



Principles, barriers, and challenges of Indigenous water governance around the world

Mercy O. Kehinde^{a,1}, Lalita A. Bharadwaj^{b,2}, Sonia Bataebo^{c,3,4},
Corinne J. Schuster-Wallace^{c,*,5} 

^a Department of Health Sciences, University of Saskatchewan, Saskatoon, SK S7N 5E5, Canada

^b School of Public Health, University of Saskatchewan, Saskatoon, SK S7N 2Z4, Canada

^c Department of Geography and Planning, University of Saskatchewan, Saskatoon, SK S7N 5C5, Canada

ARTICLE INFO

Keywords:

Indigenous
Water governance
Water management
Water crisis
Water security
Scoping review

ABSTRACT

Globally, Indigenous Nations are disproportionately faced with water challenges. This is partly because current approaches to water governance continue to systematically exclude Indigenous peoples and their worldviews from contemporary water governance structures. Given the need to reform current water governance systems to redress injustices and secure water resources for Indigenous peoples, this paper presents the findings of a scoping review designed to identify the principles, values, challenges/problems, and existing models of Indigenous water governance around the globe. Findings indicate that “water is life” is a fundamental principle of Indigenous water governance frameworks, as is “water as an interconnected whole” that forms a greater part of a community’s life and identity. The “Living Water, First Law” model and the Kistihtamahwin framework are examples of Indigenous water governance models identified. Colonization and the relegation of Indigenous knowledge remain a critical challenge to effective implementation of existing models of Indigenous water governance systems. This requires reform of contemporary water governance structures or formation of new systems that unsettle colonial legacies and privilege Indigenous worldviews and governance frameworks. These must focus on the overall health of the rivers, lakes, or freshwater entity and the holistic health of communities and be preceded by genuine nation-to-nation relationships.

1. Introduction

The persistent issue and complex scope of water crises in Indigenous communities in countries around the globe have been recorded by various scholars (Islam and Susskind, 2015; Gupta et al., 2014; Waldner et al., 2017; Cooley et al., 2013; Bradford et al., 2017; McGregor, 2014; Wilson and Inkster, 2018; Von Der Porten, and De Loë, 2014; Berry et al., 2018). Given that water-related challenges are widely perceived as issues of water governance, the failure of current water governance systems to provide adequate water supply to the world’s Indigenous and most vulnerable populations is compounded by the mismanagement of

water resources (Cooley et al., 2013; Akhmouch et al., 2018; Jackson, 2018; Pahl-Wostl et al., 2013). While the mitigation of water crises in Indigenous communities is gaining significant attention in countries around the globe, the issue of water security is far from being resolved (Bradford et al., 2017; Jackson, 2018; Gupta et al., 2014; Von Der Porten, and De Loë, 2014). This is because water security in an Indigenous water governance framework encompasses not just access and availability to safe drinking water but clean water to maintain cultural and traditional practices, spirituality, and community identity (Gupta et al., 2014; Wilson and Inkster, 2018; McGregor, 2014; Berry et al., 2018).

* Correspondence to: Department of Geography and Planning / Global Institute for Water Security, University of Saskatchewan, Saskatoon, SK S7N 5C5, Canada.
E-mail addresses: Meo599@usask.ca (M.O. Kehinde), lalita.bharadwaj@usask.ca (L.A. Bharadwaj), Sonia.bataebo@statcan.gc.ca (S. Bataebo), cschuster.wallace@usask.ca (C.J. Schuster-Wallace).

¹ ORCID:0000-0002-4055-5006

² ORCID:0000-0003-2690-0907

³ ORCID:0000-0002-0265-525X

⁴ Statistics Canada, Ottawa, ON K1A 0T6 (current affiliation).

⁵ ORCID:0000-0003-0187-0326

2. Indigeneity, colonialism, and Indigenous water governance

Critical to this review is a discussion of Indigenous/Indigeneity and colonialism as they are defined differently by Indigenous peoples across the globe (Sarivaara et al., 2013; Merlan, 2009; Grovogu, 2011; O'Donnell, 2023). Colonialism is a practice of domination and dispossession, which involves the control and subjugation of "one" Peoples over another. It is frequently described as the domination of a society by settlers from a different society and the superimposition of an alien social order by settlers on an already existing society (Merlan, 2009; Grovogu, 2011). This includes a global geopolitical, economic, and cultural doctrine that changes the structure and order of the world's Indigenous society (Sarivaara et al., 2013; O'Donnell, 2023). While colonialism in the global north is marked by ongoing colonization or what is commonly known as settler colonialism, countries in the global south are marked by post-colonialism where the original owners of the land have reassumed control and sovereignty over their lands and resources (Grovogu, 2011). Nonetheless, this review paper focuses on settler-colonial states where settlers make a new home on a pre-existing land, dispossess the original owners of the land, and impose sovereignty over all things in their new domain. We include post-colonial states where the term "Indigenous" is explicitly defined.

Indigeneity, on the other hand, connotes belongingness and processes of attachment and identification that distinguish those native to a territory/place from others (Merlan, 2009; Sarivaara et al., 2013). Similarly, Indigenous is frequently used to describe the Peoples that inhabited a territory before colonization or the formation of the existing State (Merlan, 2009; Sarivaara et al., 2013; Coates, 2008). It is also widely used to describe the people whose ancestors lived in the area before colonial settlements (Merlan, 2009; Sarivaara et al., 2013; Coates, 2008; O'Donnell, 2023). However, globally, the term "Indigenous/Indigeneity has no universally acceptable definition due to the diversity of Peoples around the world with distinct political, economic, social, and cultural histories (Sarivaara et al., 2013; Merlan, 2009). For example, Indigeneity is viewed differently between colonial and post-colonial states (Merlan, 2009). Countries such as Aotearoa New Zealand, Australia, the United States, and Canada, view Indigeneity based on blood relations, often bounded by legal systems (Sarivaara et al., 2013). For example, in Aotearoa New Zealand, a person is legally Māori (Indigenous people of Aotearoa New Zealand) if they have at least one Māori ancestor (parents, grandparents, great-grandparents, etc.) (Coates, 2008). The Sami people (Finland, Sweden, Norway, and parts of Russia) ascribe Indigeneity based on their unique history, language, and worldviews. A person is considered Sami if they identify as Sami and fulfill one of three legal criteria: (1) speaks the language or has at least one parent/grandparent who speaks the language; (2) has Sami ancestry registered as a Fell, Forest or Fishing Sami in the land, taxation or census register; (3) has a parent who is registered as entitled to vote in an election of the Sami parliament (Ministry of Justice, 1995). In many countries in Africa, Latin America, and Asia, Indigeneity is viewed differently as most of these countries have internal diversity due to their independent control and sovereignty (Merlan, 2009). For instance, in countries such as India, China, and Indonesia the term "Indigenous" is rejected (Baviskar, 2007; Tsing, 2007). Indigenous in Latin America is commonly used to describe rural settlers and peasant farmers (Perreault, 2008; Boelens, 2008).

While the meaning of Indigeneity varies globally, three common themes emerge across all the definitions: (1) rights to self-identification as Indigenous (2) an association of Indigeneity with ongoing or historical colonialism, (3) an association of Indigenous People to the lands and resources in their territory (United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP)) (United Nations, 2007). Similarly, the impacts of the "terra nullius" colonization doctrine of discovery and the associated dispossession of Indigenous lands and water are global (O'Donnell et al., 2023). Terra nullius commonly framed as "aqua nullius" is a doctrine where colonizers deem all lands including water as

vacant and belonging to no one. Thus, they assume sovereignty and control over all Indigenous lands and water in their domain (Marshall, 2017). Globally, colonialism not only normalizes the dispossession of Indigenous peoples of their water and lands but also legitimizes the exploitation of water in Indigenous territories (O'Donnell et al., 2023). The social, political, and cultural impacts of present-day and historical colonialism left many Indigenous Nations with multi-generational trauma through a struggle to resist assimilation, remain unceded, and/or assume sovereignty (O'Donnell, 2023). This suggests that the reproduction of colonial relations is still evident in the structure of contemporary socio-political and governance systems of both colonial and post-colonial States (O'Donnell, 2023; Grovogu, 2011).

With the reproduction of colonial relations in contemporary governance systems, the concept of Indigenous water governance has been identified in water governance literature as a priority area of concern (McGregor, 2014; Wilson and Inkster, 2018; Wilson, 2019, 2020; Daigle, 2018). Indigenous governance is described as a broad field of scholarship that examines subjects of indigeneity, self-determination, Indigenous knowledge, values, and laws, as they relate to Indigenous peoples and governance systems in pre-colonial and contemporary colonial society (McGregor, 2014; Wilson and Inkster, 2018; Von der Porten and de Loë, 2013).

Indigenous water governance is framed within the concepts of Indigenous water principles and laws (First Laws) (Wilson and Inkster, 2018; McGregor, 2014; RiverOfLife et al., 2021; Poelina et al., 2019). The premises of Indigenous water governance systems are founded in the creation and re-creation stories of oral traditions where water is conceived not only as a biophysical system but as a hydro-social system that is inseparable from communities, culture, spirituality, politics, and economy (McGregor, 2014; Wilson and Inkster, 2018). Indigenous water governance framework is pragmatic with place-based cultural principles that legitimize efficient social norms in protecting and sustaining current and future water resources in Indigenous territories (McGregor, 2014; Wilson and Inkster, 2018). This means that Indigenous systems of water governance offer a sustainable water management approach that can prevent exploitive human behavior and accommodate diverse human interests and worldviews in the sustainable use of water resources. For example, in Aotearoa New Zealand, through the Waipa River Act 2012, the Nga Wai O Maniapoto (Māori iwi) practice legal traditions and system of governance. The Nga Wai O Maniapoto Indigenous water governance framework offers a sustainable water management approach that seeks to recognize and acknowledge multiple ontologies and epistemologies where diverse interests and worldviews are accommodated and exploitive behaviors are constrained to restore and protect the health and well-being of the Waipa River. Similarly, the Indigenous governance term, En'owkin (or En'owkinwixw) was adopted by the Okanagan region of British Columbia (in Canada) as an important principle of decision-making in water management (Melnychuk et al., 2017). En'owkin (or En'owkinwixw) refers to a process of consensus in decision-making dialogue and it encourages cooperation, knowledge sharing, and the exchange of diverse perspectives, and worldviews (Melnychuk et al., 2017). En'owkin, as an approach to collaborative water governance between local/First Nations communities and government agencies, takes an ecosystem-based framework that acknowledges that the environment (including water) has rights and privileges that are equal to humans and must be protected (Melnychuk et al., 2017). The successful application of En'owkin (or En'owkinwixw) in the Okanagan region is reflected in the increased collaboration and meaningful engagement with the Okanagan First Nations and other parties in each regional district (Melnychuk et al., 2017; Yates et al., 2017).

Nonetheless, in many countries around the globe, the ontological premises of Indigenous water governance systems are often cast as cultural constructions, relegated to mythical beliefs, and rendered invalid in decision-making processes (Gupta et al., 2014; Jackson, 2018; Wilson and Inkster, 2018; McGregor, 2014). This often results in the systematic exclusion of Indigenous peoples from contemporary water

governance structures (Wilson and Inkster, 2018; McGregor, 2014). Thus, Indigenous leaders and scholars are exploring various alternative approaches to water governance in Indigenous territories (McGregor, 2014; Chiblow, 2020; Poelina, 2019; Charpleix, 2018; RiverOfLife et al., 2020; Wilson, 2014; Arsenaute, 2021; Fuente-Carrasco et al., 2019). This study intends to support these endeavors through a scoping review of the existing academic literature in the area. The specific objectives of the study are to (1) identify the principles of sustainable water governance in Indigenous contexts; (2) establish the challenges that Indigenous Nations face within contemporary water governance systems; and (3) synthesize Indigenous water governance models and hybrid approaches to inform a more inclusive Indigenous-driven water governance system. The overall rationale of the study objectives is to inform mainstream water actors on the need to evaluate and reform current approaches to water governance and management in Indigenous territories to shift the current water governance system towards a new approach that prioritizes Indigenous water principles, worldviews, and systems of water governance in practice.

3. Positionality statement

The researchers identify as non-Indigenous allied researchers. The team represents diversity with respect to immigrant and Canadian nationalities, people of color, and women that have shaped their lived experiences and therefore their collective perspective. The principal investigators (Schuster-Wallace and Bharadwaj) have extensive experience in research within the areas of water governance, local water security, and health in Canada and internationally. The student researchers (Kehinde and Bataebo) have considerable experience working with Indigenous nations to support them in research around water governance and health.

All researchers in this study acknowledged that their positionality has been shaped by their experiences with Indigenous nations, the Indigenous peoples they work with have supported their learnings, and the area of study in which they work. However, it is also acknowledged that their backgrounds, perceptions, and innate knowledge and value systems differ from Indigenous worldviews. As such, direct sources and quotes are used to minimize biases that may emerge from the researchers' worldviews.

4. Methodology

This scoping review represents the first phase of a project intended to explore different approaches to water resources management and governance from a First Nations perspective in Canada. It forms a basis for understanding Indigenous water management and governance in a global context. Building on this review, and in partnership with First Nation communities and water organisations, a mixed-method research design will 1) explore the recognition, application, and implementation of First Nations water governance framework within an existing approach to ending long-term drinking water advisories in First Nations across Canada; and, 2) explore development of alternative water management frameworks within the province of Saskatchewan as an initial setting (See Fig. 1).

The scoping review was based on the framework developed by (Arksey and O'Malley, 2005) and advanced by Pham et al., (2014). It included five steps: (1) Identification of the research question; (2) Identification of relevant articles; (3) Article selection; (4) Charting of the data; and, (5) Collating, summarizing, and reporting of the results. A systematic qualitative thematic and meta-theme cross-cultural analysis as described by Wutich et al. (2021) was used to analyze the data. This analytical method enables the identification of overarching themes and the inter-relationships between themes that cut across different datasets including data collected from diverse historical, political, or cultural backgrounds (Wutich et al., 2021). The information gathered from the articles was analyzed using Microsoft Excel where the data were

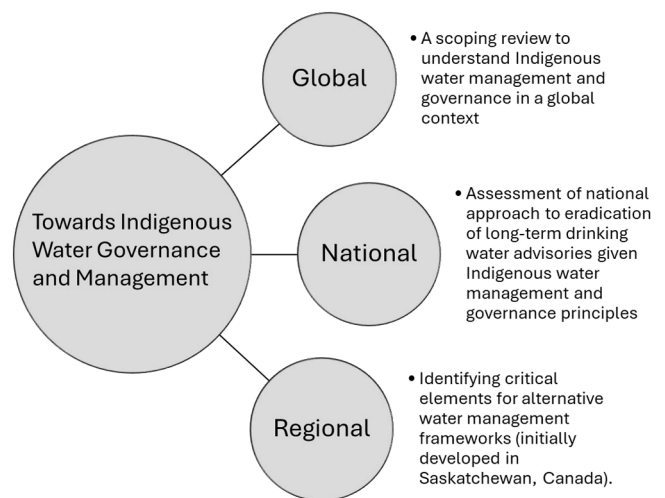


Fig. 1. Role of this review within a broader research context.

categorized into datasets based on the geographical location (Countries as shown in Fig. 2). Thereafter, themes were identified in each dataset, and meta-themes that cut across each dataset were noted. Percentages were used to normalize the data when quantitative metrics were calculated. The scoping review framework follows a systematic approach, but the steps are not linear as some of the steps were repeated to ensure accuracy.

To guide the review process, a research question was formulated by a team of researchers which consisted of the authors (two graduate students, and two professional research investigators). The research question developed for the study was: What are the principles, values, challenges/problems, and existing models of Indigenous water governance around the globe?

5. Data sources and search strategy

Key search terms (Table 1) were set based on the authors' prior knowledge. To account for the specific geographic locations of the study scope, six regions under the operation of the World Health Organization were utilized. The WHO subregions and their respective countries and specific Indigenous groups in each region were identified and included in the search terms. Web of Science and Scopus electronic databases were used to identify relevant articles. The search queries were tailored according to each specific database and conducted from January 2021 to May 2021. The same search strings were applied to the databases and the searches were programmed to include only peer-reviewed journal articles published in English between 2005 and 2021. A total of 2,541 articles were identified from the overall search and all articles were exported to Excel®. Information exported included, the article Title, Author (s), Keywords, Abstract, Journal abbreviation, Publication year, Volume, Issue, and DOI. After the initial criteria screening based on the year of publication, language, and article type, duplicates were removed manually. A total of 377 articles were retrieved after duplicate screening (Fig. 2).

Thereafter, title and abstract screenings were undertaken from June 2021 to August 2021. Title screening was undertaken in Excel®. The article titles of all 377 articles were compiled in a single excel sheet and were screened manually based on the study focus. The inclusion criteria for title screening required a focus on water governance or water management. A total of 232 articles were retrieved after title screening. The abstracts of all included articles (232 articles) were downloaded, exported into a Microsoft word document, and read for screening. Articles were selected based on the following criteria: (1) A focus on Indigenous water governance, principles or values of water governance, or management; (2) Challenges associated with Indigenous systems of

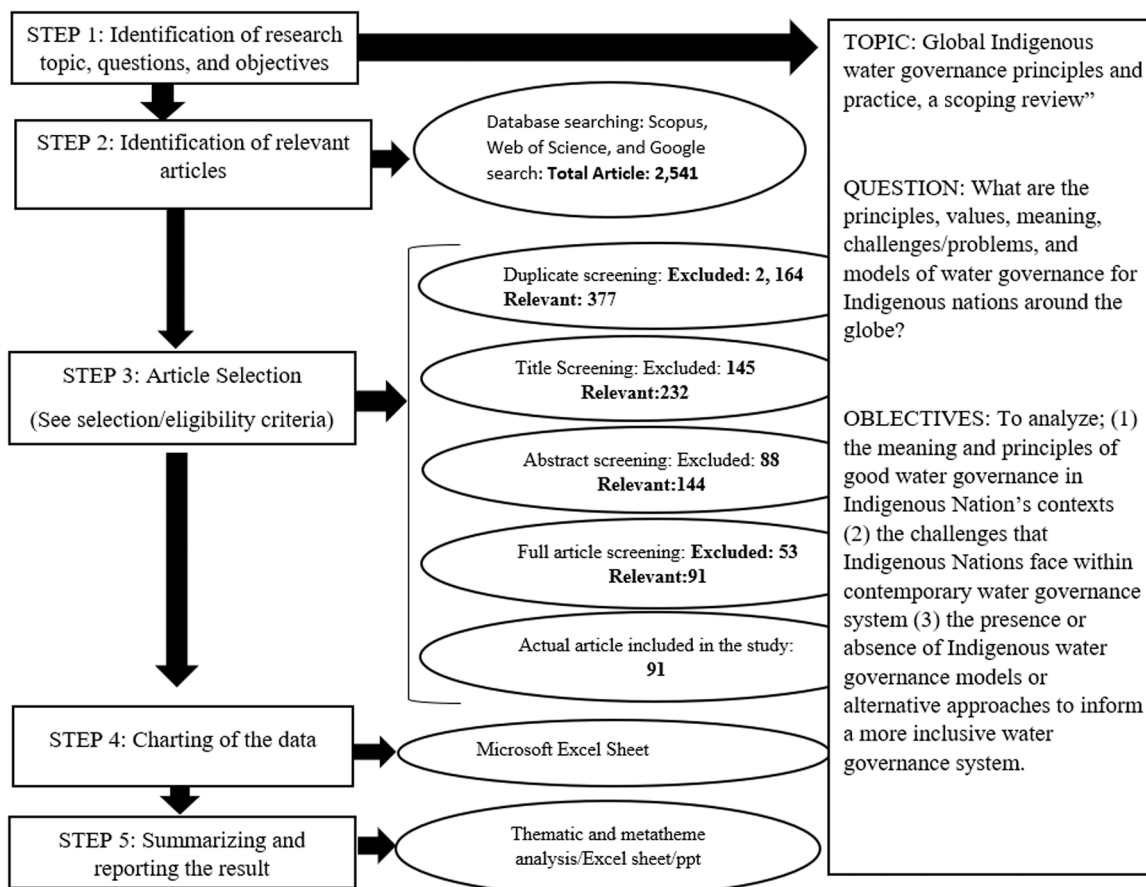


Fig. 2. Flowchart of the scoping review framework and the selection processes of the study articles.

Table 1

Key search terms used in identifying relevant articles for the study: (Search String: Key Search term (Concept A or B or C) AND Water Governance AND Indigenous name (e.g., First Nations) AND geographic location/country (eg. Canada)).

Key search terms		
Concept A:	Concept B:	Concept C:
Principles of Good Governance	Challenges to Water Governance	Solutions to promote Indigenous water governance
Good governance	Barriers	Model
Good decision making	Problem	Approach
Legitimacy	Dilemma	Collaboration
Voice	Limitation	Spirituality
Transparency	Gap	Self-governance
Accountability	Obstacle	Sovereignty
Fairness	Complexity	Autonomy
Inclusiveness	Uncertainty	Partnership
Bottom-up	Inequity	Local
Home-grown	Issue	Co-management
Participation	Divergence	Complement
Respect	Concern	Worldviews
Rule of law	Climate change	Value-driven
	Power over	Seasonality
		Holistic
		Stewardship
		Power with
		Interconnect
		Collective responsibility
		Seasonality

water governance or management practices in contemporary water governance structures; (3) An evaluation of an Indigenous and/or mainstream model of water governance; and (4) A focus on freshwater.

For articles to be included, abstracts needed to meet at least two of the above four criteria one of which had to be the focus on freshwater.

A total of 144 articles were retrieved after the abstract screening. The full text of all 144 articles was downloaded, read, and screened using a criteria matrix developed by the researchers based on the study objectives (see Table 2). Articles were considered relevant to the study if they included information on one or more of the following: 1) The principles/values of Indigenous water governance; 2) Challenges and barriers to Indigenous water governance; 3) Strategies to overcome challenges and barriers; or, 4) An evaluation of Indigenous models of water governance frameworks.

The full-text screening was conducted from September 2021 to May 2022 and a total of 91 articles were considered relevant to the study. Information retrieved during the full-text screening was documented in Excel© for analysis. Data such as the general publication information of the article, the location of the study, methods used, Indigenous groups (s), and key information relevant to the study research question and study objectives were also documented (see Table 2).

Given that research by Indigenous scholars is not always published in journals that fall within SCOPUS or Web of Science, an additional search was undertaken through the Indigenous Studies Portal Studies database. This additional search was constrained to scholarly peer-reviewed articles published from 2005 to 2021, similar to the initial search. Given the smaller number of articles included in the database, search terms were kept broad – “water governance” and “water management”. A total of 510 articles were identified (see Fig. 3) and screened following the same procedures and criteria as stated above. After title screening and elimination of duplicates, including with the initial search, 28 articles were retrieved for abstract and full-text review/screening. A total of 10 articles were considered relevant and included in the review as a result of this process.

Table 2
Full-text criteria selection matrix and data extracted from the reviewed literature.

Information on the general characteristics of the articles
Author(s)
Year of publication
Title
Journal title
Country(s) of focus
Indigenous group (when identified)
Other stakeholders identified
Methods used to collect data (e.g., Is the article a case study? Was a Community Based Participatory Research approach employed?)
Scale (local, regional, or national)
Water Focus (drinking water, rivers, lakes, wetlands, watersheds, or water in general)
Governance / Management Focus (Does the article focus on Indigenous water governance, water policy/regulations, or both?)
Driver (water challenge or governance/management issue)
Information collected based on the study objectives
Indigenous water principles/values and key element(s) to promote Indigenous governance systems
Challenges and barriers to Indigenous water governance
Strategies adopted to overcome challenges and barriers to Indigenous water governance
Solutions and recommendations to promote Indigenous systems of water governance

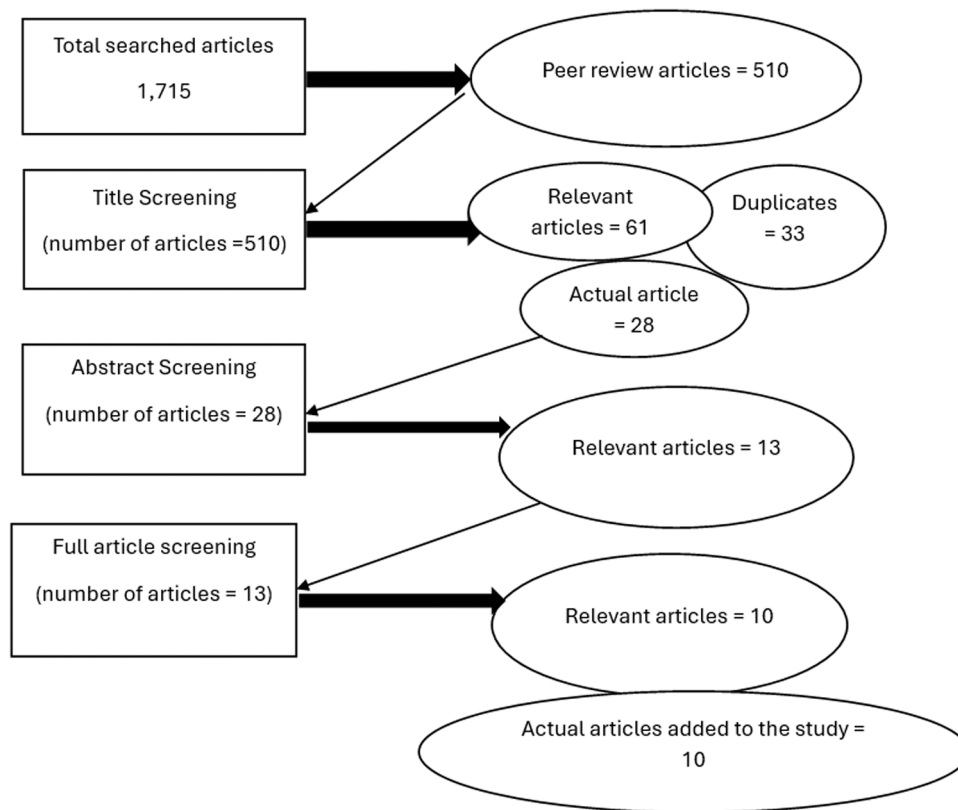


Fig. 3. Flowchart of the selection process using the Indigenous Studies Portal.

In addition, nine (9) articles that were within the scope of the study and were relevant to the objectives of the study were analyzed and included in the study. These are references identified through scholarly expertise. Notably, this does not undermine the systematic nature of the review. Rather, the inclusion of additional references helps to contextualize and enrich the overall findings.

6. Results

A total of 110 articles were included in the study. Regionally, the majority of these articles were focused on countries in North America and Oceania (33% and 47% respectively), with about 8% focused on countries in Latin America (Fig. 4). This is likely due to constraining the

search to English language publications. Also, the review focuses on articles where the term “Indigeniety” or “Indigenous” is explicitly defined. Approximately 65% of the articles were published between 2017 and 2020. Notably, the majority used qualitative methods (80%), but only about 23% of these articles specified utilization of interviews, fieldwork, community workshops, observation, or narratives. Different water sources and uses were explored in the articles, with general water resources being the dominant subject (36%), followed by rivers and lakes (45%) and watersheds (9%). Drinking water (8%), and transboundary waters were less explored (Fig. 3). Importantly, Indigenous water governance principles and critical elements for contemporary governance reform were widely reported in approximately 70% of the review articles. Barriers and challenges to Indigenous water governance were

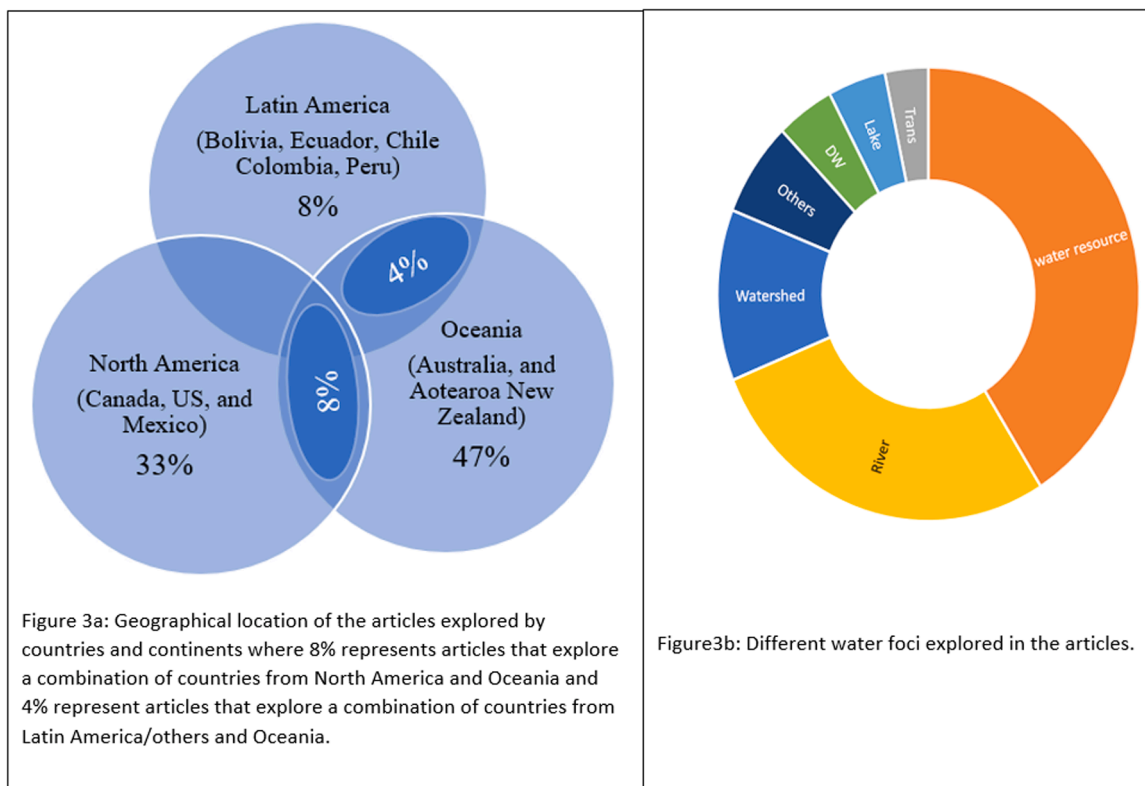


Fig. 4. A Venn diagram showing the overlap between three main geographical locations/regions of focus in the review articles (3a) and a sunburst chart representing the water foci explored in the review articles (3b).

noted across all articles, but Indigenous strategies to overcome challenges and facilitate Indigenous worldviews and systems of governance in contemporary mainstream society were only reported in about 45% of the literature reviewed.

Globally, Indigenous Peoples have complex, distinct, and diverse socio-cultural, political, economic, and spiritual relationships with water (Parsons and Fisher, 2020). For example, the Martuwarra/Fitzroy River catchment in the Kimberly region in Australia has different Indigenous groups which have different names for water and protocols for engaging with water [Laborde & Jackson, 2022]. While Peoples, languages, places, and protocols vary throughout the Martuwarra/Fitzroy River catchment, the nature of the relationships with the waters and countries are similar [Laborde & Jackson, 2022]. A research participant opined;

“All these waters have names (...) all the language groups, we all have names in the River”. These names are not simply geographical descriptors; they also convey the sentience and agency of water places within relational ontologies” (An Interview participant in Laborde & Jackson (2022])

As such, while the diversity of Indigenous peoples around the world is recognized, the results presented in this study focus mainly on the similarities that emerged across different Indigenous groups.

7. Indigenous water and water governance principles and values

Data were categorized according to water principles or water governance principles and laws (Table 3). While these vary with individual Indigenous nations’ worldviews and creation stories, similar themes emerged across the different Indigenous groups identified in the study. Indigenous water governance principles are framed from the ontology and epistemology of Indigenous traditions; place-based Traditional Knowledge that acknowledges the relational connectivity

between humans, other living things, and the environment [Charpleix, 2018; Wilson, 2014; 2020; McGregor, 2008; 2014; O’Donnell & Macpherson, 2019; Harmsworth et al., 2016; Hemming et al., 2019; RiverOfLife et al., 2021; Te Aho, 2019; Day et al., 2020]. This finding is supported by Chiblow (2020), Kamal et al., [2018], Berry et al., (2018), LaBoucane-Benson et al., (2012), and Sepulveda (2018) (See Supplementary File 1 for full bibliographic information of references in square brackets). Globally, Indigenous peoples are connected to the environment, creating a complex and inseparable interconnection between humans, water, and land. The social, kinship, cultural, and spiritual relationships between humans and water were widely reported in the literature [Fox et al., 2017; Wilson, 2014; 2020; McGregor, 2008; 2014; O’Donnell & Macpherson, 2019; Hemming et al., 2019; RiverOfLife et al., 2021; Te Aho, 2019; Sepulveda, 2018; Day et al., 2020; LaBoucane-Benson et al., 2012]. Further, water was viewed as more than a cultural construct and more than a human entity, having its own life, rights, and privileges [Ruru, 2018; O’Donnell & Macpherson, 2019; Fox et al., 2017; Wilson and Inkster, 2018; McGregor, 2008; 2014; Harmsworth et al., 2016; Hemming et al., 2019; RiverOfLife et al., 2021; Te Aho, 2019; Valladares & Boelens, 2019]. This, in part, emerges from water being the lifeblood of Mother Earth, an ancestral being, and a living and indivisible entity that must be respected, nurtured, and protected by all humans [Wilson and Inkster, 2018; Wilson, 2014, 2020; McGregor, 2014; O’Donnell & Macpherson, 2019; Fox et al., 2017; Daigle, 2018; Boelens, 2012; Day et al., 2020; LaBoucane-Benson et al., 2012; Arsenault et al., 2018; McGregor, 2008]. For example an Elder participant in Day et al., [2020] asserts, “The first mother was our sacred Mother, the Earth. The water that runs through her, runs through us” (Elder Barbara Dumont-Hill (Day et al., 2020)).

Meanwhile, the Indigenous Peoples of Aotearoa New Zealand assert:

“Waipa River, she is the lifeblood of the people. Waipa she is the lifeblood of the land, verily she is! Indeed she is the unfailing spring of the earth! She is the water that anoints the thymos of man to bind

Table 3

An overview of Indigenous water governance principles and laws. with specific examples and quotes.

Water principles that cut across the study articles	Examples and specific quotes
Water is life, lifeblood, and an ancestral being, a spiritual and sacred gift	The Waipa River Act, 2012 which informed a co-governance arrangement between the Māori iwi and the Crown; The Nga Wai o Maniapoto water principle is embedded into the Act. <i>"Waipa River, she is the lifeblood of the people. Waipa she is the lifeblood of the land, verily she is! Indeed she is the unfailing spring of the earth! She is the water that anoints the thymos of man to bind to the tribe the waters of life that issues forth from the lineage of the atua. She is the water that blesses the umbilical cord to ensure the health of the descendants of Maniapoto"</i> (The Nga Wai o Maniapoto claim; Waipa River Act 2012, Section 4 in [Ruru, 2018]). In the Martuwarra/Fitzroy River catchment in the Kimberly region (Australia), water is understood as a life force, and part of the world being created by ancestral beings that still inhabit the landscape (Jackson and Barber 2013). <i>The river "is a being, a mother, a complete and whole body comprising the water, the bed, and the banks from its source to the sea. The life of the river and thus of the tribe is in its intactness—no limb struck from its body or the head separate from the heart ... [it] looks after us throughout our lives. The river feeds us, nurtures us, and takes care of us, healing our hurts and protecting us from harm"</i> (Waikato-Tainui in Fox et al., 2016) <i>The first mother was our sacred Mother, the Earth. The water that runs through her, runs through us"</i> (Elder Barbara Dumont-Hill in (Day et al.,2020)). <i>"Spiritually we are connected to everything. We are part of the land. We are part of the water. It is part of our lifestyle. We live it. We live it every day. And we thank the Creator for all those things that is natural for us to utilize"</i> (An Indigenous Elder in Wilson, 2020). <i>"Wahkohtowin"</i> (a Cree word meaning Kinship which is an important water principle). <i>"The Barmah Lakes and the Moira Lakes are part of us, they are our kidneys"</i> (Elders of the Yorta Yorta nations in Australia in [Robinson et al., 2015]). <i>"We are the water, and the water is us; if we respect the water, we are respecting ourselves. To pollute the water is to pollute our bodies, which will eventually put our very survival at risk"</i> (An Elder participant in (LaBoucane-Benson et al., 2012)). <i>"The river is who we are and we are the river, the river is us, the river is in our veins and if our mother (river) becomes sick, then we will be sick"</i> [Research participant from Walpole Island First Nations, in Canada] [Fox et al., 2017].
Water is an indivisible entity; humans, water, and land are not separable from each other	
Water is a family relation; an extended network of kinship	
Water as medicine, with cleansing, purifying, and healing powers	
Water as a human and communal identity	
Water as more than human and non-human entities and more than a resource	
Water governance principles that cut across the study articles	Examples and quotes
Relationality- Water relationships are characterized by respect, responsibility, reciprocity, authority, rights, and privileges.	The Waikato River Settlement Act 2010 which established a co-governance arrangement between the Māori iwi and the Crown. The Waikato Indigenous water principles and water governance principles were embedded into the Act; <i>"The Waikato River is our tupuna (ancestor) which has mana (spiritual authority and power) and in turn represents the mana and</i>

Table 3 (continued)

Water principles that cut across the study articles	Examples and specific quotes
	<i>mauri (life force) of Waikato-Tainui, our relationship with the Waikato River, and our respect for it, gives rise to our responsibilities to protect te mana o te Awa and to exercise our mana whakahaere in accordance with long-established tikanga to ensure the wellbeing of the river. Our relationship with the river and our respect for it lies at the heart of our spiritual and physical wellbeing, and our tribal identity and culture"</i> (Waikato-Tainui Raupatu Claims [Waikato River] Settlement Act 2010, Section 8[3] in [Ruru, 2018]). In North America, the O-Pipon-Na-Piwin Cree Nation (OPCN), Northern Manitoba, Canada, uses the concept "Kistihmahwin" (a Cree word that means "respect for all being, both living and nonliving") as a foundational water governance principle [Kamal et al., 2018]. The concept signifies the reciprocal relationship of human and non-human beings as a community of oneness by respecting nature and the entire river system responsibly. Idle No More's (An Indigenous water movement) vision statement encapsulates the bioethical relations of humans as caretakers and stewards The Vision revolves around Indigenous Ways of Knowing rooted in Indigenous Sovereignty to protect water, air, land, and all creation [Strang, 2014]. <i>Water is a very, very powerful element, [a] grandmother and I think if we look at her that way, learn to respect her that way, then we will have life for our children"</i> (Anonymous Cree Elder from an Indigenous group in Canada in (LaBoucane-Benson et al., 2012)). To the Māori, water is the essential ingredient of life, a priceless treasure left by ancestors for the life-sustaining use of their descendants. The descendants are in turn, charged with a major kaitiaki (stewardship) duty, to ensure that these treasures are passed on in as good a state or indeed, better, to those following (1992 Waitangi Tribunal River Report in [Strang, 2014]). <i>"Our relationship with our mother the earth, the water, with all of the different plants, medicine, the herbs, the animals, the birds, all the four legged being[s]. Everything we encounter in our lives there is a relationship that we are always reminded of and are mindful about. We see ourselves belonging to the entire existence of our world; we are not separated from anything. Wahkohtowin talks about embodying that entire holistic idea of how we exist"</i> (Interview participant in [Wilson, 2020]).
Stewardship - all humans have the duty and obligation to care for and protect water.	
Intergenerational - sustainable ecological management for future generation	
Interconnectedness - humans, other living beings, water, and land are interdependent.	
Personhood - water is treated as a family relation with its own rights, authority, and privileges.	In Aotearoa New Zealand, through the enactment of the 2017 Whanganui River Claims Settlement Act and the Whanganui River Act, the Whanganui River and all tributaries, streams, lakes, and wetlands "Te Awa Tupua" (the face of the River) became a legal entity with 'all the rights, powers, duties and liabilities of a legal person'. [Ruru, 2018; Charpleix, 2018; Strang, 2014]. This recognition is an innovative landmark in the history of Māori water governance as it reasserts a founding place for Māori traditions and

(continued on next page)

Table 3 (continued)

Water principles that cut across the study articles	Examples and specific quotes
Indigenous laws and teachings Seven Grandfathers teachings	legal systems in contemporary water governance structures [Ruru, 2018]. Teachings to maintain balance and harmony with all of creation, and a way to fulfill sacred responsibilities to the Creator [Taylor et al., 2019].
Haudenosaunee law	Provides principles for responsible governance—governance founded on the understanding that all creation is interconnected and each entity has a sacred responsibility to fulfill, including water. Core principles are peace, power (unity), and righteousness and encompass relations with all creation, including land and water [Taylor et al., 2019].
Dish with One Spoon principle	Is a reminder of ‘the collective responsibility of the people to share equally’ [Taylor et al., 2019].
Warloongarri and Wunan laws	Founded on the principle that the priority of law is to protect and manage the sustainable harmony of the land over the self-interests of humans. Rivers are living [sacred] ancestral beings (the Rainbow Serpent), from source to seas, with their own “life-force” and “spiritual essence”; the “River of Life” has a “Right to Life” [O’Donnell & Macpherson, 2019; Poelina et al., 2019].

to the tribe the waters of life that issues forth from the lineage of the atua. She is the water that blesses the umbilical cord to ensure the health of the descendants descendants of Maniapoto. ‘Tis the water that permanently renders the knot of the navel cord secure and fast’ (The Nga Wai o Maniapoto claim [Waipa River Act 2012, Section 4]).

“The Waikato River is our tupuna (ancestor) which has mana (spiritual authority and power) and in turn represents the mana and mauri (life force) of Waikato-Tainui” (Waikato-Tainui Raupatu Claims [Waikato River] Settlement Act 2010, Section 8[3]).

From these perspectives and as discussed in other articles reviewed, the spiritual and health values of water were emphasized [Wilson, 2014; 2020; McGregor, 2014; O’Donnell & Macpherson, 2019; Fox et al., 2017; Daigle, 2018; Emanuel, & Wilkins, 2020; Harmsworth et al., 2016; Hemming et al., 2019; RiverOfLife et al., 2021, 2020; Te Aho, 2019; Valladares & Boelens, 2019; Day et al., 2020; LaBoucane-Benson et al., 2012]. For example, Elders of the Yorta Yorta nations in Australia assert that “the Barmah Lakes and the Moira Lakes are part of us, they are our kidneys” [Robinson et al., 2015]. A research participant from Walpole Island First Nation, Canada, opined that “The river is who we are and we are the river, the river is us, the river is in our veins and if our mother (river) becomes sick, then we will be sick” [Fox et al., 2017].

The principles of relationality, respect, reciprocity, responsibility/stewardship, intergenerational, and interconnectedness form a collective foundational framework of Indigenous water governance that was echoed across the study literature [Wilson, 2014; Poelina et al., 2019; Kamal et al., 2018; McGregor, 2014; RiverOfLife, et al., 2021; Arsenault, 2021; Taylor et al., 2019; Stewart-Harawira, 2020]. In many instances, these principles represent the sacred teachings and First Law that guide the governance and management of water in Indigenous territories [McGregor, 2014; Taylor et al., 2019; RiverOfLife, et al., 2021; Te Aho, 2010; Hemming et al., 2019; Poelina et al., 2019]. Specific examples include the Teachings of the Seven Grandfathers law [McGregor, 2014; Taylor et al., 2019], the Haudenosaunee law [Taylor et al., 2019], and the Warloongarri and Wunan laws [RiverOfLife, et al., 2021; Poelina et al., 2019]. As First People, Indigenous Peoples are custodians of the lands and waters in their territories [McGregor, 2014; Chiblow, 2020;

Wilson and Inkster, 2018; Emanuel & Wilkins, 2020; Day et al., 2020; LaBoucane-Benson et al., 2012; Boelens, 2012]. The inherent rights and duty to manage and govern the waters in their territories were reported frequently [Hemming et al., 2019; Wilson and Inkster, 2018; Moore et al., 2017; O’Donnell & Macpherson, 2019; Diver et al., 2019; McGregor, 2014; RiverOfLife, et al., 2021, 2020; Poelina et al., 2019; Hartwig et al., 2018; Day et al., 2020; LaBoucane-Benson et al., 2012; Arsenault et al., 2018; McGregor, 2008; Boelens, 2012].

Particularly in North America, the role of women in the management and governance of water was strongly highlighted by McGregor. (2008) and other Indigenous scholars [Day et al., 2020; LaBoucane-Benson et al., 2012; Arsenault et al., 2018; McGregor, 2008]. In Day et al., (2020), a First Nations participant expressed the connection between current approaches to water management and the recognition of women’s role:

“ I feel that if we empower women, communities will be in a better position to have a stronger spirit of water or a better quality of water”.

Although it was emphasized that all peoples have a collective responsibility to care for and protect water, women have a special relationship with water as Mother Earth, and their place in the management and governance of water was reported to be crucial (McGregor 2008; Day et al., 2020; LaBoucane-Benson et al., 2012; Arsenault et al., 2018). A research participant from Rainy River First Nations in Canada asserts “Everyone has a responsibility to care for the water. Women, however, carry the responsibility to talk for the water” (McGregor 2008).

Further, the recognition of rivers as a legal person to guide the management and governance of rivers was reported especially in areas of Oceania and Latin America [O’Donnell & Macpherson, 2019; Te Aho, 2019; 2010; RiverOfLife, et al., 2021; Hartwig et al., 2018; Strang, 2014; Charpleix, 2018; Stewart-Harawira, 2020; Valladares & Boelens, 2019]. For example, in Aotearoa New Zealand, through the enactment of the 2017 Whanganui River Claims Settlement Act and the Whanganui River Act, the Whanganui River and all tributaries, streams, lakes, and wetlands “Te Awa Tupua” (the face of the River) became a legal entity with ‘all the rights, powers, duties and liabilities of a legal person’ [Ruru, 2018; Charpleix, 2018; Strang, 2014]. This recognition is an innovative landmark in the history of Māori water governance as it reasserts a founding place for Māori traditions and legal systems in contemporary water governance structures [Ruru, 2018]. Similarly, underscoring the model of a legal person, in a constitutional ruling in Colombia, the Atrato River was recognized as a legal subject which was adopted to reflect the biocultural rights of Indigenous Peoples and to create a jurisdiction for Indigenous participation in water planning and governance [Macpherson, 2019].

Indigenous water governance principles emphasize the point that water is a sacred gift from the creator and that humans have a duty/responsibility to care for, protect, and respect water in a reciprocal relationship in which water, in turn, meets the needs and well-being of all humans, both present and future generations [Wilson, and Inkster, 2018; McGregor, 2014; O’Donnell & Macpherson, 2019; RiverOfLife et al., 2021, 2020; Stewart-Harawira, 2020; Day et al., 2020; LaBoucane-Benson et al., 2012; Arsenault et al., 2018; McGregor, 2008; Boelens, 2012]. For example, the Embera Katio Indigenous people in Colombia emphasize the sacredness of water as a gift from their ancestors, Karagabi. They believe that everyone has a responsibility to care for and conserve nature [Boelens et al., 2012; Jaramillo, 2011]. The respectful reciprocal relationship between humans and water was also described by Cree Elders in Canada:

“Water is a very, very powerful element, [a] grandmother and I think if we look at her that way, learn to respect her that way, then we will have life for our children”.

“We are the water, and the water is us; if we respect the water, we are respecting ourselves. To pollute the water is to pollute our bodies,

which will eventually put our very survival at risk” (LaBoucane-Benson et al., 2012)

The spiritual connection between humans and water was also expressed. Articles spoke to the complex relationship between humans and water and emphasized the interconnectedness of humans and water and water as a living spirit that is part of an extended family/kinship relationship [O’Donnell & Macpherson, 2019; McGregor, 2014; Radonic, 2017; Valladares & Boelens, 2019; RiverOfLife et al., 2021; Stewart-Harawira, 2020; Harmsworth et al., 2016; LaBoucane-Benson et al., 2012; Boelens et al., 2012]. Water is articulated as an interconnected whole that forms a greater part of a community’s life and identity [O’Donnell & Macpherson, 2019; McGregor, 2014; Radonic, 2017; Valladares & Boelens, 2019; RiverOfLife et al., 2021; Stewart-Harawira, 2020; Harmsworth et al., 2016; LaBoucane-Benson et al., 2012; Boelens et al., 2012]. For example in Aotearoa New Zealand, the Māori (although distinct) all derived their identity from the mountains, lakes and rivers [Ruru, 2018; Strang, 2014]. In describing the relationship and interconnection between water and Indigenous people in Latin America, Boelens et al., (2012), opined that water control, use, and rights are embedded in context-specific relationships that determine the values and functions of water, and these values and functions are often connected to the identity of the community. By extension, they emphasized that water, land, territory, and community form a whole that must be viewed in its entirety (Boelens et al., 2012).

Therefore, to many Indigenous Nations, poor water quality reflects damaged social relationships and cultural identity. Water governance and a focus on water security from an Indigenous perspective must consider water as a whole and as a living entity. The relationships, interconnection, and interdependence of water and Indigenous peoples must be incorporated into the current approaches to water governance and management. While contemporary water governance systems conceive of water as a commodity and a resource for human consumption, this is in direct contrast with Indigenous worldviews and fuels the exploitation of water resources in countries around the globe [McGregor, 2014; Valladares & Boelens, 2019; McLean, 2017; Arsenault et al., 2018; Yates et al., 2017; Emanuel & Wilkins, 2020; Daigle, 2018; Wilson, 2014, 2019]. The application of contemporary systems of water governance is dominant in Indigenous territories and it reinforces the mismanagement of water resources in many Indigenous nations [Valladares & Boelens, 2019; Tan & Jackson, 2013; Chambers et al., 2018; Boelens, 2008; McLean, 2017; Arsenault et al., 2018; Yates et al., 2017; Emanuel & Wilkins, 2020; Daigle, 2018; Wilson, 2019, 2020; Gibbs, 2009; Diver et al., 2019]. Thus, to resolve the persistent issue of water crises in Indigenous nations around the globe, water governance and management approaches should be framed to encompass all that water supports and all that supports water. Indigenous water principles and values, knowledge, First Laws, and customary practices require that the fishes, plants, animals, medicines, and other resources associated with water should be fully considered [O’Donnell & Macpherson, 2019; Wilson, and Inkster, 2018; McGregor, 2014; RiverOfLife et al., 2021, 2020; Stewart-Harawira, 2020; Daigle, 2018]. For example, a sector approach to water, such as a focus solely on the provision of drinking water in Indigenous communities with little attention to the overall health of the rivers, lakes, or water sources and the holistic health of communities represents an unacceptable approach to water governance and management from an Indigenous perspective [O’Donnell & Macpherson, 2019; Wilson, and Inkster, 2018; McGregor, 2014; RiverOfLife et al., 2021, 2020; Wilson, 2014; Stewart-Harawira, 2020; Daigle, 2018]. Elders of the Walalakoo Aboriginal Corporation asserted that “*Water has meaning beyond the need to drink*” [RiverOfLife et al., 2021]. Similarly, the management and provision of clean water in Indigenous communities through water treatment processes are often considered a relegation of Indigenous water principles [O’Donnell, & Macpherson, 2019; Irvine et al., 2020; Yates et al., 2017; White et al., 2012]. Water directly from the source, in its natural form, is viewed as clean and the

use of safe source water for drinking and other traditional, spiritual, economic, and social uses is an important water value to Indigenous peoples which aligned with the principles and practices of Indigenous water governance [Wilson, and Inkster, 2018; Daigle, 2018; O’Donnell & Macpherson, 2019; RiverOfLife et al., 2021].

Indigenous water governance frameworks serve as indicators of sustainable water governance practices, which have the potential to pave the way for adequate water security in Indigenous territories and countries around the globe [Te Aho, 2019; Fuente-Carrasco et al., 2019; Wilson, 2014; Kamal et al., 2018; RiverOfLife et al., 2021; Taylor et al., 2021; Jaravani et al., 2016; O’Donnell, & Macpherson, 2019; Charpleix, 2018]. For example, the emphasis that Indigenous Peoples place on relations with water and non-human entities is an ethical principle that can foster sustainable practices in contemporary water management [Jackson and Palmer, 2015]. For instance, Laborde & Jackson (2022), developed a conceptual Indigenous water governance/management model known as “Living Water” for the Martuwarra/Fitzroy River system in the Kimberly region of Australia. The model as a system shows the interconnection and relationships that exist between and amongst all people and other beings including water and non-human entities (Laborde & Jackson 2022). All relationships described in the model are reciprocal and water is conceptualized as an integral part of social and political life (Laborde & Jackson 2022). In Aotearoa New Zealand, the vision of the Waikato River Acts that seeks to restore the health and well-being of the River is premised on the understanding that the Waikato River is an ancestor. This fosters sustainability in Indigenous water management frameworks and constrains exploitative human behavior in decision-making processes in water governance discourse [Ruru, 2018; Te Aho, 2010].

Our relationship with the Waikato River, and our respect for it, gives rise to our responsibilities to protect te mana o te Awa and to exercise our mana whakahaere in accordance with long-established tikanga to ensure the wellbeing of the river. Our relationship with the river and our respect for it lies at the heart of our spiritual and physical wellbeing, and our tribal identity and culture’ (Waikato-Tainui Raupatu Claims [Waikato River] Settlement Act 2010, s. 8[3])”.

The O-Pipon-Na-Piwin Cree Nation (OPCN), Northern Manitoba, Canada, uses the concept Kistihmahwin (a Cree word that means “respect for all being, both living and nonliving”) as a foundational water governance principle [Kamal et al., 2018]. The concept signifies the reciprocal relationship of human and non-human beings as a community of oneness by respecting nature and the entire river system responsibly. Also, the Walalakoo Aboriginal Corporation (WAC) (Australia) developed an Indigenous cultural water governance framework in 2018 known as “Living Water, First Law” [RiverOfLife et al., 2021]. This governance framework was developed in response to a consultation of a groundwater allocation plan run by the Western Australian Department of Water and Environmental Regulation (DWER) [RiverOfLife et al., 2021]. The “Living Water, First Law” cultural water governance frameworks reflect Indigenous water principles, laws, and legal orders and it is centered on the values, ethics, and rules of co-existence between humans and the environment (including water) [RiverOfLife et al., 2021]. However, notwithstanding or perhaps despite the effectiveness of these governance frameworks, the reproduction of colonial practices in the governance and management of water resources is dominant. The successful implementation of Indigenous water governance practices and concepts is often hindered by the existing structure of contemporary water governance. In the case study of the OPCN, the concepts of Kistihmahwin are often excluded in the decision-making processes in Hydro projects in Northern Manitoba, even when the community is being affected by such projects [Kamal et al., 2018]. For instance, in the operation of the Churchill River Diversion (CRD) hydroelectric project, meaningful and prior informed consent of the OPCN was not sought in the decision-making processes [Kamal et al., 2018]. The operation of the project led to the forceful relocation of the community (OPCN) due to

flooding [Kamal et al., 2018]. Also, although, "Living Water, First Law" cultural governance frameworks contributed to the practices of water management in the Fitzroy River Catchment in Western Australia [Poelina et al., 2019; RiverOfLife et al., 2021], the 2004 National Water Initiative (NWI) governance framework remains dominant in water governance discourse in Australia [RiverOfLife et al., 2021].

8. Strategies adopted to facilitate Indigenous water governance systems

The literature reveals the inconsistency and incompatibility between the ontological frameworks of Indigenous water governance systems and the existing contemporary governance frameworks [Chamber et al., 2018; Bark et al., 2012; Moore et al., 2017; Diver et al., 2019; Fuente-Carrasco et al., 2019; Wilson, 2020; McGregor, 2014; Arsenault, 2021; Von Der Porten and De Loë, 2014; Gibbs, 2010; Valladares, C., & Boelens, R. 2019; Boelens et al., 2012] (See supplementary file for more references; [90, 85, 86, 77, 18, 22, 59, 60, 64, 71]). This challenges the effective implementation of Indigenous water governance practices and water management approaches and constrains the responsibility of Indigenous peoples to govern their water resources. However, strategies employed by Indigenous peoples to assert their inherent rights to self-governance over water were reported in 32% of the study articles (Table 4). Indigenous peoples are re-politicizing water governance by rejecting the mainstream processes of water governance and creating interventions to insert themselves into the contemporary governance system with the aim of shifting the authority of governance [Arsenault et al., 2018; RiverOfLife et al., 2021; McGregor, 2014; Fox et al., 2017; Poelina et al., 2019; Perreault, 2008; Curran, 2019].

Several mechanisms are being implemented to this end. Indigenous groups are being formed to create a unified voice and a more inclusive and pluralistic water governance system [RiverOfLife et al., 2020; 2021; Arsenault, 2021; Curran, 2019; Hoogesteger & Verzijl, 2015; Fuente-Carrasco et al., 2019]. For example, in Australia, the Cultural Water Paradigm is a framework of water management in the Murray-Darling Basin (MDB) developed by Indigenous leaders to address the ongoing exclusion of Indigenous peoples in the MDB [O'Donnell et al., 2023; Jackson et al., 2021] (Table 5). The Ngarandjeri Nation in the Lower Lakes and Murray Mouth region of the MDB employed innovative strategies such as negotiations of co-governance relationships with the South Australian government under this framework. This negotiation and subsequent agreements positioned the Ngarandjeri Nation in a Leader-to-Leader interactive relationship with government agencies and mainstream water actors in Southern Australia [Jackson et al., 2021].

Across the studied articles, the continuous assertion of Indigenous title and rights, and the use of water declarations, protests, community mobilization, court litigations, and UNDRIP to legitimize Indigenous water rights and governance systems were widely reported [Arsenault et al., 2018; RiverOfLife et al., 2021; McGregor, 2014; Te Aho, 2019; Arsenault, 2021; Fox et al., 2017; Poelina et al., 2019; Daigle, 2018; Middleton-Manning et al., 2018; Radonic, 2017; Valladares & Boelens, 2019]. For instance, in a fight to protect the Medicine Lake Highlands

(MLH) from geothermal development and to assert their right to protect their lands and water, the Pit River Tribe in California, United States, employed a series of court litigations and also petitioned the federal government (at the United Nations Committee on Human Rights) to abide by UNDRIP and honor its promise to respect the rights of Indigenous Peoples to protect their territory and traditional way of life (Middleton-Manning et al., 2018). However, despite years of litigations and fights for meaningful co-management relationships, the issue remains unresolved, and the Indigenous People of Pit River are in a continuous struggle to protect the MLH and their territory (Middleton-Manning et al., 2018).

In Latin America, struggles to defend water access and rights through community mobilization protests and the development of grassroots organizations were major strategies used to promote local and Indigenous water rights and governance systems [Perreault, 2008; Boelens, 2008; Hoogesteger & Verzijl, 2015; Valladares & Boelens, 2019; Fuente-Carrasco et al., 2019]. The Water War in Bolivia (2000) and the Indigenous mobilization protest in Ecuador (1994, 1996, and 1998) are strategies and struggles that facilitated changes in contemporary water legislation and established local Indigenous organizations in many Andean countries including Ecuador, Peru, and Bolivia [Boelens, 2008]. For example, the 1994 Indigenous mobilization protest in Ecuador reversed the neoliberal Agrarian Development law that proposed the privatization of water and land rights [Boelens, 2008]. Also, in 1998, Ecuador's Indigenous mobilization protest influenced the reform of the national Constitution which led to the reform of several neoliberal policies, and the recognition of Indigenous collective rights, cultural pluralism, and forms of Indigenous/local self-governance [Boelens, 2008]. The Embera Katio in Colombia also employed violent protest, social mobilization, and political and legal actions to defend their territory/water from hydropower development (Boelens et al., 2012). With a protest march of 700 Kilometers by 700 Embera Katio people, the office of the Ministry of Environment was temporarily occupied until an agreement was signed with the hydropower company after several months (Boelens et al., 2012).

Indigenous peoples, especially in North America and Oceania have employed a collaborative co-management approach as a means to insert themselves into the contemporary governance system with a mandate to promote Indigenous worldviews and governance systems in relation to State agencies [Diver et al., 2019; Wilson, 2019; 2020; Latta, 2018; Arsenault, 2021; Hemming et al., 2019; RiverOfLife et al., 2021; Poelina et al., 2019; Memon & Kirk, 2012; Charpleix, 2018 Yates et al., 2017; Pirsoul & Armoudian, 2019; Jackson & Nias, 2019]. In many cases, collaborative and co-governance arrangements through the spirit and intent of historical and modern treaty negotiations, settlement agreements, modern land claims, and self-government agreements were predominant [Diver et al., 2019; Wilson, 2019; 2020; Latta, 2018; Arsenault, 2021; Hemming et al., 2019; RiverOfLife et al., 2021; Poelina et al., 2019; Memon & Kirk, 2012; Charpleix, 2018 Yates et al., 2017; Jackson & Nias, 2019; Pirsoul & Armoudian, 2019]. Several of the study articles reveal existing models of collaborative water governance and co-governance arrangements that are framed as strategies to support Indigenous water governance principles, promote Indigenous rights to

Table 4

An overview of the strategies employed by Indigenous peoples to facilitate the Indigenous system of water governance ((Refs [3, 6, 7, 8, 10, 11, 13, 15, 20, 21, 23, 22, 27, 30, 32, 47, 49, 55, 59, 60, 64, 72, 80, 82, 83, 87, 88, 91]).

Indigenous strategies to overcome dominant water governance challenges
Re-politicizing water governance
Settlement agreements and assertion of treaty rights
Court litigation
Assertion of aboriginal title and rights
UNDRIP
Water declaration/exploration of Indigenous laws and customs
Community protest and mobilization (Example, Boelens et al., 2012) Self-organization
Involvement in water governance research

Table 5
A synthesis of existing Indigenous water governance framework case studies.

Case studies of existing Indigenous water governance frameworks highlighted in the review	Findings from review articles
“Cultural Water” Framework in the Murray-Darling Basin (MDB), Australia.	<p>This framework (Cultural Water Paradigm) informed a pluralistic water governance structure as it includes water for economic development which overlaps with, but is not the same as, the contemporary notion of resource development or capitalist commercialization [O’Donnell et al., 2023; Jackson et al., 2021].</p> <p><i>“Within the paradigm, First Nations are empowered to assert their rights to care for and make decisions about water, establishing a foundation for transformational change in water-management policy in a contemporary context. Although yet to be applied in full, elements of the paradigm are already demonstrating the power of Indigenous-led, holistic water management [O’Donnell et al., 2023]”.</i></p> <p>The Cultural Water Paradigm creates awareness about Indigenous titles and rights, increases the voices of Indigenous Australians, fosters the inclusion of Indigenous peoples in government offices, water policies, and programs, and facilitates several strategies that empower Australian Indigenous peoples, traditional land owners, communities, and Nations [Jackson, et al., 2021; O’Donnell et al., 2023]. For instance, through the “Cultural Water” framework the Ngarrandjeri Nation in the Lower Lakes and Murray Mouth region of the MDB employed innovative strategies such as negotiations of co-governance relationships with the South Australian government. This negotiation and subsequent agreements positioned the Ngarrandjeri Nation on a Leader-Leader interactive relationship with government agencies and mainstream water actors in Southern Australia [Jackson et al., 2021].</p>
The Yukon First Nations co-governance arrangement in the Yukon Territory, Canada.	<p>In Canada, the modern land claim and self-government agreement, (Yukon Umbrella Final Agreement (UFA)), signed by Yukon First Nations and the Federal government created a co-governance arrangement that acknowledges Yukon First Nations as governments with province-like powers rather than bands under the 1985 Indian Act [Wilson, 2019; 2020]. The Yukon modern land claim and self-government agreement allow Yukon First Nations to manage and protect water on Settlement lands, create local legislation and regulations, and participate in decision-making processes on issues concerning water and lands within their territories [Wilson, 2019; 2020]. Yukon First Nations have the authority to enact legislation for the use and occupation of settlement lands and to levy fees for the use of lands (Wilson, 2019; 2020). They (Yukon First Nations) have the authority to develop and administer environmental/land management programs and the right to make decisions that reflect their inherent rights, legal orders, and relationship to water and to protect water for traditional use both on and off Settlement Lands (Wilson, 2019; 2020). Also, Yukon First Nations have the right to water which substantially remain unaltered as to the quantity, quality, and</p>

Table 5 (continued)

Case studies of existing Indigenous water governance frameworks highlighted in the review	Findings from review articles
The Treatment As a State” (TAS) co-governance framework between the US governments and States-recognise Native American tribes	<p>rate of flow, including seasonal rate of flow” (Wilson, 2019; 2020). However, critiques of the water co-governance arrangement in the Yukon Territory (Canada) described the arrangement as a reflection of the colonial system of governance [Wilson, 2019; 2020]. Participating First Nations operate in a system of water governance outside the traditional framework as Indigenous leaders were not able to negotiate agreements that reflect their inherent authority as custodians of their waters [Wilson, 2019; 2020]. Yukon First Nations’ co-governance agreements fail to adequately reflect their water principles, ontologies, epistemologies, and system of governance and were subjected to the ‘Laws of General Application’ including the Yukon Waters Act (2003), which asserts that, “Water belongs to the Crown”. [Wilson, 2019; 2020]. Water is widely viewed as a resource, and Yukon First Nations’ relationships to water were framed with property rights. The Yukon Water Board, (a body responsible for the management of water resources in the territory), and other co-management boards in the territory are mandated to evaluate traditional knowledge and scientific knowledge as equal consideration in decision-making processes [Wilson, 2019; 2020]. This assertion reduces Indigenous knowledge to data and fails to reflect First Nations’ relationships to water and since the dominant water actors are government scientists and administrator experts that conform to their training, traditional knowledge is often pushed to the side during final decision-making processes (Natcher and Davis, 2007).</p> <p>The “Treatment As a State” (TAS) framework under the US Clean Water Act (CWA). This model allows eligible Native American tribes to advance tribal self-determination and responsibilities as state governments in setting and implementing water quality standards [Diver et al., 2019]. Native American tribal governments can incorporate traditional and/or ceremonial uses and can implement water quality standards that are more stringent than those of neighboring states and tribes (Diver et al., 2019). The TAS enables Native tribes to assert their rights to govern and protect water within their traditional lands [Diver et al., 2019]. The US Treatment as a State (TAS) water governance framework has been criticized [Diver et al., 2019]. Only tribes recognized by the State are eligible to benefit from the TAS framework, thereby, limiting the inherent rights of other tribes [Diver et al., 2019].</p>
The Whanganui and Waikato Rivers Co-governance framework between the Māori and the Crown in Aotearoa New Zealand	<p>in Aotearoa New Zealand, through the renegotiation of the 1840 Treaty of Waitangi between 2002 and 2014, the Whanganui and Waikato Rivers Settlement Claim Agreements were signed between the Crown and Maori iwi [Strang, 2014; Charpleix, 2018; Muru-Lanning, 2012]. The agreements promote collaboration and establish a co-governance arrangement with an equal partnership between the</p>

(continued on next page)

Table 5 (continued)

Case studies of existing Indigenous water governance frameworks highlighted in the review	Findings from review articles
	<p>Crown and Maori tribal governments [Strang, 2014; Charpleix, 2018; Muru-Lanning, 2012]. The Whanganui River Settlement Act which was passed into legislation in 2017 emphasizes the sacred relationships between the river and Maori tribes and declares that the River is a legal person with all the rights, duties, powers, and liability of a person [Ruru, 2018; Strang, 2014].</p> <p>Under the Waikato River Settlement Act (2010), the integrity of the river and the right of the river to be healthy for its own sake was a central piece of the Act [Ruru, 2018; Strang, 2014; Muru-Lanning, 2012]. The river was recognized as an ancestor with its own life force [Ruru, 2018; Strang, 2014]. The Whanganui and Waikato Rivers Settlement Claim Agreements are revolutionary and are global landmarks in the recognition of Indigenous water governance [Ruru, 2018]. These agreements serve as a contemporary strategy and solution that attempts to genuinely recognize and create a space for Indigenous systems of water governance alongside contemporary governance structure in Aotearoa New Zealand [Ruru, 2018].</p> <p>However, the Te Awa Tupua (the face of the Whanganui River) model of co-governance arrangement in which the Whanganui River was granted the rights and privileges of a person has also been criticized [Strang, 2014; Charpleix, 2018; Stewart-Harawira, 2020]. The Te Awa Tupua Act is considered a political compromise, allowing no ownership of the river as a “whole” and its accounting of multiple stakeholders may result in legal pursuits that may undermine Indigenous legitimacy [Strang, 2014; Charpleix, 2018; Stewart-Harawira, 2020]. The Act carved up the river into different proprietary regimes where the riverbed is separated from the water, which negates the Indigenous principle that views water as an indivisible entity [Strang, 2014; O’Donnell & Macpherson, 2019].</p> <p>Further, Muru-Lanning, (2012) criticized the Waikato River Settlement collaborative management and co-governance arrangement between the Maori and the Crown (Aotearoa New Zealand) as a political compromise and a stage for Crown domination.</p>

self-determination, decolonize Indigenous-State relationships, create a space for co-existence, and strengthen Indigenous traditions and legal orders [Diver et al., 2019; Wilson, 2019; 2020; Latta, 2018; Arsenault, 2021; Hemming et al., 2019; RiverOfLife et al., 2021; Poelina et al., 2019; Memon & Kirk, 2012; Charpleix, 2018 Yates et al., 2017; Barrett et al., 2019]. For example, In Canada, the modern land claim and self-government agreement, (Yukon Umbrella Final Agreement (UFA)), signed by Yukon First Nations and the Federal government created a co-governance arrangement that acknowledges Yukon First Nations as governments with province-like powers rather than bands under the 1985 Indian Act [Wilson, 2019; 2020] (Table 5). The “Treatment As a State” (TAS) model under the US Clean Water Act (CWA) allows eligible Native American tribes to advance tribal self-determination and responsibilities as state governments in setting and implementing water

quality standards [Diver et al., 2019] (Table 5). Similarly, in Aotearoa New Zealand, the Whanganui and Waikato Rivers Settlement Claim Agreements signed between the Crown and Māori iwi establish a co-governance arrangement [Strang, 2014; Charpleix, 2018; Muru-Lanning, 2012] (Table 5). The Whanganui and Waikato Rivers Settlement Claim Agreements are revolutionary and are global landmarks in the recognition of Indigenous water governance [Ruru, 2018]. These agreements serve as a contemporary strategy and solution that attempts to genuinely recognize and create a space for Indigenous systems of water governance alongside the contemporary governance structure [Ruru, 2018].

Further, with the increasing awareness of the use of research to further Indigenous dispossession, many Indigenous nations are engaging in research projects to assert their worldviews and reconfigure the ideologies of current water governance frameworks [Leonard et al., 2023; Robbinson et al., 2015; Arsenault, et al., 2018; Jackson, & Barber, 2013; Arsenault, et al., 2018; Hartwig et al., 2018; Jackson, & Palmer, 2012; Jackson et al., 2021; O’Donnell et al., 2022, 2023; Taylor et al., 2016]. In areas of North America and Oceania, especially in countries where treaty agreements were not signed, the continuous involvement of Indigenous peoples in mainstream water management and governance projects including research projects was reported as a means to insert Indigenous worldviews into contemporary water governance systems ([Jackson et al., 2021; O’Donnell et al., 2023; Maclean & Inc, 2015; Chiblow, 2020; Diagle, 2018]. For example, unlike other colonial states, the lack of treaty agreements in Australia shapes the water law and ways in which Indigenous peoples engage with mainstream water governance discourse. Indigenous Peoples in the MDB are gradually penetrating the dominant system of water governance as communities continue to campaign for the recognition of inherent water rights, advocate for the protection of their ancestral waterscapes, engage in water assessments and research, develop policy options and programs [Jackson et al., 2021].

Indigenous leaders and scholars are also using research to privilege the epistemologies and ontologies of Indigenous water governance with the aim of shifting the current approaches to water governance within Indigenous communities (Leonard et al., 2023; Arsenault, et al., 2018; McGregor, 2014; Poelina et al., 2019; Te Aho, 2019; Diver et al., 2019; Wilson, 2019; 2020; Latta, 2018; Arsenault, 2021; Hemming et al., 2019; RiverOfLife et al., 2021; Charpleix, 2018 Arsenault, et al., 2018; Taylor et al., 2016). For example, “Water Back” is an Indigenous research framework coined from the Land Back, Water Back Indigenous Declaration, and Activist Movement (Leonard et al., 2018). This research framework centers on Indigenous epistemologies and ontologies as a strategy for advancing Indigenous sovereignty in water research (Leonard et al., 2018)

9. Barriers and challenges to Indigenous water governance

While the various Indigenous strategies outlined above, including the existing Indigenous-State water governance models and frameworks identified in the study articles, are innovative strategies and pathways towards Indigenous inclusion in contemporary water governance, challenges and barriers of these models/frameworks to strengthen Indigenous self-determination and decolonize colonial legacies were reported in all the reviewed literature [Table 6]. The relegation of Indigenous customs, knowledge, laws, worldviews, and system of governance including the poor recognition of aboriginal title and rights to self-determination were reported [Wilson, 2019; 2020; McGregor, 2014; Daigle, 2018; Diver et al., 2019; O’Donnell, 2023; Jackson et al., 2021; Parsons and Fisher, 2020; Strube & Thomas, 2021; Bark et al., 2012; Perreault, 2005; Moore et al., 2013; Norman, 2012; Simms et al., 2016; Irvine et al., 2020.; Arsenault, 2021]. These challenges are often associated with colonization and settlers’ dominant supremacy complex, especially in Canada and the USA, Aotearoa New Zealand, Australia, and Latin America [Taylor et al., 2019; Daigle, 2018; Gibbs, 2009; 2010;

Table 6

An overview of the challenges and barriers to practicing the system of Indigenous water governance in countries around the globe (Refs: [1–91]).

Challenges to Indigenous water governance (meta theme analysis)
Colonization
Crown assertion/jurisdiction over all surface and groundwater
Eurocentrism, the view of water as a resource, resource development, and exploitation
Institutional barriers and legislation
Power inequalities
Conflicting interests, ontologies, and value systems
Indigenous customary relegation, rendering Indigenous knowledge and worldviews invisible
Lack of funding/capacity
Poor recognition of Indigenous title and rights, (rights to sovereignty and self-determination), knowledge and worldviews
Poor engagement and consultation practices
Limited participation
Lack of trust and transparency

Wilson, 2019; 2020; Hartwig et al., 2020; Valladares & Boelens, 2019; McLean, 2017; Boelens, 2008; White et al., 2012; Yates et al., 2017; Von Der Porten & De Loë, 2017; Tan & Jackson, 2013]. The issues of Eurocentrism and crown assertion of ownership, control, and jurisdiction over all surface and groundwater were highlighted. Also, the view of water as a resource and the commodification of water was reported as a central and core orientation of mainstream water governance systems including co-governance and collaborative water governance arrangements [Te Aho, 2010; Taylor et al., 2019; Daigle, 2018; Gibbs, 2009; 2010; Wilson, 2019; 2020; Hartwig et al., 2020; Valladares & Boelens, 2019; McLean, 2017; Boelens, 2008; White et al., 2012; Yates et al., 2017; Von Der Porten & De Loë, 2017; Tan & Jackson, 2013].

Jurisdictional contestation, conflicting interests, institutional barriers, existing water legislation, resource development, and power inequalities were concerns that emerged as associated with colonial water governance structures [Diver et al., 2019; Wilson, 2020; Gibbs 2009; Parsons et al., 2019; Douglas et al., 2019; Taylor et al., 2019; Valladares & Boelens, 2019; Tan & Jackson, 2013; Bischoff-Mattson et al., 2018; Simms et al., 2016]. For example, in Laborde & Jackson (2022), the innovative models developed for the Martuwarra/Fitzroy River catchment in Australia help reveal the fundamental issue of Jurisdiction which continues to block the genuine/legitimate process of collaboration of water management in the catchment. Also, globally, the Organization for Economic Cooperation and Development's (OECD) water governance principles and governance indicators for contemporary water governance (Organization for Economic Co-operation and Development, 2015) create a continuous barrier to promoting Indigenous water governance practices [Taylor et al., 2019]. The article indicates that the OECD governance principles assume state authority over all water resources, view water as a resource, and make Indigenous water governance systems invisible, perpetuating the discourses of water colonialism [Taylor et al., 2019].

In addition, neoliberalism was widely reported in areas of Oceania and Latin America [Chambers et al., 2018; McLean, 2017; Valladares & Boelens, 2019; Hohl et al., 2021; Boelens, 2008; Perreault, 2005; Hoo-gesteger & Verziil, 2015; Mascarenhas, 2007; O'Donnell et al., 2023]. Neoliberalism supports the marketing of water, including the processes of privatization, and commodification of water [McLean, 2017; Valladares & Boelens, 2019; Mascarenhas, 2007]. For example, The 2004 National Water Initiative (NWI) (a fundamental piece of legislation that formed an integral part of the water governance framework in Australia), supports a nationally-compatible marketing regulatory, and planning-based system of water management that optimizes the economic, social, and environmental uses of water (O'Donnell et al., 2022). Also, major efforts to conserve water for the environment in MDB in Australia include water marketing and water delivery efficiency (O'Donnell et al., 2023). The adoption of neoliberalism in the management and governance of water reinforces the logic of settler colonialism as water is categorized as a commodity to be sold and exploited for economic gain [McLean, 2017; Valladares & Boelens, 2019; O'Donnell et al., 2022, 2023]. The social, spiritual, and cultural

dimensions of water are often relegated, and water users are signified as customers/stakeholders [Chambers et al., 2018; Valladares & Boelens, 2019; O'Donnell et al., 2022, 2023; Mascarenhas, 2007]. Ultimately, the notion of neoliberalism strips Indigenous peoples of their inherent rights to govern water according to the principles and practices of Indigenous water governance [Strube & Thomas, 2021; Mascarenhas, 2007; Chambers et al., 2018; Valladares & Boelens, 2019; Perreault, 2005; Boelens, 2008]. Mascarenhas (2007) described neoliberalism as a new "style" of ecological, economic, and environmental colonialism orchestrated by Settlers to further undermine the capability of Indigenous peoples to counter complex forms of environmental injustices including the struggles to care for and protect water. For example, in Ecuador, the recognition of Nature's rights as a more than human entity was embedded in Ecuador's Constitution as an acknowledgment of Indigenous water rights [Valladares & Boelens, 2019]. At almost the same time, the Ecuadorian government began promoting privatization and resource development, such as mining, as central to Ecuador's future [Valladares & Boelens, 2019]. This contradiction undermines the legitimate right of the Ecuadorian Indigenous peoples to govern their water resources.

Thus, even in cases where Indigenous self-determination, water principles, and governance systems were recognized and adopted by governments and mainstream water actors, the premises of such a framework are often located within the regulatory system of the mainstream colonial water governance structure [Bark et al., 2012; Cosens & Chaffin, 2016; Von der Porten and De Loë, 2013; Diver et al., 2019; Wilson, 2019; 2020; Kamal et al., 2018; Chambers et al., 2018; Valladares & Boelens, 2019; Hughey et al., 2017; Laborde & Jackson, 2022]. Decision-making processes and management frameworks followed the scientific and technical Eurocentric pattern, perpetuating colonial foundations [Wilson, 2019; 2020; Diver et al., 2019; Kamal et al., 2018; Chambers et al., 2018; Valladares & Boelens, 2019; Grafton et al., 2020; Bark et al., 2012; Cosens & Chaffin, 2016]. The use of science in making decisions and the relegation of Indigenous knowledge as a non-valid basis for decision-making were identified as an ongoing issue of settler's dominant supremacy complex and colonial legacy [Wilson, 2019; 2020; Diver et al., 2019; Jackson & Barber, 2013; Lyons & Barber, 2021; Fisher, & Parsons, 2020 Jackson, 2019]. In most examples of collaborative and co-governance water governance arrangements reported in the review, water governance in Indigenous territories was reported often to fall short of nation-to-nation relationships in real-life decision-making processes [Wilson, 2019; 2020; Diver et al., 2019; Strang, 2014; Kamal et al., 2018; Chambers et al., 2018; Valladares & Boelens, 2019]. Indigenous participation was reported as limited and restrictive with regard to who could participate in the conversation as well as their influence on the overall final decision [Wilson, 2019; 2020; Escott, et al., 2015; Bark et al., 2012; Von der Porten and De Loë, 2013; Diver et al., 2019; Kamal et al., 2018; Chambers et al., 2018; Jackson & Nias, 2019]. For example, in the collaborative planning/management arrangement for the Martuwarra/Fitzroy River catchment in Australia, while the importance of protecting Indigenous cultural values was acknowledged

in the water allocation process, Aboriginal custodians were positioned as stakeholders to be consulted, rather than custodians and Nations with management responsibilities and decision-making power [Laborde & Jackson 2022; [RiverOfLife et al., 2021](#)]. Also, critiques of the water co-governance arrangement in the Yukon Territory (Canada) described the arrangement as a reflection of the colonial system of governance [[Wilson, 2019, 2020](#)]. Participating First Nations operate in a system of water governance outside the traditional framework as Indigenous leaders were not able to negotiate agreements that reflect their inherent authority as custodians of their waters [[Wilson, 2019, 2020](#)]. Yukon First Nations' co-governance agreements fail to adequately reflect their water principles, ontologies, epistemologies, and system of governance and were subjected to the 'Laws of General Application' including the Yukon Waters Act (2003), which asserts that, "Water belongs to the Crown". [[Wilson, 2019, 2020](#)]. Water is widely viewed as a resource, and Yukon First Nations' relationships to water were framed with property rights. The Yukon Water Board, (a body responsible for the management of water resources in the territory), and other co-management boards in the territory are mandated to evaluate traditional knowledge and scientific knowledge as equal consideration in decision-making processes [[Wilson, 2019, 2020](#)]. This assertion reduces Indigenous knowledge to data and fails to reflect First Nations' relationships to water and since the dominant water actors are government scientists and administrator experts that conform to their training, traditional knowledge is often pushed to the side during final decision-making processes ([Natcher and Davis, 2007](#)). Similarly, the US Treatment as a State (TAS) water governance model has been criticized [[Diver et al., 2019](#)]. Only tribes recognized by the State are eligible to benefit from the TAS framework, thereby, limiting the inherent rights of other tribes [[Diver et al., 2019](#)]. In Aotearoa New Zealand, the Te Awa Tupua (the face of the Whanganui River) model of co-governance arrangement in which the Whanganui River was granted the rights and privileges of a person has also been criticized [[Strang, 2014; Charpleix, 2018; Stewart-Harawira, 2020](#)]. The Te Awa Tupua Act is considered a political compromise, allowing no ownership of the river as a "whole" and its accounting of multiple stakeholders may result in legal pursuits that may undermine Indigenous legitimacy [[Strang, 2014; Charpleix, 2018; Stewart-Harawira, 2020](#)]. The Act carved up the river into different proprietary regimes where the riverbed is separated from the water, which negates the Indigenous principle that views water as an indivisible entity [[Strang, 2014; O'Donnell & Macpherson, 2019](#)]. Further, Muru-Lanning, (2012) criticized the Waikato River Settlement collaborative management and co-governance arrangement between the Māori and the Crown (Aotearoa New Zealand) as a political compromise and a stage for Crown domination.

Ineffective consultation, participation, and engagement processes relating to current water management and governance approaches in Indigenous territories were noted as a continuous challenge to collaborative and co-governance systems [[Moore et al., 2017; Emanuel & Wilkins, 2020; Wilson, 2019, 2020; Hart et al., 2019; Douglas et al., 2019; Barber & Jackson, 2012; Cosens & Chaffin, 2016; Simms et al., 2016; Mascarenhas 2007; Jackson et al., 2019](#)]. The engagement of Indigenous peoples as stakeholders or interest groups instead of a nation-to-nation relationship was mentioned across the included articles [[Yates et al., 2017; Wilson, 2019;2020; Diver et al., 2019; Moore et al., 2017; Emanuel & Wilkins, 2020; Curran, 2019; Von der Porten and De Loë, 2013](#)]. In most cases, consultation, participation, and engagement processes are often initiated with Indigenous communities at the final stage of decision-making [[Moore et al., 2017; Emanuel & Wilkins, 2020; Strube & Thomas, 2021; Curran, 2019 Boelens et al., 2012](#)]. Similarly, the unwillingness to unsettle existing colonial authorities and legislations in the current water governance system discourages effective participation for both Indigenous leaders and, government water actors including private stakeholders [[Wilson, 2019; 2020; Valladares & Boelens, 2019; Diver et al., 2019](#)]. While consultation processes are often limited to mitigation and impact benefits, the cultural, social, and

spiritual principles of Indigenous water governance are rarely included [[Emanuel & Wilkins, 2020; Boelens et al., 2012; Von der Porten and De Loë, 2013; Moore et al., 2017; Strube & Thomas, 2021; Daigle, 2018; Wilson, 2014](#)]. Thus, participation, consultation, and engagement processes often reify the colonial form of water governance while entangling Indigenous peoples in a pattern of dispossession. More so, a lack of trust and transparency was noted as an issue in effective participation, consultation, and engagement processes [[Wilson and Inkster, 2018; Wilson, 2020; Simms et al., 2016; Jackson, 2019; Maclean & Inc, 2015 Hart et al., 2019](#)]. It was reviewed that historical grievances and the systematic exclusion/neglect of Indigenous self-determination fuels distrust and lack of transparency between Indigenous peoples, and mainstream water actors [[Wilson and Inkster, 2018; Wilson, 2020; Simms et al., 2016; Jackson, 2019; Maclean & Inc, 2015; Hart et al., 2019; Bark et al., 2012; Cosens & Chaffin, 2016; Simms et al., 2016; Jackson, 2019](#)].

Finally, a fundamental challenge of lack of funding and capacity was reported especially in cases of co-governance and collaborative water governance arrangements [[Wilson, 2019; 2020; Diver, et al., 2019; Poelina et al., 2019; Mascarenhas, 2007; Te Aho, 2010](#)]. In Mascarenhas (2007), participants of First Nations in Canada expressed that, the consistent lack of resources provided by government to First Nations leaders undermines their abilities to build capacity and competency in cases of environmental collaborative decision-making processes. Where the power to manage and govern water is shared between Indigenous peoples and governments, the financial resources and capacity for Indigenous leaders to implement such power are often missing from the agreements [[Wilson, 2019; 2020; Diver, et al., 2019](#)]. For example, lack of capacity and funding was reported as a critique of the Yukon modern land settlement agreement and co-governance arrangement [[Wilson, 2020](#)] and the United States TAS model [[Diver, et al., 2019](#)].

10. Recommendations: Key elements to reforming contemporary water governance, and promoting Indigenous water governance systems

A A cross-cultural analysis of the reviewed articles emphasized the importance of genuine nation-to-nation relationships in water governance approaches in Indigenous territories as fundamental to reforming the current water governance system. This is supported by Latta [2018], Hemming et al. [2019], [Von Der Porten and De Loë \(2014\)](#), [Von Der Porten et al., \(2016\)](#), [Arsenault et al. \[2018\]](#), [Irvine et al. \[2020\]](#), and [Godden et al. \[2020\]](#). Notably, such reform must involve a critical analysis of the failures and successes of existing Indigenous-State water governance models including the ontology and epistemology of these frameworks. The diversity of Indigenous Nations must be considered in any new system(s), alongside elements that strengthen Indigenous sovereignty and dissolve the legacies of colonization and the Eurocentric framework of contemporary water governance systems. Consultation, participation, and engagement processes in water management and governance approaches in Indigenous nations should be based on relationship-building and respect for Indigenous water principles, laws, and governance systems [[Wilson and Inkster, 2018; McGregor, 2014; Wilson, 2019; 2020; Latta, 2018; RiverOfLife et al., 2021; Hemming et al., 2019; Poelina et al., 2019; Mascarenhas, 2007; Milgin et al., 2020; Day et al., 2020](#)]. Equitable power distribution, negotiation of conflicting interests, and a genuine acknowledgment, and respect of Indigenous title and rights to self-determination were recommended as a starting point toward building a genuine relationships system [[Wilson and Inkster, 2018; McGregor, 2014; Wilson, 2019, 2020; Latta, 2018; RiverOfLife et al., 2021; Hemming et al., 2019; Poelina et al., 2019](#)]. However, while these elements have been recognized and acknowledged theoretically in most models of Indigenous-State water governance, the practicality in real-life settings may be considered a pathway toward a new water governance system that supports Indigenous Peoples' sovereignty as Nations ([Table 7](#)). A genuine nation-to-nation relationship

Table 7

An overview of the recommendations to promote Indigenous systems of water governance in the contemporary governance structure (Refs [1, 2, 4, 5, 6, 10, 12, 15, 16, 18, 19, 20, 23, 27, 31, 32, 33, 34, 59, 73, 72, 79, 80, 82, 84, 85, 86, 87]).

Key Elements to reforming contemporary water governance
Acknowledgment and respect for Indigenous water principles, legal traditions (first law), and governance systems.
Recognition and respect for aboriginal title and rights.
Nation to Nation consultation and participation process.
Validation and legitimacy of Indigenous knowledge and worldviews.
Practical application of UNDRIP.
Legitimacy, transparency, and accountability in decision-making processes.
Conceptualization of water beyond eurocentrism.
Capacity building and empowerment.
Respect for ontological differences and knowledge sharing.
Acknowledgment of pluralism and multiplicity.

such as those maintained in international transboundary water governance (for example, the US and Canada transboundary water governance system) should be envisioned as a starting point toward Indigenous-State relations in water governance frameworks.

Further, to genuinely recognize and acknowledge Indigenous rights to self-governance as Nations, governments and other mainstream water actors must respect Indigenous legal traditions and cede ground to share power and resources. Respect for Indigenous Knowledge and legal traditions was well documented by Wilson and Inkster (2018) and McGregor, (2012); (2014). A deliberate education of mainstream water actors in the Traditional Knowledge, laws, and principles of Indigenous water governance systems is recommended [Mehlretter et al., 2023; McGregor, 2012; 2014; Von Der Porten et al., 2016]. Also, mainstream water actors must be ready to follow instead of lead through processes centered on Indigenous-led decision-making. This will include building capacity and empowering both parties (Indigenous groups and mainstream water actors) with the necessary funding and ability to negotiate, enact, and implement agreements, and policies.

Importantly, as a first step towards the recognition of Indigenous sovereignty, there is a need to articulate Indigenous struggles and claims to protect water in their territories and upscale their demands for recognition and justice. For example, some networks defending Indigenous rights and justice include Idle No More, Defenders of the Land, Amnesty International, and Indigenous Environmental Network. These international networks support and defend Indigenous rights, including the protection of lands and waters. For instance, Idle No More started in Canada as a protest in response to legislation, Bill C-45 (The Jobs and Growth Act, enacted in 2012 in Canada). This legislation negatively affected environmental protection laws in Canada including the Environmental Impact Assessment Act, thereby endangering the protection of Indigenous lands and water.

Lastly, the genuine and practical incorporation of the United Nations Declarations Idle No More on the Rights of Indigenous Peoples (UNDRIP) into current water governance frameworks is recommended Day et al. [2020]. UNDRIP was ratified in 2007 as an international declaration that supports the recognition and assertion of the rights of Indigenous peoples to self-governance. Particularly, Article 25 of UNDRIP states:

Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters, coastal seas, and other resources and to uphold their responsibilities to future generations in this regard.

Although the document is not legally binding, it articulates Indigenous strengths and claims. The passing of UNDRIP into current water laws and the genuine incorporation of Article 25 into current water governance frameworks such as the Integrated Water Resource Management (IWRM) framework and the Organisation for Economic Cooperation and Development (OECD) water governance principle, is a fundamental step in Indigenous-State relations in water co-governance

arrangements.

11. Conclusions

The scoping review study reveals Indigenous water governance principles and challenges that Indigenous peoples face in securing their rights to water. The meaning of effective and sustainable water governance concerning Indigenous lands is reflected in the Indigenous water principles, governance framework, and laws. The concepts of Indigenous water principles and governance systems were identified in the study literature as a priority area of concern within the broader effort to mitigate the persistent water crisis in Indigenous Nations around the globe.

With the reproduction of colonial and Eurocentric relations in contemporary water governance and management practices in countries around the globe, Indigenous resurgence efforts to maintain their land and waters often occur in a variety of community mobilization, protests, negotiations, agreements, and partnership arrangements with mainstream governments and other water actors. The unwillingness to distribute authority and dissolve colonial legacies by Western water actors constrain the ability and capacity of Indigenous nations to adequately govern and manage their water resources. This continues to threaten the security of water resources in many Indigenous communities.

To unsettle the current water governance framework and ensure water security in Indigenous communities, a new water governance system that privileges Indigenous worldviews and system of governance will be required. The utilization and implementation of Indigenous First Law and water principles in approaches to water governance and management in Indigenous territories will be essential to reform current water governance practices. The genuine incorporation of UNDRIP into existing water governance models legislation, policies, programs, and projects could be a starting point. Existing water governance models, legislations, policies, and programs that affect Indigenous peoples need to be evaluated and reformed under Indigenous leadership and based on Indigenous water principles, laws, and customs.

A shift towards an Indigenous water governance framework may provide a pathway for relationship building and would establish the codes of conduct, ethics, and values necessary to unsettle colonial legacies and achieve equity in water governance including collaborative and co-governance arrangements. This shift is warranted both because of the prior existence of Indigenous peoples and because Indigenous water principles and governance frameworks have sustained the quality and quantity of water for centuries before the advent of contemporary water governance. For the intent of reconciliation and peaceful co-existence, it is necessary to counteract current power imbalances that privilege and normalize settler worldviews and forms of governance that continuously destroy Indigenous identity, landscape, and waterscape.

Author Contributions

Mercy O. Kehinde, Lalita A. Bharadwaj, and Corinne Schuster-Wallace: Conceptualization. Mercy O. Kehinde and Sonia Bataebo: Investigation, Methodology. Mercy O. Kehinde: Formal analysis. Mercy O. Kehinde: Writing-original drafting, Writing-review & editing; Lalita A. Bharadwaj, and Corinne Schuster-Wallace, Validation, Supervision, Project administration. All authors have reviewed and agreed to the published version of the manuscript.

Funding

Mercy O. Kehinde was supported financially through the Health Sciences Student Grant, University of Saskatchewan. Sonia Bataebo was supported financially through the Canadian Institutes of Health Research Development Grant Network Environments for Indigenous Health Research (NEIHR) [Grant Number 405010]. The funding sources were not involved in any part of the study.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2025.103987.

Data availability

No data were used for the research described in the article.

References

- Akhmouch, A., Clavreul, D., Glas, P., 2018. Introducing the OECD principles on water governance. *Water Int.* 43 (1), 5–12.
- Arksey, H., O'Malley, L., 2005. Scoping studies: towards a methodological framework. *Int. J. Soc. Res. Methodol.* 8 (1), 19–32.
- Arsenault, R., 2021. Water insecurity in Ontario first nations: an exploratory study on past interventions and the need for Indigenous water governance. *Water* 13 (5), 717.
- Baviskar, A., 2007. Indian indigenities: Adivasi engagements with Hindu nationalism in India. In *Indigenous experience today*. M. de la Cadena and O. Starn, eds. Pp. 275–304. Oxford: Berg. In Merlan, F. (2009). *Indigeneity: Global and local*. *Current anthropology*, 50(3), 303-333.
- Berry, K.A., Jackson, S., Saito, L., & Forline, L. (2018). Reconceptualising water quality governance to incorporate knowledge and values: Case studies from Australian and Brazilian Indigenous communities.
- Bradford, L.E., Ovsenek, N., Bharadwaj, L.A., 2017. *Indigenizing water governance in Canada*. Water policy and governance in Canada. Springer, Cham, pp. 269–298.
- Charpleix, L., 2018. The Whanganui River as Te Awa Tupua: Place-based law in a legally pluralistic society. *Geogr. J.* 184 (1), 19–30.
- Chiblow, S., 2020. An indigenous research methodology that employs Anishinaabek elders, language speakers and women's knowledge for sustainable water governance. *Water* 12 (11), 3058.
- Coates, N. (2008). Who are the indigenous peoples of Canada and New Zealand?. In Sarivaara, E., Maatta, K., & Uusiattu, S. (2013). *Who is indigenous? Definitions of indigeneity*. *European Scientific Journal*.
- Cooley, H., Ajami, N., Ha, M.L., Srinivasan, V., Morrison, J., Donnelly, K., Christian-Smith, J., 2013. *Global water governance in the 21st century*. Pacific Institute, Oakland, CA, p. 34.
- Daigle, M., 2018. Resurging through Kishiichiwan. *Decolonization: Indigeneity*. *Educ. Soc.* 7 (1), 159–172.
- Grovogu, S., 2011. A revolution nonetheless: The Global South in international relations. *Glob. South*, 5 (1), 175–190.
- Gupta, J., Hilderling, A., Misedjan, D., 2014. Indigenous people's right to water under international law: a legal pluralism perspective. *Curr. Opin. Environ. Sustain.* 11, 26–33.
- Islam, S., Suskind, L., 2015. Understanding the water crisis in Africa and the Middle East: How can science inform policy and practice? *Bull. At. Sci.* 71 (2), 39–49.
- Jackson, S., 2018. Water and Indigenous rights: Mechanisms and pathways of recognition, representation, and redistribution. *Wiley Interdiscip. Rev.: Water* 5 (6), e1314.
- Jackson, S., Palmer, L., 2015. Reconceptualising ecosystems services: possibilities for cultivating and valuing the ethics and practices of care. *Prog. Hum. Geogr.* 39 (2), 122–145.
- Jaramillo, E., 2011. Kimy, palabra y espíritu de un río. *Bogotá: Editorial Codice Ltda*. In Boelens, R., Duarte, B., Manosalvas, R., Mena, P., Avendaño, T. R., & Vera, J. (2012). *Contested territories: Water rights and the struggles over indigenous livelihoods*. *Int. Indig. Policy J.* 3 (3).
- Macpherson, E., 2019. The pluralism of river rights in Aotearoa New Zealand and Colombia. In O'Donnell, E. (2023). *Water sovereignty for Indigenous Peoples: Pathways to pluralist, legitimate and sustainable water laws in settler colonial states*. *PLOS Water* 2 (11), e0000144.
- Marshall, V., 2017. *Overturning aqua nullius: securing Aboriginal water rights*. Aboriginal Studies Press, Canberra, Australia.
- McGregor, D., 2014. Traditional knowledge and water governance: The ethic of responsibility. *Altern.: Int. J. Indig. Peoples* 10 (5), 493–507.
- Melnichuk, N., Jatel, N., Warwick Sears, A.L., 2017. Integrated water resource management and British Columbia's Okanagan Basin water board. *Int. J. Water Resour. Dev.* 33 (3), 408–425.
- Merlan, F., 2009. Indigeneity: Global and local. *Curr. Anthropol.* 50 (3), 303–333.
- Ministry of Justice, Finland, 1995. *Act on the Sámi Parliament, Act 974/1995, Finland*. Translated Act Available from: <https://www.finlex.fi/en/laki/kaannokset/1995/en19950974.pdf>.
- Natcher, D.C., Davis, S., 2007. Rethinking devolution: Challenges for aboriginal resource management in the Yukon Territory. *Soc. Nat. Resour.* 20 (3), 271–279.
- O'Donnell, E., 2023. Water sovereignty for Indigenous Peoples: Pathways to pluralist, legitimate and sustainable water laws in settler colonial states. *PLOS Water* 2 (11), e0000144.
- Organization for Economic Co-operation and Development, 2015. *OECD Principles on Water Governance*. OECD.
- Pahl-Wostl, C., Conca, K., Kramer, A., Maestu, J., Schmidt, F., 2013. Missing links in global water governance: a processes-oriented analysis. *Ecol. Soc.* 18 (2).
- Parsons, M., Fisher, K., 2020. Indigenous peoples and transformations in freshwater governance and management. *Curr. Opin. Environ. Sustain.* 44, 124–139.
- Pham, M.T., Rajić, A., Greig, J.D., Sargeant, J.M., Papadopoulos, A., McEwen, S.A., 2014. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Res. Synth. Methods* 5 (4), 371–385.
- Poelina, A., Taylor, K.S., Perdrisat, I., 2019. Martuwarra Fitzroy River Council: an Indigenous cultural approach to collaborative water governance. *Australas. J. Environ. Manag.* 26 (3), 236–254.
- RiverOfLife, M., Taylor, K.S., Poelina, A., 2021. Living waters, law first: nyikina and mangala water governance in the kimberley, Western Australia. *Australas. J. Water Resour.* 25 (1), 40–56.
- Sarivaara, E., Maatta, K., Uusiattu, S., 2013. Who is indigenous? Definitions of indigeneity. *Eur. Sci. J.*
- Tsing, A. 2007. *Indigenous voice*. In *Indigenous experience today*. M. de la Cadena and O. Starn, eds. Pp. 33–67. Oxford: Berg. In Merlan, F. (2009). *Indigeneity: Global and local*. *Current anthropology*, 50(3), 303-333. In Merlan, F. (2009). *Indigeneity: Global and local*. *Current anthropology*, 50(3), 303.
- United Nations, 2007. *Declaration on the Rights of Indigenous Peoples*. A/RES/61/295. United Nations General Assembly. New York.
- Von der Porten, S., De Loë, R.C., 2013. Collaborative approaches to governance for water and Indigenous peoples: a case study from British Columbia, Canada. *Geoforum* 50, 149–160.
- Von Der Porten, S., De Loë, R.C., 2014. Water policy reform and Indigenous governance. *Water Policy* 16 (2), 222–243.
- Waldner, C.L., Alimezelli, H.T., McLeod, L., Zagozewski, R., Bradford, L.E., Bharadwaj, L. A., 2017. Self-reported effects of water on health in First Nations communities in Saskatchewan, Canada: results from community-based participatory research. *Environ. Health Insights* 11, 1178630217690193.
- Wilson, N.J., 2014. Indigenous water governance: insights from the hydrosocial relations of the Koyukon Athabascan village of Ruby, Alaska. *Geoforum* 57, 1–11.
- Wilson, N.J., 2019. "Seeing Water Like a State?": Indigenous water governance through Yukon First Nation Self-Government Agreements. *Geoforum* 104, 101–113.
- Wilson, N.J., 2020. Querying water co-governance: Yukon First Nations and water governance in the context of modern land claim agreements. *Water Altern.* 13 (1), 93–118.
- Wilson, N.J., Inkster, J., 2018. Respecting water: Indigenous water governance, ontologies, and the politics of kinship on the ground. *Environ. Plan. E: Nat. Space* 1 (4), 516–538.
- Wutich, A., Beresford, M., SturtzSreetharan, C., Brewis, A., Trainer, S., Hardin, J., 2021. Metatheme analysis: a qualitative method for cross-cultural research. *Int. J. Qual. Methods* 20, 16094069211019907.
- Yates, J.S., Harris, L.M., Wilson, N.J., 2017. Multiple ontologies of water: Politics, conflict and implications for governance. *Environ. Plan. D: Soc. Space* 35 (5), 797–815.