primarily governance crises" (OECD 2015a). The challenges are particularly evident in developed countries with mature water policy regimes and governance systems that must adapt to the complexity and uncertainty associated with climate change and other complex socio-ecological contexts.

Scholars and practitioners from a wide range of disciplines and fields doing research 'for' policy, 'about' policy and 'on' policy, focus on governance and policy outcomes at a variety of scales. Traditionally water policy scholars focused on public policies developed within the context of the nation state and comparative analysis across nation states, however, governance research casts the research net quite broadly as scholars and practitioners from a wide range of fields accept the global and international dimensions of public policy and the reality that a wide range of actors and institutions from the public, private, and non-government sectors are involved in collective action and water governance.

This article presents findings from research that applies water governance indicators to the complex environment and water policy regime in the North American Great Lakes region. The first section outlines the theoretical foundations and various research assumptions underpinning environmental and water governance indicators. The second section defines water governance and outlines the evolution of the OECD's water governance indicators. The third section briefly reviews the water governance regime and challenges in the Great Lakes case followed by an overview of the methodology used in this study. In the fourth section, findings from this research are presented. Finally, the article concludes with a review of the findings and some reflections on the theoretical and methodological challenges of moving forward with policy research that uses environment and water governance indicators.

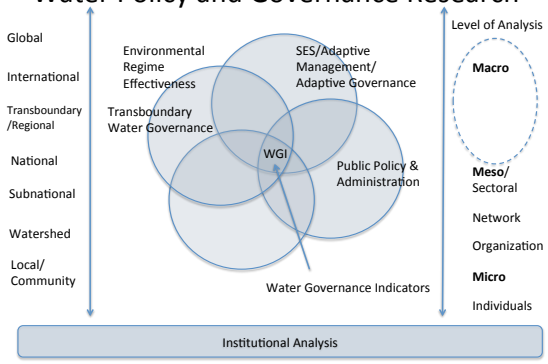
Theoretical Foundations: Environment and Water Governance Indicators

Environmental policy studies have been using indicators for some time in both scholarship and practice based on the theoretical assumption that indicators are valuable for advancing our understanding of environment and water policy and assessing progress on policy implementation. Indicators are intended to provide information for environmental policy related to the extent and nature of environmental degradation, change in environmental outcomes, or performance of policies, institutions and management tools (Bennet & Roche 2000, 24). Indicators are understood as comprising "a variable or some aggregation of variables" – a set of metrics designed to provide information on the state or condition of something and when tracked over time to highlight progress or change (Lorenz et al. 2001, 117). Indicator development involves the construction of clear criteria based on theoretical conceptual links between problems and solutions and clearly constructed quantitative and qualitative methodologies based on these links. The challenges, limitations and hazards of environmental indicators are well-recognized (Dale and Beyeler 2001; Barnett at.al. 2008) yet demand for indicator research is increasing as jurisdictions and policy makers try to use evidence to determine and prioritize collective efforts and investments.

Several decades of scholarly work, practitioner development, and use of environmental indicators provides the theoretical and empirical foundations of water governance indicators. This reflects the fact that policy and water governance research is not just the domain of policy scholars who find their main disciplinary roots in political science but has evolved to include a much broader and interdisciplinary set of scholars and practitioners with interest in research questions about water governance and policy effectiveness. Within environmental policy and water policy research there are several longstanding theories focused on environmental regime effectiveness at various scales from various fields and subfields. As outlined in Figure 1 research on water governance indicators brings several bodies of theory and research together. While space does not permit a fulsome review of each of these literatures, for purposes of this paper we focus on those that share some foundations in institutional theory.

Figure 1: Theoretical Foundations

Water Policy and Governance Research



In addition to policy scholars who have focused on water governance in public policy and public administration, there are other subfields in political science and other disciplines focused on research questions related to policy regime effectiveness. With the proliferation of international organizations and the signing of many international environmental agreements, there was growing interest by international relations scholars in international regimes designed to address environmental problems. This literature focuses on the role of states within these regimes as the primary actor and the international agreements and soft law under which nation states hold primary responsibility for outcomes (Stokke, 2012). Some of this literature focuses on central theme of water conflict and cooperation, hydro-hegemony, water security, hard vs. soft international environmental law, and water justice (Wolf 1998; 2002, Young 2001, 2002, 2003; Miles et.al. 2002; Breitmeier, Young, and Zurn 2006; Mitchell 2006; Dombrowsky 2008; Zeitoun et.al. 2014). The focus is on assessing the degree to which environmental regimes at the international, transboundary and nation-state scale are achieving the policy objectives set out in bilateral or multilateral agreements with regime performance as the dependent variable (Frantzi 2008). Some have used case studies and comparative regime studies. Others have used the Oslo-Potsdam method which combines an assessment of the current state of the resource being governed, an assessment of the contribution of the regime to that current state, and a counter-factual estimate of what the state of the resource would be if the regime did not exist (Underdal 1992; Helm and Sprinz 2000; Dombrowsky 2008; Johns, Thorn and VanNijnatten 2016). In addition, there is some scholarship that is very critical of the use of 'objective' environmental indicators in global governance (Elgert 2015).

Another long-standing body of scholarship with an interest in questions of environmental governance and water governance focuses on socio-ecological systems (SES), and uses the ecological sciences and social sciences to highlight the challenging dynamics of adaptation and resilience in linked environmental and human systems (Holling 1974, 2001). There are several key assumptions and concepts that flow from the SES literature that have been very influential in water policy and governance research. The literature on Integrated Water Resource Management (IWRM) from this tradition includes numerous articles and some 30 definitions, causing some to conclude that debates about the concept of IWRM "have reached a stalemate in which views are polarized and further conceptual elaboration has stopped" and "the international water policy community has

shifted towards new policy concepts" (Mukhtarov and Gerlak 2014, 103). IWRM has been criticized as being too grounded in engineering, management, hydrology and organizational science, and not enough in other social science fields that focus on power and socio-economic context (ibid, 103). IWRM and adaptive management have also been criticized for being difficult to define, observe and measure and too grounded in the assumption that humans can manage complex environmental and water problems (Medema 2008, Biswas 2008, 2010).

However, many of the concepts in the SES and adaptive governance literature provide a set of strategies for designing effective and resilience institutions that can manage complex systems (Dietz et al. 2003), probe the interplay between socio-ecological resilience and human (social) well-being and governance (Armitage et. al. 2012), and include a focus on institutions and network governance structures (Folke etal., 2005; Huitema et.al. 2009; Pahl-Wostl et al., 2010, 2012; Chaffin, Gosnell, and Cosens, 2014; Plummer 2015; Knieper and Pahl-Wostl 2016, Pahl-Wostl 2017). The scholarship on adaptive governance also does include a broader range of formal and informal rules, institutions, and state and non-state actors at operating at multiple levels (Folke et al., 2005; Pahl-Wostl, 2012; Edelenbos, J., & G. Teisman, 2013; Knieper and Pahl-Wostl 2016). As such, *adaptive water governance***,** has been defined by as the "range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services at different levels of society" (Edelenbos and Teisman, 2013, p. 92). These theoretical foundations incorporate a more dynamic and systems oriented approach to water governance research.

In addition to SES and the scholarship on environmental regime effectiveness, there are other interdisciplinary scholars who have focused more specifically on the challenges of transboundary water governance (Earle, Jagerskog and Ojendal 2010; Suhardiman et.al. 2012; Krantzberg and Grover 2019). This group of scholars from disciplines including geography, political science, law, science and engineering also share a focus on research questions related to the improvement of transboundary water governance, policy and management in order to achieve better outcomes. Earle et.al. (2010) include various analytical approaches to transboundary water management, the important role of the water resource community (government, private sector and civil society as implementers), water researchers (international and domestic) and political will, as they argue it becomes difficult for functional cooperation at this level to become more institutionalized as it is often driven by, and dependent on, specific individuals (Earle, Jagerskog and Ojendal 2010, 4). These scholars identified nearly a decade ago the 'need to develop more robust indicators of transboundary cooperation' (Ojendal, Earle and Jagerskog 2010, 247) and move towards more 'process-focused' research on transboundary governance (Suhardiman and Giordano 2012). These calls have been addressed in more recent scholarship on transboundary water governance systems (VanNijnatten, et.al 2016; Krantzberg and Grover 2018; Johns 2018).

Many of the interdisciplinary studies focused on environmental and water governance explicitly acknowledge governance institutions as important. Institutional arrangements (formal and informal) are used by many scholars to bring these disparate scholarly communities together. Related concepts such as 'institutional capacity', 'governance capacity', 'state capacity' and 'policy capacity' and 'transboundary governance capacity' are used to ground governance research on a foundation of institutional analysis

(VanNijnatten et al. 2016). These approaches also increasingly embrace complexity through theories of governance, network theory and methods, and more explicit calls for to integrate theories of complexity from other disciplines in recognizing that public policies are "complex systems that are embedded in larger interlocking social and natural systems" and "policy systems, which are human systems, also coevolve with natural systems" (Morcol 2012, 10-11). As a result, institutional analysis provides a common foundation for different scholarly communities to approach water governance, based on the shared belief that analyzing and understanding institutions is central to making policies and water governance regimes work better and achieve better outcomes. The fundamental assumption is that water policy institutions matter in terms of explaining, understanding and improve water policy outcomes.

After 25 years of development and applications in environmental policy and across many environment and water policy systems, the literature on indicators has also developed alongside of the rapid development of information and communication technologies to emphasize consolidation, integration and more multi-level and transboundary applications in complex water systems. This has been compounded by the recent move towards open-data by governments around the world and the global concern about the implications of climate change for water governance. In this paper water governance indicators are used as the foundation of theory and methods to analyze and understand existing policy regimes and the degree to which these existing policy regimes are adapting to address enduring and new policy challenges. Water governance indicators are based on how water governance is defined.

There are many different definitions of water governance in the scholarly and practitioner literatures. Some definitions emphasize water access, some water security, some water quality and human-health foundations, and some ecosystem-based foundations. For purposes of this paper, the OECD's definition of water governance is used: "the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision-makers are held accountable for water management" (OECD 2015a). The OECD's definition allows for the application analysis of water governance indicators in both developing and mature domestic and transboundary water policy regimes.

The OECD's Water Governance Indicators

In addition to the scholarship on water governance indicators there has been a significant amount of effort by international organizations and non-government organizations to develop and apply water governance indicators. For several decades the OECD has been working on environmental indicators. From 1971 to 1992, the OECD Council focused on pollution, integrated water resource management, and the role of economic instruments related to water management. Initially embedded in the OECD's Environmental Performance Reports, work on water governance became the focus in the OECD's *Managing Water for All* with its emphasis on taxes, tariffs and transfers as a means of addressing chronic investment shortfalls for water and sanitation (OECD 2009a). This report is also noteworthy for its explicit recognition of the governance capacity required for such instruments to be successful.

By the 2000s the international emphasis on 'good governance' and 'capacity-building' were well established. Based on a survey of 17 OECD countries in 2011, the OCED identified 'water governance gaps' and called for a more 'systemic' approach to water policy to overcome critical multilevel governance challenges, stating that member states should be using "a multilevel approach integrating international, national and local actors can help diagnose inherent governance challenges" (OECD 2011, 18) and that "further research should study 'micro-governance' to identify good local practices for managing commons (OECD 2011, 28). To address this complexity the OECD developed a 'multi-level' framework that focuses on analyzing seven key implementation gaps related to water policy in member countries.

In order to address implementation gaps the OECD began to work on water governance indicators (WGIs). In 2014-15 the OECD conducted an inventory of environment and water governance indicators and found over 60 organizations were engaged in research related to assessment and performance indicators (OECD 2015). The report included English language inventories of those focused on environmental indicators, or which water was a subset, and those that focused specifically on water. The inventory examined all of the indicator frameworks in terms of purpose, geographic coverage, variables and indicators included indicators for systems of scarcity and abundance; developing and developed countries; water quality and quantity; and both lake and river systems. The inventory revealed most water indicators were focused on surface water, with some on groundwater; some were global/international, some regional and some national; and in many cases water indicators were part of broader environmental indexes. For example, the Yale Environmental Performance Index (EPI) that has 3 key WGIs: access to drinking water; access to sanitation; percentage of population with water treatment/wastewater management which is collected for 180 countries (Yale EPI 2018).[1]

The OECD's inventory revealed that 8 of the 60 indicator programs were classified as focusing on water governance indicators, however, on examination some of the other indicator suites included water governance indicators but did not label them as such. For example, Transparency International's Water Management Transparency Index focus on how much information about water resources is available to the public. Others, such as some of the scholarly models such as the extensive set developed by (Pahl-Wostl et.al. 2012) and the Equity Index for Water and Sanitation developed by Luh et.al. (2013) were not included. For the most part, the frameworks and indicators included in the international review and inventory conducted by the OECD were jurisdictionally focused, mostly at the national level.[2]

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[1] The baseline target for the Yale EPIs is a target of 100% of population. Secondary data is collected from a mix of government and academic sources and then countries are ranked accordingly.

[2] Another indicator set not included in the OECD inventory is the Transboundary Water Assessment Program (TWAP) from the Global Environment Facility (GEF) originally established in 1990s by the World Bank funding in partnership with the UNDP and UNEP related to several UN Conventions. In 2009-10 this cluster of organizations started the TWAP. The first step was to take stock of transboundary water systems across the globe. The component focused on lakes used spatial analysis of primarily NASA and USGS global-scale databases to generate list of 1600 transboundary lakes and reservoirs. Using transboundary criteria the list was then reduced to 204 transboundary lakes and reservoirs, including 33 in Africa, 51 in the Asia region, 30 in South America, 70 in the European region, and 20 in North America. The TWAP consists of five independent indicator-based assessments and the linkages between them, including their socioeconomic and governance-related features.

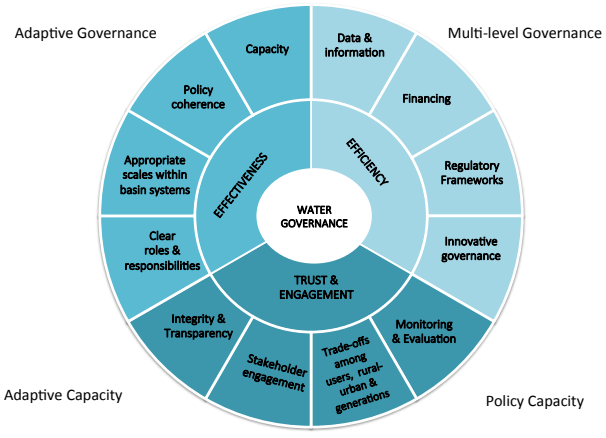
Like many frameworks and sets of performance indicators, the OECD's inventory revealed two general types: those that are data driven and those that are theory driven. Data-driven are those where data availability is the central criterion for indicator development and data is provided for all selected indicators. Theory-driven are those that focus on selecting the best possible indicators from a theoretical point of view, while data availability is only considered one of the many aspects to take into account (Niemeijer 2002). Several are combinations of the two and in practice these two types are not mutually exclusive. The inventory also reveals that there has been a growth in the number of water indicators developed over time. Pressures for accountability and improving performance and adaptation have resulted in the proliferation of governance assessment, policy and performance focused research.

From its inventory, the OECD Water Programme worked with a consortium of experts from member countries and developed 12 water governance principles that were adopted by its 34 member countries in 2015 (OECD 2015). These principles, see Figure 2, clearly reflect key policy goals and principles highlighted in both the scholarly literature and the practitioner literature as the key factors or variables that underpin performance of water governance regimes both within and across boundaries of nation states.

The Principles provide a framework for understanding water governance systems and help generate dialogue and change on how to improve water governance. They are intended to apply to all levels of government, all water management functions, and all water uses. As outlined in Figure 2, the principles are clustered around three main dimensions: effectiveness; efficiency; trust and engagement. The 12 water governance principles are the key factors that jurisdictions must have in order to achieve the inner circle goals. This 'principles wheel' is also meant to recognize of dynamic and multi-level nature of water governance.

Figure 2

OECD Water Governance Principles



Source: Organization for Economic Cooperation and Development (OECD) 2015.

Typically, the OECD requests member countries to adopt and report on the various indicators using existing data. To support the implementation of the OECD WG Principles, in 2016-17 the OECD developed 36 indicators, three for each of the 12 water governance principles (OECD 2018a). In 2017-18, the OECD pilot tested the 36 water governance

indicators (WGIs) in 12 OECD jurisdictions at various scales: basin, national, regional, and local. The approach is based on a voluntary self-assessment framework and multi-stakeholder dialogue to assess how water governance systems are performing at a given moment in time (static) or are expected to perform over time (dynamic). The OECD's WGIs were designed to be *perception-based*, on the view of experts or various types of stakeholders, and *fact-based*, using available/objective data.

At the World Water Forum in March 2018, the full list of water governance indicators and methodology options were publicly released in the report *Water Governance at a Glance* (OECD 2018b). Findings from the first round of applications in 12 pilot jurisdictions were also presented. To date, applications of the 12 principles (Seijger et.al. 2018) and 36 WGIs within jurisdictions have generated some useful findings (Akhmouch et.al. 2018a, 2018b); and demonstrated the value of WGIs. However, water governance indicators need to be able to reflect the reality that many water systems do not align with member country boundaries, and the scholarship that clearly indicates the unique and complex governance realities in transboundary water systems across the globe.

The North American Great Lakes Case

The Great Lakes is the largest freshwater basin on earth shared between Canada and the US. Combined, the five lakes and their draining river systems span two countries, two provinces, eight US states, thousands of municipalities, and hundreds of Indigenous communities. This water system supports millions of people and a diverse range of economic activity. This complex transboundary water system is governed by a well-developed and well-studied transboundary water governance regime with a well-developed reporting and accountability regime. This section outlines why it is a good case to apply the OECD's water governance indicators.

Since the 1970s governments at all levels have been trying to improve environmental outcomes in the Great Lakes region. The International Joint Commission established under the Boundary Waters Treaty in 1909 has been trying to tackle environmental issues in the region since the 1960s. The Great Lakes Water Quality Agreement (GLWQA) has existed since 1972. Signed by the US and Canadian federal governments as 'parties to the agreement' this international agreement contains numerous environmental policy goals that require a robust water governance system and implementation infrastructure at multiple levels. Revised and updated in 1978, 1987 and 2012, the GLWQA forms the foundation of many different domestic policies related to implementation of 10 Annexes on a wide range of environmental issues related to water quality.

Complex governance arrangements involving numerous governments and a variety of users and stakeholders have evolved to collectively manage water quantity and quality in the region. The development and evolution of the GLWQA and the IJC are well documented. Progress and success has been mixed (Sproule-Jones 2002; Botts and Muldoon 2005; VanNijnatten et.al.2016; Johns 2018, Johns and VanNijnatten forthcoming; MacFarlane and Clemens forthcoming). Although there have clearly been some important environmental success stories related to acid rain, toxic substances and return of species on the brink of extinction, evidence of progress in achieving policy goals of fishable, swimmable, drinkable

waters remains elusive in many communities, and significant governance and implementation challenges remain.

Under the GLWQA both the parties and the IJC track and report on progress. There is a highly developed scientific regime that has been generating reports on the state of the lakes since the 1990s. Both the IJC and 'the parties' (Environment and Climate Change Canada/ECCC and US Environmental Protection Agency/EPA) have spent considerable time and effort developing key indicators for reporting purposes. The State of the Lakes Ecosystem Conference (SOLEC) established in the late 1990s produces reports every two years on the state of ecosystem health in the region. In 2012 this was replaced with efforts to generate State of the Lakes reports every three years as part of the new reporting regime. The parties worked very hard on updating and revising the suite of ecosystem indicators previously used in SOLEC reports to better align indicators with the nine general objectives of the 2012 GLWQA, using nine key indicators as the basis of collecting and aggregating relevant scientific information.

The IJC also started with some work on performance measures in its 2011 report (IJC 2011), commissioning a report in 2013 exploring the idea of GLEEM—Great Lakes Environmental Effectiveness Metrics (Hill and Engle 2013), organizing an indicators workshop in 2014 where experts and stakeholders were brought together to discuss the existing ecosystem health, human health, response, and program effectiveness indicators, and testing the GLEEM approach and method related to two general objectives in the GLWQA (beaches and invasive species) using surveys of experts and stakeholders in the region to assess indicators' progress and achievements (Johns, Thorn and VanNinjatten 2016).

The most recent GLWQA in 2012 reaffirmed the commitments of governments on both sides of the border to assess and publicly report on progress. The parties and relevant Annex committees report regularly at the Great Lakes Executive Committee (GLEC) meetings held twice per year. In addition to biannual GLEC meetings and public forums every three years, there are now three important progress reports: the Progress Report of the Parties (PROP), which covers binational and domestic actions related to the implementation of the agreement; the IJC's Triennial Assessment of Progress (TAP) report, and the State of the Lakes Report (SOGL), which was presented at the Great Lakes Forum in October 2016 and publicly released in 2017.

The Progress Report of the Parties (PROP) in 2016 indicates that for most issues progress is 'fair and unchanging' (Binational.net 2017). The report focuses on nine indicators and sub-indicators to assess progress over time and "how the lakes are responding to management actions," including baseline data basin-wide and lake level data to report on current status (good, fair, poor, undetermined) and trends over time (improving, unchanging, deteriorating, undetermined). The overall results have been reported as "fair and unchanging" based on the aggregation of best available science for each of the nine indicators and sub-indicators. The last PROP aggregates an impressive amount of scientific evidence and results were reported for each lake where data was available. It was clear that across the nine indicators, Lake Erie and Lake Ontario—with the most population density, urban development, agricultural development, and transportation density—were the lakes with the most significant environmental challenges (Johns 2018). Some issues have re-emerged such as nutrient pollution in Lake Erie, and some are new challenges associated with climate change.

However, there was no indication in the PROP if this overall assessment is satisfactory, how this information and policy tool is used in terms of policymaking or setting priorities, and what this report says about the state of water governance in the region. The IJC's TAP report required to assess progress under Article 7 of the GLWQA, report provides advice and recommendations to assist the federal governments and other levels of government, academia, nongovernmental organizations, private industry and the public to better meet the general and specific objectives of the GLWQA. The 2017 TAP report noted there was much to celebrate in terms of progress since the signing of the 2012 GLWQA including a nearshore framework, phosphorus load reduction targets for Lake Erie, progress on delisting Areas of Concern and overall improving accountability and reporting (AOCs)(IJC 2017, 10). However, the TAP report also highlighted several areas where progress and governance could be improved such as setting a 15-year goal for completing remedial actions in all AOCs (IJC 2017, 15), improving public engagement, and establishing clear, time-bound targets for action, and long- term aspirations for improvements (IJC 2017, 17).

All this reporting has evolved into a mature reporting and accountability regime (VanNinajtten and Johns forthcoming). The governance regime is highly institutionalized. While there have been some important accomplishments and achievements under the transboundary environmental and water governance regimes in the Great Lakes region, particularly in the past few years, both scientific and policy research to date indicate that the existing governance regime, designed more than forty years ago, is achieving only limited success in improving environmental outcomes. There are concerns that the governance regime is not adapting well to new contexts and that there is a need to continuously reflect on the state of water governance in the region. While progress has been steady and notable since 2012 (Johns 2019), and the policy regime has shown a capacity to adapt and be flexible to some degree, basic policy goals such as swimmable, fishable and drinkable waters remain elusive and some important water governance challenges remain.

In mature water policy and governance regimes like the Great Lakes region there are long-standing policy objectives and agreements, both domestically and at the transboundary scale. Indeed, governance in the region is hailed as a model and reporting regimes related to ecosystem and human health indicators are well-developed. However, after nearly 50 years, progress remains 'fair and unchanging' using ecosystem and human health indicators. Scholars and practitioners share concerns about the adaptiveness and outcomes associated with the GLWQA and this mature transboundary environmental governance system. Progress report and accountability mechanisms have improved over time (IJC 2017, Johns 2019; VanNijnatten and Johns forthcoming) however the re-emergence of enduring environmental problems, new challenges such as climate change, and changes in government at all levels threaten the ability of the governance regime to improve outcomes and adapt.

Progress reports by the IJC, Parties and scholars indicate is that governance challenges remain and there is potential for using water governance indicators to complement the extensive public reporting on ecosystem and human health indicators that have been used in the region to date. New knowledge is required to understand the complexity, capacity, and limitations of the existing transboundary regime, and new approaches are required to adapt and redesign policies and governance arrangements if

this regional and global ecological system is going to be sustainable in the future. There is a need for governance indicators, in addition to the ecosystem and human health indicators currently used in the Great Lakes region. Although the IJC has done some work on progress and program indicators, these efforts and initiatives by the IJC have not been viewed positively by the parties and GLEC. It has been difficult for the IJC or parties to develop these themselves. Given that there are efforts by scholars and international organizations to develop and apply water governance indicators, this presents an opportunity to apply water governance indicators to this complex, transboundary water system. The OCED's water governance indicators offer an external set of WGIs that may be useful to enhance scholarly understanding of governance and improve practical-reflection about various dimensions and aspects of governance in the region.

Methods

Our research design began with a review of the OECD's water governance indicators and methodology options. We reviewed all documentation and pilot applications to assess applicability for transboundary cases. We determined that the OECD's 36 indicators and the OECD's methodology could be adapted for application in the Great Lakes region at the transboundary scale. This involved clearly indicating the indicators were referring to water governance at the transboundary scale, using the OECD's response categories, and modifying the data collection instrument to collect indicator assessment and qualitative data from key actors involved in water governance in the region. In summer 2018, a backgrounder on the OECD water governance principles and indicators was developed, data collection instruments were created, a pre-test was conducted with 4 experts in the region, and the methodology was modified for clarification and to incorporate an iterative component. The research design and methods were approved by the Ryerson Research Ethics Board and the Wilfrid Laurier University Research Ethics Board.

Between November 2018 and February 2019, 43 key stakeholders with expertise related to water governance in the Great Lakes region at the transboundary scale were invited to participate in our research project. We asked participants to complete a worksheet containing all 36 of the OECD's water governance indicators and complete a questionnaire with five questions related to the OECD's indicators and their applicability and value in the Great Lakes region. We received 17 completed responses. As part of the questionnaire, participants were asked if they wished to provide additional feedback or elaborate on qualitative comments in a follow up interview. We conducted 8 online interviews to probe responses provided by some participants.

Results from this phase of data collection were aggregated and a draft report with preliminary findings was sent to all participants in April 2019 providing them with the opportunity to provide additional comments. In keeping with our ethics requirements, all data was aggregated without any identifying information and aggregated findings in this draft report do not include any attribution to ensure all participants remain anonymous and their responses remain confidential.

Findings

All of the participants were able to complete the indicators data collection sheet. There was a general consensus that most of the indicators were applicable and a general consensus that the Great Lakes has many of the 36 indicators 'in place and functioning' or 'in place and partly implemented'. The vast majority of the participants found the indicators could be applied at the transboundary scale, and they expressed that the exercise was positive and useful.

As summarized in Table 1, there was consensus on several indicators that suggests a high level of agreement on the presence of knowledge-sharing and collaborative institutions. For most indicators there was a majority consensus on responses with over 50% responding similarly to the same response option. Some of the responses were split. In most cases these were in the first two response categories (in place/functioning and in place/partly implemented). There was some indication that OECD WGIs 5b (standardized, harmonized, official, basin-wide water-related statistics) and 6c (mechanisms to assess short-, medium- and long-term investment needs) are currently under development, and six of the indicators are not in place in the region at all.

However, there were several indicators where responses were mixed and no consensus was clear. For example, Indicator 4c, related to education and training of water professionals, received mixed responses. This is likely due to interpretation as jurisdictions do have domestic education and training programs for water professionals but some respondents were indicating that no specifically *transboundary* education and training programs exist. There were also some split responses related to indicator 6b (domestic revenues and allocations related to water). This may be the result of different responses from Canadian and American participants, or the result of interpreting what this indicator means.

The purple coding in the summary indicates several indicators where there was a wide distribution of responses and no consensus [3c: mechanisms to review cross-sector policy coherence; 4a merit based independent implementers, 8a transboundary policy frameworks/incentives to foster innovation, 9c mechanisms to identify corruption and 11b transboundary ombuds/institution to protect water users including vulnerable groups]. While it may be more obvious why 9c (mechanisms to deal with corruption) is more difficult to ascertain in the North American context, the other indicators highlight some confusion as to whether there are transboundary accountability mechanisms (ombudsperson; merit-based implementation) or transboundary mechanisms that can encourage push the boundaries of conventional forms of policy-making (the ability to bring about cross-sectoral coordination and policy coherence; mechanisms for transboundary policy innovation). This distribution may indicate disagreement on the state of the indicator or difference in interpretation of the indicator. Indeed, open-ended responses to the questionnaire suggest that these indicators were difficult to apply and, in some cases, deemed not applicable in the Great Lakes case.

Four indicators 6a, 6b [related to revenues and resources related to water governance in the region] and 9b, 9c [related to independent audit and mechanisms to identify corruption] were identified as not applicable by more than 20% of respondents. These indicators deal with resourcing and with accountability mechanisms, perhaps

indicating that these functions remain firmly rooted in domestic authorities and have not migrated to the transboundary level.

In addition to mixed response, some participants did indicate on the data collection matrix that they had difficulties understanding certain indicators by inserting "?" instead of "X" or leaving responses for some indicators blank. This highlights the value of additional qualitative data collected in order to better assess the value and challenges with applying the OECD water governance indicators at the transboundary scale in the Great Lakes. Some of this information was collected through the qualitative questionnaire and follow-up interviews with study participants. Many participants then elaborated on the ability to respond using the data collection sheet, on the indicators themselves and on the response categories in their qualitative responses in the questionnaire and follow-up interviews.

Qualitative Findings from Questions About Applicability

The qualitative questions indicated there were strengths, limitations and challenges in applying the indicators. Additional comments received indicted that the majority of participants felt most indicators had some applicability to the Great Lakes. However, others noted that "some are quite broad and vague", "some are tricky to apply", and "it is not really a question of applicability but more how do you use them to determine and establish priorities"' "the indicators are opinion-based but I would like to know what others opinions are".

Some commented on specific indicators: "2c asks about the level of cooperation across all water users, which is difficult to assess given there are so many various types of water users"; "4b and 5c do not provide enough specificity"; "for 6a and 6b it is hard to see how collecting necessary revenues and resources at transboundary scale and similarly domestic revenues and allocations" "some do not really apply such as 9c – mechanisms to identify corruption" (several respondents indicate this either on the indicators worksheet or in their comments); "; " 9b independent audit/adjudication to safeguard public interest; agreements themselves serve this function and domestic agencies can audit, not clear why a transboundary approach would be helpful"; and "11b transboundary ombuds/institution to protect water users including vulnerable groups, not sure vulnerable groups are truly transboundary".

Overall, there were several strengths and limitations noted by participants related to applying the OECD's WGIs to the Great Lakes region. Table 2 summarizes the comments received to the qualitative questions. Several respondents also noted that the applicability and utility of using the OECD's WGIs really depends on how policy makers might use them. As noted by one respondent, "perhaps the indicators can highlight what the barriers are and what needs to change" and another noted, "perhaps we need to advance and further develop some of the indicators that are highly relevant for the Great Lakes".

OECD Water Governance Indicators Worksheet: Summary of Submissions November 2018 – February 2019

Indicator	In place, functioning	In place, partly implemented	In place, not implemented	Under development	Not in place	Not applicable	No Response Don't Know
1a. existence of water agreement/law							
1b. designated lead agencies							
1c. formal review mechanisms							
2a. cooperative mechanisms							
2b. institutions at basin-wide scale							
2c. cooperation across all water users							
3a. cross-sector approach/policies							
3b. transboundary horizontal coordination							
3c. mechanisms to review cross-sector barriers and policy coherence							
4a. merit based independent implementers							
4b. mechanisms to identify and address capacity gaps							
4c. transboundary/domestic education and training programmes for water professionals							
5a. transboundary water information systems							
5b. standardized, harmonized, official, basin-wide water-related statistics							
5c. mechanisms to identify data gaps							
6a. frameworks to collect necessary revenues to meet mandates							
6b. domestic revenues and allocations related to water							
6c. mechanisms to assess short, medium and long-term investment needs							
7a. sound water management regulatory frameworks							
7b. dedicated public institutions with key regulatory functions							
7c. regulatory tools for both water quality and quantity							
8a. transboundary policy framework/incentives to foster innovation							
8b. transboundary institutions encouraging bottom up initiatives, dialogue and learning							
8c. transboundary knowledge and experience sharing mechanisms							
9a. legal and institutional frameworks on integrity and transparency							
9b. independent audit/adjudication to investigate and safeguard public interest							
9c. mechanisms to identify corruption							
10a. transboundary legal frameworks to engage stakeholders							
10b. structures to engage stakeholders							
10c. mechanisms to diagnose/review stakeholder engagement							
11a. formal provisions/legal frameworks fostering equity across water users							
11b. transboundary ombuds/institution to protect water users including vulnerable groups							
11c. mechanisms to manage trade-offs across users							
12a. regular transboundary monitoring and evaluation of water policy/governance							
12b. transboundary monitoring and evaluation to assess policies/practices and help adjust							
12c. transboundary monitoring and evaluation mechanisms to measure extent to which water policy fulfils intended outcomes and water governance framework fits is purpose							

*all responses may not total to the total 'n' as some participants did not respond to all 36 indicators indicating a 'don't know' or unsure '?' response

NOTES

Corresponding colour indicates clear majority of responses
Two colours indicate split in responses
Purple indicates distribution of responses across more than two response categories

Table 2 **Summary of Strengths and Limitations of Applying OECD WGIs to Great Lakes Case**	
Strengths	• comprehensive, very broad • generally applicable to the Great Lakes Region • appropriate for the mature governance structures in the region • applicable enough to provide a valuable framework and apply in a number of different contexts • generally, they reflect that the GL region is doing well yet there is room for improvement • it is clear these were developed somewhere else but they apply fairly well • they generally capture the activities of the main organizations involved in regional governance
Limitations	• very focused on institutions; formal things in place • challenging to apply across different aspects of water governance such as water quality and water quantity • do not capture that the application of these indicators is not always consistent or harmonized across all jurisdictions in the region • in need of more detailed definitions and specificity • some very open ended and can engender different interpretations in responses • perhaps need for some consideration of similar/shared culture, language, attitudes and values • only relate to a given point in time and cannot describe overall condition or historical conditions • responses require a more detailed qualitative assessment • limited in terms of one's perspective when responding • not well suited as there is not a single transboundary authority and shared governance • seem too simplistic because the status of each indicator is complex • indicators just don't tell the full story of the Great Lakes • not sure the OECD approach is suitable for the Great Lakes as most, if not all, are in place and functioning but not in an integrated and fully coordinated manner • there is a bias towards transboundary mechanisms which may have benefit in some context but are not needed/optimal in a mature relationship

In addition to comments about the applicability of the OECD WGIs to the Great lakes, several respondents commented on the methodological aspects of the indicators and the data collection instrument that was adopted and adapted from the OECD's indicator descriptions and response categories.

- I think the response sheet is in need of a different set of choices for the assessment
- need for a 'don't know' or 'not sure' response option
- there are some overlaps between certain indicators
- perhaps different assessment criteria such as 'high, moderate or low' instead of 'in place functioning and not in place'
- need option to indicate that element is operating in parts of the basin under specific jurisdiction and not at the transboundary scale
- helpful to have a space to provide comments to explain one's responses (for each indicator)
- each of the numbered subheadings needed one or two sentences to frame the context of the indicator
-

- instead of a scorecard, written responses to each of the questions/indicators would provide a fuller picture
- include a response column to allow people to indicate they do not feel comfortable providing an assessment due to lack of knowledge on a particular subject needs to be some
- need some thought about degree of agreement, the notion of 'functioning' is not a measure of agreement
- "there may be opportunity to condense or amalgamate some of the 36 indicators"
- I like that there was an opportunity in the qualitative questions to follow up and add that other indicators would be helpful on different aspects of water governance in the region

There were also several comments provided in response to the 'additional comments' question. Some related to the water quality and institutional focus of the indicators. "I think there is a more cohesive community around water quality than around water quantity; researchers would need to consider what sort of biases like these are going to influence the results and the implications of that for making comparisons between different basins"; Some noted that other important water governance factors are not captured in the OECD's WGIs: "an additional important factor is that truly effective and sustainable water governance requires strong and sustained political and social will of all parties, coupled with sustained investment, this factor was not captured" and "there should be indicators about educating the public and youth; indicators about the public's behavior, governments can only do so much"; and "it is not clear how they include upstream-downstream, nearshore/offshore, intersections of built and natural systems, cultural and rights aspects of water, Indigenous considerations, or a focus on the aquatic ecosystem beyond water"; "it would be useful if the 36 indicators were expanded to include levels of governance".

Finally, some noted in their qualitative responses to the questions the possible value of using the findings as the basis of comparison between the Great Lakes and other transboundary water systems: "I would be interested in knowing how OECD countries are actually using them; are they being used to re-orient programming and investment in these regions?"; "these indicators seem generalizable to any transboundary environmental medium, system or process, rather than specific to water".

Additional Insights from Interviews

The follow-up interviews allowed several participants to elaborate on the comments they provided to the five written qualitative questions. There were several questions related to the OECD's WGIs, the applicability at different scales, applicability related to the existing reporting and accountability regime in the region, and some broader discussions of governance, water governance, and adaptation of water governance in the region.

Some interviewees commented that the use of the OECD water governance indicators depends on how you think about water governance. As noted by one interviewee: "I am not really sure what water governance is; it depends on whether you think of governance as a human system or like an ecosystem". The OECD indicators helped some think about water governance. However, as noted by one interviewee: "I think they are heavily institutionally focused; focused on formal things in place; they are comprehensive but I struggled with the scale and what does 'functioning' mean? Just because they are in place does not mean they are effective". Another noted governance in the Great Lakes region can be summed up "in three words: collaborative, cooperative, but

unaccountable" and outlined that using governance indicators can enhance thinking about water governance in the region and perhaps comparatively.

In response to an interview question about the potential to apply the OECD's WGIs at different scales, participants felt the OECD WGIs were broadly applicable at the transboundary scale; they noted, "it is hard for practitioners to have a big picture, this type of synthesis is useful". However, several participants provided comments that they found it challenging to apply the indicators in a multi-level governance system like the Great Lakes. Interviewees noted the value of applying them at the transboundary scale but also argued that for a fuller picture they "need to be applied at different scales"; "they may be useful at relevant scales", "they may be useful to uncover things at other scales", and there is a "need to consider how these various indicators at the transboundary scale might differ at other scales". One interviewee stated, "Yes, depending on what is being examined they could be used related to binational efforts, GLEC and LAMPs". However, another noted, "they don't really get at whether the system is centralized or decentralized or the need for balance of these at various scales" and yet another interviewee commented that, "I am not really sure how watersheds fit in". Some interviewees also commented that they felt issues at other scales were difficult to capture, noting that: "I don't think they capture issues and cross-issue work very well"; and "thinking about governance of quality and quantity will become more of a problem [in the future]". This gap in an ability of transboundary institutions to work horizontally, across issues, comes through in the worksheet responses as well.

Several interviewees elaborated on the value of the OECD water governance indicators related to existing progress reporting, stating that: "perhaps they can highlight what the barriers are and what needs to change; it is clear that there is a need for more individual and organizational change." Another noted that, "they do emphasize accountability somewhat but the emphasis is on reporting, not really accountability". Additional comments along these lines included "gap analysis is only part of it"; "they are only useful if practitioners are interested in examining their own governance structures"; and "it really depends on the appetite for reflection and change".

There were some who outlined that governance indicators and findings from applying the OECD water governance indicators need to be brought into alignment with current assessment and progress reporting in the region. Several interviewees made comments such as: "Just because they are in place does not mean they are effective"; "the challenge is to correlate these with existing performance indicators"; and "this is a system based on agreements and accountability. Although the IJC plays an assessment role it is good to have an extraterritorial perspective; there are other examples of regional governance around the world". Further, one interviewee stated that, "the value might be in the comparison to other transboundary systems". Several interviewees noted the need for the OECD WGIs to be applied over time. Interviewees commented that the indicators apply to a specific point in time but can't tell us much about progress and change unless used over time and alongside existing reporting and other indicators. "The State of the Great Lakes report indicates overall that water governance in the region is fair and unchanging; there is some progress but things cannot improve significantly in the near future; resources are a major factor in this. Indicator 6 in the OECD indicators tries to get at this". Another noted that, "here is nothing to gage over time in terms of adaptiveness and resilience. There is a sense we are not adapting fast enough but what would constitute adapting in terms of the environment and water quality?"

A few interviewees commented about adaptiveness in response to a question about the adaptiveness of water governance in the region: "depends on what you mean by ability to adapt"; "governance in the region has the potential for flexibility in principle but in practice things are rigid; human and organizational behavior are rigid", there is "not a lot of institutional innovation and change; the reporting regime is a good example and the challenge of a clearer role and voice for municipalities and First Nations communities"; and "this is where case studies are more useful for example new work on nutrient management, rapid response and invasive species illustrate how the system adapts". However, another interviewee commented that: "I think in terms of water governance adaptability we do pretty well comparatively. With the GLWQA and Compact we do have governance for both quality and quantity. Implementation challenges and resource challenges will always exist".

All 8 interviewees did indicate that water governance in the region is adapting, but did not reveal any consensus about the pace and sufficiency of adaptation or whether the OECD indicators provide any value related to this. Those who commented about this noted that having some assessment over time would be useful as the indicator set in the data collection worksheet only provides a snapshot in time from a limited number of participants with high-level knowledge of water governance at the transboundary scale.[3] When asked about obstacles to change and adaptation, several interviewees noted the following: "there are some governance obstacles, some not unique to the Great Lakes region"; "existing governance needs to initiate more innovation; perhaps an external, independent audit and report on both the IJC and Parties reports. It is so dependent on the commissioners and federal leads. There is a need for more thinking beyond GLEC, IJC staff and commissioners. Different thinkers and ideas needed. Sometimes this comes with new issues". Another noted that, "the community does have a sense of responsibility and does good work; sharing information is important but there is no penalty for inaction and the community is very comfortable with the status quo". As another noted: "who is responsible for what is important. Annexes are good for this but there are limitations on what they can do". Others suggested that "resources and people are limitations"; and indicated a need for more "harmonization of binational efforts". Another interviewee noted examples: "perhaps nutrient management in Lake Erie and invasive species in Annex 7" (are good examples of adaptive governance). Others noted, "we have good science, but on some issues, science is limited"; "there needs to be more integration of water quality and quantity efforts"; "we need to think more about this [governance] and have the time to think about it"; "there needs to be more interdisciplinarity; more capacity to deal with emerging and future issues". One interviewee noted an important aspect is missing from the indicators and discussions of adaptation is "political will".

3 The OECD does have a temporal dimension as part of their methodology to allow for some reflections and analysis of expected progress over a 3-year time frame. Please see conclusion section below for more details. These are limitations that are part of the methodology and were considered by the research team when adopting and adapting the OECD's methodology for application in our transboundary cases.

Conclusions:

Environmental indicators have been used by scholars and practitioners for decades. Over time, specific sets of indicators have been developed for a variety of environmental policy issues. In the past several years there has been significant theoretical and practitioner work on water governance indicators. This work has been informed by policy theory, scholarship and the increasing number of interdisciplinary scholars and practitioners trying to understand why jurisdictions around the world have not been able to achieve water policy outcomes and improve water governance.

Overall, participants in this study were able to apply the OECD WGIs at the transboundary scale in the Great Lakes region. All study participants were able to complete the data collection worksheet and provide additional comments using the questionnaire. As noted above, most participants found the indicators broadly applicable and valuable. Some participants found the indicators challenging to apply in a transboundary, multi-level, multi-organization, multi-agency water governance system and some noted that not all indicators aligned to attributes of water governance such as domestic vs. transboundary mechanisms in the Great Lakes region.

The primary value of applying the OECD water governance indicators identified by participants included: i) the ability to think about the state of water governance in the region using a set of indicators developed by the OECD and other jurisdictions; ii) the opportunity to think about different aspects of water governance; iii) the ability to reflect on the institutions and mechanisms at the transboundary scale; and to identify gaps or indicators that may identify opportunities for attention; and iv) the potential value of gaining insights from the findings in comparison to other transboundary water governance systems.

The findings also generate some insights that build on existing knowledge about water governance in the region. They indicate there are some important gaps related to mechanisms for long-term resource allocations and investments; standardized and harmonized water-related statistics; the management of trade-offs and equity across various water users and lack of mechanisms to identify and address capacity gaps. These provide scholars and practitioners some insight on where to focus future water governance efforts.

However, findings from applications in this case also reveal that there are several challenges related to applying the OECD water governance indicators including: i) interpretation of various indicators; ii) inapplicability of some of the indicators at the transboundary scale; iii) general inapplicability of some indicators to the Great Lakes region; iv) confusion about the scale at which the indicators apply, given the multi-scalar reality of transboundary interactions; v) doubts about the value-added of using the indicators in a well-studied and highly developed water governance system; vi) limitations in applying indicators only at the transboundary/macro scale; vii) limitations in connecting the indicators to existing progress reporting and ecosystem indicators; viii) limitations in using the indicators at only one point in time; viii) limitations in using the indicators to gage adaptation of the water governance system over time; and ix) confusion about the scale at which the indicators apply, given the multi-scalar reality of the Great Lakes as a complex transboundary water system.

In addition, the findings revealed some limitations with adapting the methodology using a data collection worksheet, qualitative questionnaire and follow-up interviews. First, response rates were low. The initial findings could be more robust with more study participants. However, those who did respond included key policy actors with in-depth knowledge of transboundary water governance in the region making the findings more robust. Second, the qualitative responses through the questionnaire and follow-up interviews provided valuable feedback on the indicators and the worksheet instrument. By providing participants with a draft report, the findings were confirmed by key actors and organizations involved in water governance in the region.

The OECD uses a workshop methodology[4] to gage the degree of consensus across various stakeholders for each indicator. In their workshop methodology, they allow stakeholders to indicate if there is a 'strong' consensus on the assessment of each indicator; 'acceptable' consensus; or 'weak' consensus. This workshop approach could be used to refine the findings from this study.

Several participants noted the need for temporal and more iterative use of the indicators. The OECD does outline that a temporal dimension is encouraged as part of their methodology to allow for some reflections and analysis of expected progress over a 3-year time frame. In addition to asking experts and stakeholders to assess the current situation, in their workshop methodology they do ask participants to assess whether changes are expected for each indicator over the next three years using three options: improvement expected; stable; decreases expected. Our team had to make some methodological choices about what to use and include from the OECD's methodology but this additional temporal data could be collected through follow up workshops or supplementary methods.

For this first phase of our research, gaging whether the indicators included a dynamic element and ability to gage change over time was also something we asked about in follow up interviews. Interviewees indicated that the indicators could be used over time to see if governance elements are improving and could be used comparatively to assess how the Great Lakes is fairing compared to other complex transboundary systems. Indeed, several participants commented about their comparative potential and value in the qualitative questionnaire and interviews.

Overall, this study indicates that external water governance indicators developed by the OECD can be applied in transboundary water systems. This study is the first application in Canada, the US or North America. While the WGIs have limitations, and there are also limitations in the methodology used, the results highlight some key areas where water governance thinking and action can be improved in the region. They also provide some insights that when combined with existing State of the Great Lakes, Progress Report of the Parties and the IJC's Triennial Assessment of Progress, could yield some additional insights and connect ecosystem and human health indicators to water governance indicators. Comparative studies that apply water governance indicators in other complex transboundary water systems, or at other scales, may also yield some valuable insights.

While environment and water governance indicators clearly have limitations, are based on some faith in governance institutions and actors, and are not deeply critical of the economic and social systems in which current governance regimes are embedded (Elgert

4 OECD 2018, *Implementing the OECD Principles on Water Governance: Indicator Framework and Evolving Practices*, OECD Studies on Water, OECD Publishing, Paris, https://doi.org/10.1787/9789264292659-en.

2015), they do provide some basic foundations on which to assess and deepen our understanding of current water governance efforts and institutions. The interesting paradox from a public policy perspective is that there is a growing use of, and demand for, indicators that illuminate the basic principles and requirements for 'good water governance' yet at the same time, scholars and practitioners are struggling with how to embrace the complex realities of transboundary water governance and inter-connectedness of water governance, ecological and human systems that underpin socio-ecological and adaptive systems. This study reveals that there is a need to recognize the interesting paradox between striving for water governance indicators and embracing complexity.

Environmental indicators are not new but have evolved and advanced through theory, research and applications. Increasingly, scholars focused on water governance are embracing complexity. Indeed, previous work by the OECD almost a decade ago in its report "Applications of Complexity Science for Public Policy" (OECD 2009) recognizes the potential to incorporate more complexity into policy work. Research, development and applications of water governance indicators needs to grapple with this paradox. The concept of adaptive water governance may provide the theoretical foundation for a more fulsome integration of complexity theory and further analysis of the strengths and limitations of water governance indicators by those who develop and use them in theory and practice.

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