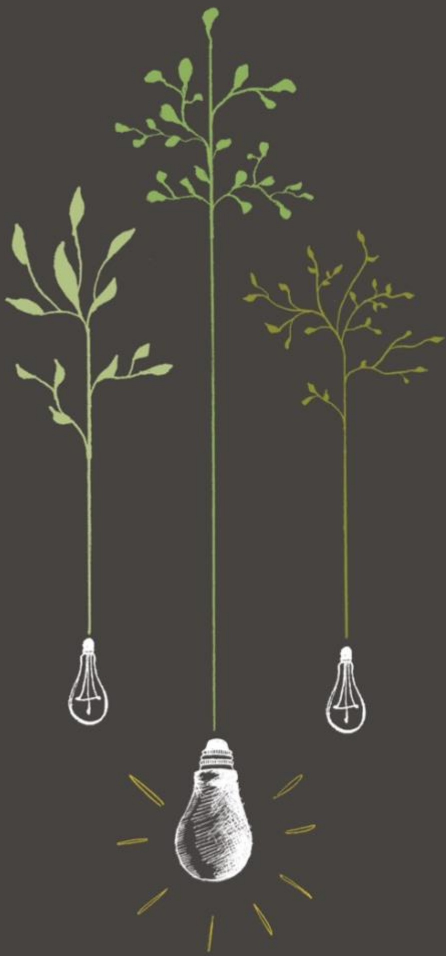
ISEMA

PERSPECTIVES ON INNOVATION, SCIENCE AND ENVIRONMENT



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- Our senior editors for volunteering countless hours to reading, reviewing, and revising, all of whom were instrumental in making this edition of ISEMA a success

About ISEMA

ISEMA is a graduate journal founded by students in the Innovation, Science and Environment (ISE) stream that preceded the Sustainable Energy Policy (SEP) program of the School of Public Policy and Administration at Carleton University. The purpose of ISEMA is to showcase the best student work on ISE and Sustainable Energy (SE) policy issues, while providing students with a unique opportunity to experience the peer-review process. Articles are nominated by professors teaching courses in the SEP program and other courses focusing on ISE-related topics. Nominated papers are subject to a double-blind peer review process by ISE alumni and other specialists in the field. The highest ranked papers then undergo an editorial process before publication. ISEMA also serves as a valuable resource for students and others wishing to learn more about the latest policy trends and issues emerging from this exciting area.

Disclaimer

Expressed views are the author(s)'s own only, and do not represent the views of the author(s)'s employer, the SPPA or ISEMA. Articles were written by graduate students in requirement for course work at Carleton University's School of Public Policy and Administration. For more information, please visit our website at: http://isemajournal.wordpress.com.

About this Edition

Since May 2020, the ISEMA Executive and the Editorial Board have worked diligently to bring together the journal's 14th volume. This year, ISEMA received 18 nominated papers from the 2019-2020 academic year written by students at Carleton University's School of Public Policy and Administration. Each of the nominated papers was thoughtful, persuasive, and exceptionally well-written. Following a rigorous double-blind peer-review process, we have selected four papers for publication in this year's edition. Each paper offers a unique perspective on topics within the energy, environment, and innovation sectors.

Silke Popescu examines the political challenge of energy transitions through a hybrid framework that combines the multi-level perspective and framing strategies. Popescu explores the dominant framing strategies used by both niche and regime actors in the sphere of energy transitions in Canada. While findings suggest that a transition is underway, niche actors are currently not taking advantage of more effective framing strategies that could facilitate this transition.

Samantha Jarvis explores the design and implementation of the Ontario Cyber Security Framework. To address its aging electricity grid and increased demand for electrical energy, Ontario has chosen to modernize the grid through increased use of smart grid applications. While bulk-system assets are required to comply with cyber security standards, a consistent set of standards for non-bulk transmitters and distributors did not exist in

Ontario. Jarvis examines the aspects of the Ontario Cyber Security Framework that contributed to its successful movement through the policy cycle, including problem identification, instrument choice, policy design, implementation and evaluation.

Patrick Russell explores how urban agriculture can help alleviate water scarcity in water-stressed regions by shifting production to urban spaces and increasing efficiencies. This exploration opens with describing and defining the scope of water scarcity and water stress to present a case for how urban agriculture can address water stress. Russell conducts a systematic review of how water efficiency and clean technology options are embraced, explores the barriers to adopting urban agricultural systems, and evaluates real-world policy options for adopting water-efficient agriculture in urban settings.

Leia Jones compares the governance structures of two protected areas on Vancouver Island, British Columbia. Jones outlines the importance of biodiversity and protected areas for ecosystem preservation before exploring the management of Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park. A comparative analysis of the two regions demonstrates how different epistemologies shape perceptions and definitions of biodiversity and the ultimate outcomes that ultimately implicate biodiversity management. Jones assesses which of the analyzed epistemologies is more conducive to enhanced biodiversity management.

The ISEMA Executive and the Editorial Board would like to extend our most sincere thanks to all those who graciously volunteered their time and effort to the internal and external review processes. You have played an integral role in publishing this year's edition. To the authors, we would like to thank you for your unwavering dedication and enthusiasm throughout the review and editing processes – congratulations on your well-deserved achievement. The Executive and Board would also like to thank Carleton University's School of Public Policy and Administration for their continued support. We hope you enjoy this edition of ISEMA and come away having gained new perspectives, understandings, and knowledge on the issues surrounding energy transitions, protecting the evolving electricity grid, adopting urban agriculture, and the governance of our protected areas.

2020 ISEMA Editorial Board

ISEMA

PESPECTIVES ON INNOVATION, SCIENCE AND ENVIRONMENT

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Promoting Renewable Energy in a Fact-Free Context: An Exploration of Framing Strategies for the Acceleration of Energy Transition in Canada

Author: Silke Popescu
Written for: Sustainable Energy Policy

Introduction

Climate change will undoubtedly be the defining challenge of the twenty-first century. Since climate policy is predominantly energy policy, the promotion of renewable energy and an energy transition is central to addressing this global challenge (Scrase & MacKerron, 2009, p. 3). The entire global industrial economy rests upon the promise of an affordable and reliable supply of energy. As national and global energy demand has increased, the exploitation of non-renewable and carbon-intensive energy has skyrocketed, leading to the accumulation of a variety of pollutants in the world's atmosphere, oceans, and soil. The collective sum of this pollution has reached a level where humanity can no longer ignore the damage; the multiple ramifications of climate change can be observed throughout the world in the forms of wildfires, extreme weather, and shrinking shorelines. However, although the incumbent carbon-intensive global energy system is the leading source of climate change, it is also the most promising target of mitigation initiatives. For example, 82% of Canada's emissions are related to energy production and consumption (Natural Resources Canada, 2018). Therefore, energy policy is critical to any discussion of climate change, and the ability of Canada and the world to transition to a cleaner and more sustainable energy system will determine the degree to which humanity suffers from its ramifications.

Debates surrounding climate policy are, for the most part, about energy policy and conflict between energy systems. While the incumbent centralized carbon-intensive energy system remains dominant, its future outlook is increasingly grim in light of climate change and limited resources. The alternative to this is a decentralized and renewable energy system. A cursory overview of history shows that this would by no means be the first energy system transition that humanity has faced. As the world's nations have developed, they have undergone several dramatic energy transitions, including switching from wood to coal, then later from coal to oil (Huberty & Zysman, 2010, p. 1027). These energy system transitions required massive social, political, and economic changes. For example, transitioning from wood to coal required altering housing designs, manufacturing methods, changing livelihoods, and implementing new policies regarding collusion among the emerging coal powers (Huberty & Zysman, 2010, p. 1027). However even though this is by no means the first energy system transition that humanity has faced, these transitions have historically taken ample time, and time is running short. Since we cannot wait for a gradual and perhaps more natural energy transition to clean and renewable energy, governments worldwide need to take aggressive energy policy action if we hope to avoid the more devastating effects of climate change.

There is, therefore, a stark need for energy policy action. Yet policymaking is neither rational, linear, nor value-neutral (Scrase & Ockwell, 2010, p. 2226). Unfortunately, this is rarely more evident than in the sphere of energy policy, where politically superior solutions are commonly implemented in lieu of those which are technically or logically superior (Mintrom & Luetjens, 2017, p. 1366). Since objectivity and rationality can be assumed to be only marginally relevant, an analysis of the ideas and discourses presented by various competing actors within the field of energy policy is integral to understanding its current state and predicting future change. Therefore, this essay will explore energy policy in Canada by analysing framing strategies used by prominent actors in this field. This analysis will do this by responding to two questions: what are the dominant framing strategies used by niche and regime actors in the context of a Canadian energy transition? And, what does this suggest regarding the current state of Canada's energy transition and the future outlook for this transition?

This essay will proceed with three main sections. First, the topic will be introduced through a discussion of the current state of energy policy in Canada and around the world. Second, the two theoretical frameworks used in this essay will be discussed: the multi-level perspective and framing strategies. These frameworks will then be incorporated to form one comprehensive hybrid framework for energy policy analysis. Third, this hybrid framework will be used to evaluate the current state of energy policy in Canada. This essay will conclude with a discussion of key recommendations and predictions regarding Canada's energy policy future.

The Current State of Energy Policy in Canada and the World

Despite increasing global awareness regarding climate change and notable progress in transitioning away from a global energy system reliant upon carbon-intensive sources, fossil-fuels still dominate the global energy mix. In 2017, renewable energy sources provided 15% of the world's total primary energy supply, while oil, coal, and natural gas cumulatively provided 80% of global energy supply (International Energy Agency [IEA], 2019a). That being said, the International Energy Agency expects renewable energy generation to increase by 50% in the next five years (IEA, 2019b). In fact, there is a general sentiment that "the era of cheap and abundant clean energy is just around the corner" (Radford, 2019).

Private investments and individual actions have an important role to play in this emerging clean energy era, but the factor that lies at the fulcrum of this transition is energy policy. Energy policy is concerned with "the production, transportation and use of energy commodities," and its drivers can be as diverse as economic growth, energy security, industrial diversification, and environmental protection (Energy Policy, 2014). Though energy policy has always been a concern for governments, government interest in this policy sphere piqued after the oil crisis in the 1970s (Energy Policy, 2014). More recently, with rising global concern regarding climate change, energy policy has once again come to the forefront of government policy agendas.

Canada has been endowed with ample amounts of both renewable and non-renewable energy sources, including wind, coal, oil, natural gas, uranium, and hydroelectricity (Energy Policy, 2014). In 2017, 60% of Canada's electricity was generated by hydro, followed by nuclear (15%), natural gas (9%), coal (9%), wind (4%), biomass (2%), solar (<1%), and petroleum (<1%) (Canadian Energy Regulator [CER], 2019). Despite this relatively favourable make-up of electricity consumption (over 65% renewables), Canada's energy mix in terms of production is far less encouraging. In 2017, Canada ranked as the fourth largest oil producer in the world, with 75% of this oil exported to foreign markets (CER, 2019). Furthermore, this energy mix varies significantly by province: even though British Colombia, Quebec, and Manitoba all rely on hydroelectricity for over 80% of their energy needs, Alberta, Saskatchewan, and Nunavut are still primarily reliant upon fossil fuels (CER, 2019).

In Canada, energy policy has become a politically contentious issue at both the federal and provincial levels, and thus has become increasingly 'fact-free.' The increasing politicization of energy policy has led to increasing polarization and court cases that have advanced to the Supreme Court of Canada (for example, provincial challenges over the federally-mandated carbon backstop). Much of this controversy can be traced back to the fact that in the Canadian Federation, provincial governments maintain jurisdiction over their natural resources, and, regardless of national or even international concerns, these provincial governments often remain set on exploiting these resources (Energy Policy, 2014). For example, in 2019, one of the biggest Canadian energy policy controversies was Alberta's inability to get oil to market, a controversy that has yet to reach any sort of resolution (Wong & Milliken, 2019).

Energy policy in Canada lies at a crossroads, and, despite notable progress, the Federal Government seems unwilling to commit to a low-carbon energy transition wholeheartedly. This much can be seen in Prime Minister Trudeau's Speech from the Throne following the 2019 federal election, where, despite strong rhetoric regarding the importance of climate action, the seemingly ever-present caveat of supporting "get[ting] Canadian [energy] resources to new markets" was still emphasized (Trudeau, 2019).[1]

Theoretical Frameworks

The Multi-Level Perspective

The sociotechnical change necessary for Canada's future energy transition will be dramatic and chaotic. However, the multi-level perspective (MLP) provides a framework for understanding how this sociotechnical change can come about. The MLP postulates that transitions are long-term transformations that transpire at three levels: the regime, the niche, and the landscape (Osunmuyiwa, Biermann, & Kalfagianni, 2018, p. 143). These are not ontological categories but "analytical and heuristic concepts" that allow for a better understanding of the complexity of sociotechnical change (Geels, 2002, p. 1259).

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[1] Note that this caveat was absent from the 2020 Speech from the Throne.

In the case of energy transitions, the regime represents the incumbent carbon-intensive energy system, which includes its industry, corporations, governance structures, and dominant energy system evaluation methods that favour the continuation of this incumbent system (Osunmuyiwa et al., 2018, p. 143). The regime thus includes the semi-coherent norms, actors, and institutions that work to (re)produce the existence and dominance of a fossil-fuel-based energy system (Geels, 2011, p. 27). Sociotechnical regimes lead to a level of stability in that they create trajectories that guide innovations and change in the same direction (Geels, 2002, p. 1259). In fact, a transition occurs when this stable trajectory is abandoned, and the regime dissipates to give rise to a new regime (Geels, 2011, p. 25).

The niche comprises an entirely different cadre of actors and institutions. Rather than being dominant and powerful incumbent players, niche actors are entrepreneurs and start-ups working insulated from the prevailing regime and working on innovations that do not conform to the existing regime's trajectory (Geels, 2011, p. 27). Thus, the niche includes a network of innovations and technologies in the "incubation" or "nurturing" stage, hoping that one day their novel innovations will displace the existing regime (Osunmuyiwa et al., 2018, p. 143). In this way, niches are crucial to transitions because they provide the necessary "seeds for change" (Geels, 2002, p. 1261). However, it is not easy for a niche innovation to move beyond the niche-level, as the regime is stabilized by its various re-enforcing components. For example, regulations, consumer preferences, infrastructure, and maintenance and repair structures are aligned to support the existing technology (for example, internal combustion engines rather than electric vehicles).

The landscape level of the MLP refers to the numerous external factors that impact the transition process, including, but not limited to, the technical and material backdrop, demographic trends, social norms and values, macroeconomic patterns, and geopolitics (Geels, 2011, p. 28). These form the context or arena in which regime and niche actors work. In the short-term, the landscape cannot be influenced by either the regime or the niche, and although landscapes do change, change is often gradual and slow (Geels, 2002, p. 1260).

There is no one way in which these three levels will interact to result in a sociotechnical transition. Furthermore, there is no one cause or driver of transition; rather, it is the culmination of many factors interacting in a complex fashion that will lead to change (Geels, 2011, p. 29). At the regime level, there must be a level of "loosen[ing] up" of the existing configuration of mutually-reinforcing facets, resulting in a destabilization of the regime (Geels, 2002, p. 1272). At the niche level, sufficient momentum must be built up through the promotion of niche innovations by niche actors (Geels, 2011, p. 29). Finally, the landscape must, in some way, be pressuring the regime, further destabilizing it (Geels, 2011, p. 29). Thus, a transition occurs when factors at each level line up and mutually reinforce each other.

Framing Theory

How a policy or innovation is framed can be more important than the actual content of the document or characteristics of the innovation. This is especially true in extremely politicized fields such as energy policy, where facts and logical arguments often do not hold as much sway as ideological claims. Framing requires attributing a cause to a problem and implicitly or explicitly presenting the kind of solution(s) that should be pursued (Butler et al., 2015, p. 671). This consists of emphasizing a certain set of relevant considerations regarding the problem and the solution, paring down information, and emphasizing certain aspects (Nolan & Tobia, 2019, p. 495). Framing is by no means lying; in fact, virtually all information is framed (Nisbet, 2009, p. 15). This simply means that whether one is reading a newspaper, listening to a politician, or reviewing an expert's work, certain considerations and information will be accounted for or emphasized. Thus, whether strategic or unintentional, framing is fundamentally a politically-contentious process with political consequences, and any analysis of framing strategies recognizes the non-neutral, non-objective, and political nature of language.

In energy system transitions, framing consists of the narratives surrounding problems with the incumbent energy system, how they have arisen, and what should be done (Butler et al., 2015, p. 667). However, framing strategies are not static but will change over time, particularly in the case of long, drawn-out sociotechnical transitions (Mintrom & Luetjens, 2017, p. 1366). Since framing strategies are used by both proponents and opponents of a given sociotechnical innovation, framing can be viewed as interactional rather than the result of one decision made at the genesis of a given technology or transition (Mintrom & Luetjens, 2017, p. 1366).

Renewable energy technologies can be framed in a variety of ways. Traditionally, climate change has been the primary driver of renewable energy and thus has been central to any framing strategy (IPCC, 2012; Long & Steinberger, 2016).

However, though climate change is essentially a matter of energy policy, energy policy is concerned with much more than just climate change (Scrase & Ockwell, 2010, p. 2226). Concerns such as health, economic well-being, energy security, geopolitical conflict, and issues surrounding scarce resources and more general environmental degradation all play into energy policy outcomes and framing strategies. In recent years, there has been a growing emphasis on these non-climate benefits of action regarding renewable energy. This is because even if people are broadly concerned about climate change, it is often a low priority compared to more immediate issues such as health or crime (Walker et al., 2018, p. 782). This is related to the challenge of framing and promoting climate change action, the effects of which are often perceived to be uncertain and distant, and thus not a priority.

Hybrid Framework: MLP and Framing

The integration of the MLP and framing strategies leads to a more complete and nuanced understanding of sociotechnical transition. While the MLP provides a framework regarding the relevant actors and their roles, taking into account framing strategies allows for an understanding of the interactions between these actors. For example, regime actors promote the continuation of the carbon-intensive incumbent energy system, but what framing strategies are used to legitimize this action and de-legitimize the renewable energy technologies threatening to unseat them? Alternatively, niche actors advocate for renewable energy technologies, but with what framing strategies? Furthermore, these strategies will not stay the same, but will evolve as the result of a changing landscape and the conflict between framing and counter-framing strategies used by niche and regime actors.

To unseat the regime, niche actors will first have to dismantle the narratives that the regime has put forward, which are present in institutions, laws, regulations, and organizational bias (Scrase & Ockwell, 2010, p. 2228). To do this, a new discourse regarding energy policy must emerge. Using the MLP and framing theoretical frameworks in tandem allows for this analysis of not only what framing strategies are used by the regime and niche, but also to what extent these framing strategies influence policymaking.

Literature Review: Efficacy of Framing Strategies

Prior to delving into an analysis of what framing strategies are used by key actors in the realm of energy policy in Canada, it is important to first review the research regarding the efficacy of various framing strategies. The literature on this topic is plentiful and widespread, and thus this literature review will specifically focus on framing strategies used to promote renewable energy.

One of the primary typologies in framing literature is ‘gain’ or ‘loss’ frames, a message focusing on “the pleasures of adherence” versus one that emphasizes “the pains of non-adherence” (Bertolotti & Catellani, 2014, p. 475). For example, actors can frame renewable energy as important because it results in economic benefits and the emergence of a green economy (gain framing). Alternatively, an actor could focus on the catastrophic impacts of climate change and frame an action as important because it would avoid those impacts (loss framing). This typology is present whether one is supporting climate action and renewable energy or not. For example, if a regime actor is arguing against renewable energy, they could focus on the benefits of the oil and gas industry (economic benefits, jobs, stability) or frame renewable energy as detrimental to the economy and driving up electricity prices. This typology has been explored and evaluated by many academics, and their findings consistently conclude that framing strategies that focus on the benefits of a given action (gain framing) are more effective than those that focus on the losses of not doing the action (loss framing) (Bertolotti & Catellani, 2014; Morton et al., 2011; Peters et al., 2018; Scannell & Gifford, 2013; Spence & Pidgeon, 2010; Wiest et al., 2015).

A second common theme present across the literature is the importance of including a variety of framing strategies and not just focusing on climate change as the driver of renewable energy. Unsurprisingly, framing renewable energy primarily as a response to climate change leads to polarization, with the two opposing groups being those who believe that climate action should be a priority and those who do not (Feldman & Hart, 2018; Mossler et al., 2017; Walker et al., 2018). This polarization should not mean that climate change is not discussed in reference to renewable energy. Rather, it is important to recognize the benefits of also including a variety of other framing strategies to supplement this (thus ensuring that the given narrative convinces a larger section of society). Furthermore, since climate change is perceived as a distant phenomenon both temporally and physically, it is beneficial to bring concerns closer to home through framing strategies that focus on other aspects such as health and jobs (Maibach et al., 2018, p. 782). The benefit of making things local and temporally relevant through the inclusion of non-climate framing strategies is extremely important. People tend to be influenced much more when an argument focuses on the local and the present, rather than global and at some point in the distant and undefined future (Nolan & Tobia, 2019; Leiserowitz, 2007; Scannell & Gifford, 2013; Spence, Poortinga, & Pidgeon, 2012; Wiest et al., 2015).

Finally, the literature makes it clear that opposition in the form of counter-frames can have a significant effect on the success of framing strategies (Kangas et al., 2013). When niche actors present a framing strategy that promotes the adoption of renewable energy technologies, the regime will often respond with a counter-frame, and vice-versa. Though the effectiveness of the counter-frame depends on the clout of the argument, these counter-frames can lead to the failure of the given framing strategy and policy or technology being framed by providing a contradictory narrative. The literature on counter-frames points to the previously discussed reality that most information is framed in some manner, though to varying extents and with different intentions in mind.

In the subsequent section, these three findings within the existing literature will be used to analyze and evaluate framing strategies: is it a ‘gain’ or ‘loss’ frame? Are framing strategies that go beyond climate change used? Lastly, are counter-frames used and are they effective?

Analysis

The following analysis will explore the dominant framing strategies used by niche and regime actors in the realm of Canadian energy policy. These actors include prominent associations, research institutions, think tanks, and a union. These actors were selected based on their level of influence and the presence of sufficient information regarding their view of renewable energy on their various websites. Analysis of the actors’ framing strategies was done by evaluating the information provided on their respective websites. Since this essay aims to understand the current state of the regime and niche's framing strategies, only recent information was reviewed (within the last five years as much as possible, ten years if no recent data was available).

The niche actors selected are the Canadian Wind Energy Association (CanWEA), the Canadian Solar Industries Association (CanSIA),[2] the Pembina Institute, Clean Energy Canada (CEC), and the Smart Prosperity Institute (SPI). The regime actors selected are the Canadian Association of Petroleum Producers (CAPP), the Canadian Nuclear Association (CNA), the Power Workers Union (PWU), the Canadian Energy Research Institute (CERI), the Fraser Institute, and the Canada West Foundation (CWF). First, the primary framing strategies of each respective group of actors will be discussed. These findings will then be related to what the literature says regarding the success of various framing strategies and the MLP.

Niche Framing of Renewable Energy Technologies

Across almost all of the identified niche actors, job creation and economic growth are presented as the main drivers of renewable energy and renewable energy policy in Canada. CanWEA focuses on wind energy creating "revenue streams" and "green jobs" (CanWEA, 2019) and CanSIA focuses on the job creation potential of solar energy and its "cost-competitive" nature (CanSIA, 2019). Similarly, CEC presents energy transition as "an opportunity for Canada to

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[2] In the time that has passed since this paper was initially written (December 2019), CanWEA and CanSIA have merged to become the Canadian Renewable Energy Alliance (CanREA).

build an innovative, growing economy, with good jobs" (CEC, 2019a), and the SPI focuses on jobs and opportunities for economic growth in Canada as the main reasons for adopting renewable energy technologies (Scott & Samson, 2019). The Pembina Institute deviates slightly from this general trend and instead focuses on the affordability aspect of renewable energy, though jobs are also mentioned (Gorski & Jeyakumar, 2019; Turcotte, 2019).

Though it is not presented as the main driver in most recent messaging surrounding renewable energy technologies, climate change is often mentioned as an aside in many (but not all) cases. For example, though the emphasis is on the job creation and economic benefits of wind, CanWEA also mentions that wind energy can help Canada meet its international climate targets (CanWEA, 2019). Similarly, although CanSIA does mention solar energy's potential to displace greenhouse gas emissions, this is only mentioned after discussing jobs (CanSIA, 2019). In the messaging of CEC and the SPI, climate change is barely mentioned; rather, the focus is purely on jobs and the economy. The messaging of the Pembina Institute deviates once again from this trend, as it sometimes discusses the dangers of climate change first and then moves on to discuss the economic benefits of renewable energy (Turcotte, 2019).

One framing strategy that is surprisingly absent from the messaging of these niche actors is health. This absence of health framing is surprising considering that this framing strategy has been shown to be extremely effective in Canada. For example, health concerns have been shown to be the most prominent driver of the coal phase-out in Ontario (Harris et al., 2015). Health concerns check all of the boxes when it comes to creating a convincing framing narrative: health issues are immediate both temporally and physically, and few people are willing to (explicitly) prioritize other concerns, such as economic benefits or jobs, over health. Furthermore, substantial evidence points to the negative health effects of the incumbent carbon-intensive fossil fuel energy system. The World Health Organization (WHO) estimates that between 2030 and 2050, climate change will lead to an additional 250,000 deaths each year due to the spread of malaria, malnutrition, diarrhea, and heat stress (WHO, 2018). The combustion of fossil fuels is also the main contributor to human-made air pollution, which is the biggest environmental risk to human health and plays a contributing role in the loss of 4.2 million lives annually (WHO, 2016).

CanWEA and CanSIA do not mention this health aspect; while the rest of the niche actors simply mention it as an aside. For example, although CEC does not include health in any major publications, it does have two smaller articles published on its website that discuss the health benefits of transitioning to a renewable energy system (CEC, 2019b; 2019c). Similarly, the Pembina Institute and the SPI only mention health parenthetically. For example, the SPI has one article published on its website that presents eight reasons to build a clean economy in Canada (Scott & Samson, 2019). The first seven focus on jobs and economic opportunity, but the last mentions health and quality of life.

Regime Framing of Renewable Energy Technologies

Several key framing strategies can be identified in the messaging of the selected regime actors surrounding renewable energy. Dominant framing strategies include framing renewable energy as unable to supply sufficient energy and presenting renewable energy as the driving force behind rising energy prices. For example, CAPP's rhetoric is that renewables simply "won't keep pace" with rising energy demand, so Canada needs to maintain and grow its oil and gas sector (CAPP, 2019a). The CNA and PWU's renewables rhetoric focus on the issues related to many renewable energy sources (for example, intermittency) and concludes that switching to 100% renewables "couldn't be done" (CNA, 2016; PWU, n.d.). These regime actors also present renewable energy as "significant contributors to Ontario's rising electricity prices" (Carpenter, 2012; PWU, n.d.). Similarly, the Fraser Institute presents renewable energy as "magical thinking" since it will be unable to provide sufficient energy and will drive up electricity costs (Green, 2019; Reed, 2019). The CWF places similar blame on renewables for rising electricity costs (CWF, 2017).

Another popular framing strategy of these regime actors is presenting renewable energy as simply not worth it since climate change is a global phenomenon, and many countries around the world are not making concerted efforts to reduce their emissions. CAPP seems to be particularly fond of this strategy, justifying increasing oil and gas exploitation rather than renewables by stating that "Canada produces less than 1.5% of the world's greenhouse gas (GHG) emissions" and "[if] Canada does not act to support and grow our oil and natural gas production and exports, other suppliers – with lesser environmental and social standards – will fill the increasing global demand for energy" (CAPP, 2019b). Similarly, CERI stated in its 2018 annual report that "[t]he majority of Canadians seem to agree that our oil and gas industry was too important – to all Canadians - to abandon on a whim with no prospect of changing the world's greenhouse gas (GHG) emissions trajectory" (CERI, 2018). The same rhetoric is in Fraser Institute and CWF messaging (Green & McKitrick, 2017; Martin, 2019).

As demonstrated above, regime actors often actively attack the niche. However, they also promote and legitimize the regime with 'gain' framing strategies. All regime actors use narratives relating to job creation and benefits to the Canadian economy. CAPP states that oil and gas are integral to Canada's economy, and "over the next 10 years, the oil sands industry is expected to pay an estimated $17 billion in provincial and federal taxes – including royalties…[and]… the oil sands [have] supported and created more than 205,000 direct and indirect jobs across Canada" (CAPP, 2019c). The CNA and PWU both promote nuclear as an incredible job-creating opportunity, and CERI and the Fraser Institute focus on the many economic benefits that the oil and gas industry have brought to Canada (CERI, 2018; CNA, 2019; Doluweera et al., 2017; Hyatt, 2019; Stedman & Aliakbari, 2019). It is worth noting that this narrative is also used to attack the niche. For example, the Fraser Institute argues that wind energy leads to more jobs being lost than gained (Reed, 2019).

See Table 1 for a summary of these niche and regime framing strategies.

Table 1
Summary of Dominant Niche and Regime Framing Strategies

Niche Framing Strategies	Regime Framing Strategies
Renewable energy technologies create jobs and drive economic growth.	Renewable energy technologies are unviable and expensive.
Renewable energy technologies are an effective solution to climate change.	Renewable energy technologies are an ineffective solution to climate change.
Renewable energy technologies improve the health and well-being of Canadians [a].	The incumbent energy system promotes jobs and economic growth in Canada.

[a] This narrative was found to be present only parenthetically.

Discussion

This section will explore what these dominant framing strategies used by niche and regime actors suggest regarding the current state of Canada's energy transition and its future outlook. The first step is to review what kinds of framing strategies these are and how effective they are (based on the conclusions of the literature review): are they 'gain' or 'loss' framing strategies? Are frames that go beyond climate change used? And lastly, are counter-frames used?

'Gain' framing has been shown to be more successful than 'loss' framing. The primary framing strategy used by niche actors (jobs and economic benefits) is a 'gain' framing strategy: a strategy that focuses on the benefits of adopting renewable energy rather than the pains of not adopting it.

The reverse can be said of most of the regime's frames, which can be identified as 'loss' framing strategies: focusing on the pains of not continuing with the incumbent carbon-intensive energy system and, instead, switching to renewable energy technologies. These 'loss' framing strategies include framing renewable energy as unable to supply sufficient energy, presenting renewable energy as the driving force behind rising energy prices, and presenting renewable energy as simply not worth it (since climate change is global). That being said, although they are less dominant, there are 'loss' framing strategies within niche actor narratives (e.g. renewable energy can avoid the dangers of climate change) and 'gain' framing within regime narratives (e.g. the incumbent energy system gives people jobs and grows the economy).

Focusing just on climate change can lead to polarization and a lack of engagement with the given narrative (due to the politicization of climate change as a partisan topic). Therefore, the literature suggests moving beyond climate change in framing renewable energy technologies. This technique is used by both the niche and the regime, as neither focuses exclusively on climate change. Though both groups of actors mention renewable energy as an effective (in the case of the niche) or ineffective (in the case of the regime) solution to climate change, neither focuses on climate change as the primary renewable energy framing strategy. Instead, jobs, the economy, and cost-effectiveness dominate renewable energy narratives.

Finally, the literature also suggests that counter-frames can lead to the failure of a framing strategy and thus the failure of a niche innovation to emerge. There is obvious sparring between the niche and regime in their narratives. For example, while the niche focuses on renewable energy as a job creator, the regime argues that renewable energy destroys far more jobs than it creates. Furthermore, while the niche presents renewable energy as a viable solution to climate change, the regime counters by arguing that reducing Canada's emissions would be futile. Based purely on this information, it is difficult to say which of these framing and counter-framing strategies will prevail, but it is important to note that this discursive battle is occurring.

Thus, while the niche appears to be employing the more effective 'gain' framing strategies to a greater extent, both the niche and the regime go beyond climate change, and both are engaged in framing and counter-framing strategies. However, what do these narrative trends say about the current state of the Canadian energy transition? The MLP suggests that a sociotechnical transition occurs when the regime is destabilized, the niche has built up momentum, and the landscape is putting pressure on the regime. A transition can be said to be underway when the stable trajectory of the regime is abandoned. These framing strategies suggest a level of defensiveness in the regime: it is no longer assumed that a continuation of a carbon-intensive energy system is the correct trajectory. In fact, the regime is bending over backwards to present itself as economically vital and present renewable energy as an ineffective solution to climate change. This framing approach is likely a result of the landscape putting pressure on the regime and destabilizing it through the global phenomenon of climate change and the general environmental degradation that the fossil-fuel industry causes. This shift is important: the arena in which the niche and the regime actors are sparring has changed, and is changing. As a result, the regime is becoming increasingly destabilized due to its contribution to the problem of climate change, and the niche is gaining increasing legitimacy as it presents itself as the solution.

These narrative strategies display a level of destabilization in the regime, and the distinct identity and strength of niche actors. In the politically-charged sector of energy policy, the framing strategies presented by the niche are backed up with facts and figures and are increasingly adopted by policymakers. For example, the job creation potential and economic growth resulting from renewable energy technologies is a major theme in the Pan-Canadian Framework on Clean Growth and Climate Change (Environment and Climate Change Canada, 2016). Thus, this analysis suggests that, though it may be happening slower than necessary, an energy system transition is underway in Canada.

Conclusion

The project of energy transitions is as much of a political challenge as it is a technical, or even an economic one (Scrase & Ockwell, 2010, p. 2225). Because of this reality, this essay reviewed the contemporary dominant framing strategies used by both niche and regime actors in the sphere of the Canadian energy transition. While findings suggest that a transition is underway, evidence from past transitions suggests that in the absence of aggressive energy policy action, the energy system transition necessary to avoid many of the more dire implications of climate change is unlikely to happen as fast as it needs to.

Niche actors are aggressively promoting their framing strategies of renewable energy technologies and are attaining a level of success in their efforts. However, one possible strategy by which they could further increase the efficacy of their work is focusing more on health as a driver of renewable energy technologies. While this framing is present, it is primarily used parenthetically. However, bringing this frame into the core of their narrative, along with jobs and economic growth, could greatly enhance the efficacy of the niche's framing strategy. This could be particularly beneficial because not only is this a 'gain' framing strategy, but it is also hard to present a counter-frame for the health benefits of renewable energy. While the regime has presented counter-frames in response to the niche's presentation of renewable energy as a source of job creation and economic growth (i.e. it destroys more jobs than it creates), and in response to the assertion that renewable energy is an effective solution to climate change (i.e. it will not help because climate change is global), it would be virtually impossible to argue that producing energy through hydro, wind, and solar instead of coal, oil, and gas is worse for human health and well-being. Thus, the obstacle of overcoming counter-arguments would not be present if this framing strategy was more aggressively deployed.

All of the evidence presented points to an increasingly dire future if Canada and the world do not initiate an ambitious renewable energy transition. Yet promoting renewable energy technologies in a context in which facts are of little concern and powerful forces resist this transition is no simple feat. Thus, niche actors will need to use all framing tools at their disposal to more effectively promote a cleaner and more sustainable future for all Canadians.

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Protecting the Smart Grid: The Success of Designing and Implementing the Ontario Cyber Security Framework

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Introduction

Ontario's electricity grid is ageing, with much of the province's electricity infrastructure nearing the end of its life expectancy. This issue is further exasperated by the advancement and proliferation of technology, which has increased the demand for electrical energy. Growing demand has increased the complexity of the grid, impacting its reliability and efficiency. To help address these challenges, Ontario has chosen to modernize the grid through the increased use of smart grid applications, as demonstrated by the implementation of smart meters.

Smart grid applications incorporate two-way communication and monitoring of electricity flow and information to improve system reliability, resilience and monitoring, reducing the frequency and duration of power outages, and allowing for a self-healing system. Further, these applications allow for the efficient delivery of electricity, reduce costs to consumers, and support the integration of renewable energy into the grid, helping address the environmental impacts of generation. However, as connectivity increases, the grid becomes susceptible to malicious activity. The grid is a critical piece of infrastructure that, when compromised, can impact data confidentiality and integrity and the availability of power delivery.

Ontario's assets that operate above 100 kV are considered bulk-system assets and are required to comply with cyber security standards under the North American Electric Corporation's (NERC) Critical Infrastructure Protection (CIP) standards; however, non-bulk transmitters (transmitters) and non-bulk distributors (distributors) are not covered by these standards (Ontario Energy Board [OEB], 2017c). While distributors and transmitters are required to ensure consumers' personal information is protected and to incorporate security risk mitigation for asset management plans, the creation of standards in Ontario was left to individual transmitters and distributors through a number of existing legislative and regulatory requirements (OEB, 2017c). However, the absence of consistent standards has resulted in a lack of fully developed response and recovery plans for transmitters and distributors, which has created a crisis that is both severe and in close proximity to Ontarians. In 2016, the Ontario Energy Board (OEB) initiated a policy consultation to identify industry standards and best practices to establish a consistent sector-wide framework to address this security gap.

This paper will argue that the *Ontario Cyber Security Framewor*k (Framework) was accepted due to the narrow scope of the policy issue, the OEB's focus on a flexible approach to design and implementation, and the decision to engage with key industry stakeholders. This paper will first explore the integration of smart grid applications into the grid's four components before defining cyber security. Next, this paper will assess the inherent linkage between increased connectivity and vulnerability to cyber threats to demonstrate the importance of cyber security standards. To examine the Framework’s success, this paper assesses its movement throughout the policy cycle, including problem identification, instrument choice and design, implementation and evaluation. As Ontario modernizes its grid, a focus on cyber security will remain essential to ensure the security of critical infrastructure and information privacy.

The Integration of Smart Grid Applications

The Canadian Electricity Association defines the smart grid as a network of applications in the electricity grid whose components create two-way communication and power flow (n.d.a), which can be applied to the grid's four components: generation, transmission, distribution, and consumption. Generation, the first component, involves electricity production (Canadian Electricity Association, n.d.b). The inclusion of smart grid applications during generation enables the integration of variable energy sources, such as wind and solar, into the grid. Smart grid applications address the variability of renewable energy sources through the continuous balancing of the system. Demand response enabled by smart meters and intelligent loads provide a demand response solution that helps absorb excess generation (Speer et al., 2015).

The transmission system, the second component, carries electricity over long distances to distribution systems (Canadian Electricity Association, n.d.b). The distribution system connects to storage systems, distributed energy sources, and consumers (Gunduz & Das, 2020). Smart grid applications at these two components allow for the detection of power outages to minimize impacts on the entire system. For example, Phasor Measurement Units (PMUs) enable operators to assess grid stability automatically. PMUs can report outages through relays that sense and recover faults in the substation, allowing automatic feeder switches to re-route power around issues (Office of Electricity, n.d.). Economic impacts caused by damage to the grid are reduced through the monitoring, anticipation, and isolation of power outages.

According to Gundaz and Das (2020), consumption, mainly by consumers and industry, can be considered the final component of electricity production. Applications at the consumption level enable consumers to balance electricity load (Smart Grid Canada, n.d.). An example of a consumer-level application is net metering, which allows the consumer to feed excess electricity generated from renewable resources into the distribution system. In Ontario, consumers who send surplus electricity to distributors are credited towards energy costs, thus trading supply against consumption (HydroOne, n.d.). A smart grid also empowers consumers to use products or devices, such as smart fridges or electric vehicles that are environmentally friendly and cost-effective. Smart fridges reduce consumption through functions that control energy usage or delay operations to save energy during peak periods. However, smart grid applications must not compromise private consumer and industry information and the grid's reliability.

Linkages Between Smart Grids and Cyber Security

Cyber Security

The Government of Canada defines cyber security as the protection of digital information stored within a cyber threat environment against cyber threats and cyber threat actors (Innovation, Science and Economic Development Canada [ISED], 2019). Cyber security is the protection of data, information, devices, and networks. The cyber threat environment refers to the infrastructure where malicious cyber threat activity can occur, including cloud computing and storage, websites, web-based applications, or internet-connected smart devices (ISED, 2019). Cyber threats are activities that are intended to compromise the security of vulnerable digital environments by changing the CIA Triad (confidentiality, integrity, and availability) of a system (ISED, 2019).

Protection of digital information captures the governance, development and use of cyber security tools and techniques. Cyber security uses information security, operational technology (OT) security, and information technology (IT) security tools and techniques to achieve regulatory compliance and to defend assets (Galinec et al., 2017). The tools and techniques of OT and IT security are further used to minimize vulnerabilities, maintain system integrity, allow access exclusively to approved users, and support information assurance objectives (Galinec et al., 2017). Canada's *Cyber Security Strategy* recognizes the importance of cyber security to ensure an innovative and prosperous Canada, stating that "collaborative action with partners and enhanced security capabilities that defend critical government and private sector systems is of the utmost importance" (Public Safety Canada, 2019b). The increased presence of threats to cyber security and the integration of smart grid applications requires understanding their inherent linkage in defending critical infrastructure.

Diminished Cyber Security due to Smart Grid Connections

The rapid development and proliferation of smart grid applications create concerns from a security and privacy perspective. Smart grid cyber security issues are related to changing the grid's CIA Triad (confidentiality, integrity, availability) (Gunduz & Das, 2020). Confidentiality relates to protecting data from unauthorized access or disclosure (Warkentin & Orgeron, 2020), as the smart grid's bi-directional real-time data-collection makes consumers vulnerable to breaches of privacy. Cyber threat actors can access and abuse consumer information and even learn whether consumers are home or not. Integrity relates to the protection of data validity to undesired change (Warkentin & Orgeron, 2020). Cyber threat actors may manipulate or destroy data critical to providing secure and real-time monitoring of the smart grid in an unauthorized or undetected manner (Gunduz & Das, 2020). Availability relates to access to information and systems by authorized individuals and processes in the form and format needed (Warkentin & Orgeron, 2020). Cyber threat actors can target data required for protection, such as data involved in preventing denial of service (DoS) attacks leading to a blackout.

The Vulnerability of the Smart Grid

The link between smart grids and cyber security is inherent to an application's bi-directional communication. More connectivity increases the potential for unauthorized system access and represents a heightened risk of exposure and vulnerability. Access to devices occurs at several points, including OT, IT and the Internet of Things (IoT). As Ontario sets to modernize the grid, the province must focus on these access points as potential vulnerabilities.

Operational and Information Technology

OT includes hardware and software that detects or causes a change through the direct monitoring and control of physical devices, processes, and events (Forcepoint, n.d.), including meters, valves, and Supervisory Control and Data Acquisition (SCADA) systems.[3] IT includes hardware and software used to input, store, process, transmit, and output data (Information Systems Audit and Control Association, 2016), such as Big Data and Advanced Metering Infrastructure.[4] IT systems have been added to improve the management of industrial control systems that perform essential mechanical functions and SCADA systems that monitor and control them (Public Safety Canada, 2019a). OT

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[3] SCADA is a remote industrial control system used to monitor and control electric transmission system components (Campbell, 2017).

[4] Advanced Metering Infrastructure enables two-way communication that collects information in real-time to manage demand and understand consumer behaviour. Demand-side management requires data processing to understand load patterns, design signals for the optimal use of the distribution grid, and manage reserve and frequency response (Mack, 2014). Advanced Metering Infrastructure further enables utilities to offer new rates to incentivize consumers to reduce energy consumption.

operationalizes the real-time bi-directional control of field devices and data, whereas IT maintains the processing and reporting of data.

The uptake in the use of OT and IT has increased the grid's vulnerability to cyber-attacks. Access to OT enables cyber threat actors to control the actuation and operation of devices or entire automated systems, such as SCADA (Campbell, 2017). Access to IT affects the effective recording, processing, and exchanging of data (Campbell, 2017). For example, when misinformation is introduced into Advanced Metering Infrastructure, load pattern data becomes inaccurate, affecting the delivery of power to consumers and potentially causing damage to the grid if an oversupply event occurs.

In 2015, three distribution centres in Ukraine were attacked, disrupting power delivery. Blackenergy 3 malware was injected into the system via spearphishing (Electricity Information and Sharing Center, 2016), allowing threat actors to gain access to credentials and virtual private networks (VPNs) to access and map the SCADA network over several months (Zetter, 2016). On December 23, 2015, the cyber threat actors launched their attack, taking substations offline and leaving 225,000 customers without power for six hours (Electricity Information and Sharing Center, 2016). The cyber threat actors further overwrote the firmware at substations' serial-to-Ethernet converters, which rendered the convertors remotely inoperable (Zetter, 2016). This OT had to be manually switched by onsite workers. The cyber threat actor further implemented KillDisk malware to overwrite the master boot record and wipe files, rendering computers unable to reboot and deleting essential logs (Zetter, 2016). Although only a small percentage of the population was affected by the power outage, similar malware was found in networks belonging to other utilities (Kamensky & Sullivan, 2017), indicating that the cyber threat could have been far more detrimental. Further, even two months after the attack, sixteen control centers were not fully operational due to firmware overwrites (Zetter, 2016), meaning the workers still had to control the OT manually.

The Internet of Things

IoT empowers consumers to play a fundamental role in the development of the smart grid. Adopting IoT allows for the large-scale, bi-directional flow of data, which increases demand response and improves connectivity throughout network infrastructure (Gunduz & Das, 2020). However, IoT provides many access points, such as smart meters, smart appliances, or sensors, for cyber threat actors. Attacks can be directed to the core consumer function, such as data analytics, or at the periphery, which creates a migration path for malware to infect and spread among core systems and across multiple sectors (Metzeger, 2018). The challenge with IoT is the lack of standardization and consumer-based understanding. IoT exists in a capitalist market where competition is the primary mode of business. The exploitation of the IoT for consumers, the industrial sector, and the government will be characterized by strong pressure to be first to market and to use least-cost strategies that do not consider cyber vulnerabilities and ensure a secure supply chain (Metzeger, 2018).

Cyber Security Requirements in Ontario's Grid

Ontario began updating the province's ageing electrical infrastructure in 2004 with the adoption of smart meters. The early implementation of smart meters formed the foundation for developing a provincial smart grid, with almost five million smart meters installed (Independent Electricity System Operator [IESO], n.d.a). After the implementation of smart meters, Ontario sought to develop the grid further. In October 2012, the OEB issued the *Report of the Board on a Renewed Regulatory Framework for Electricity: A Performance-Based Approach* that recognized the need for significant investment in the electricity sector, including smart grid development and implementation (OEB, 2017c). As the province continues to invest in smart grids, cyber security issues will remain persistent and central to policy development.

In Ontario, bulk system assets, facilities that operate at 100 kV or above (OEB, 2017a), must comply with continent-wide cyber security standards under the NERC's Critical Infrastructure Protection (CIP) standards. Ontario's reliability coordinator, the Independent Electricity System Operator (IESO), monitors CIP compliance, ensuring that the bulk energy system is safe from cyber threats (OEB, 2017c). However, local distribution systems and electricity transmitters with non-bulk assets are not covered by NERC's CIP standards. The OEB recognized this gap and issued the *Supplemental Report on Smart Grid* in February 2013 to guide expectations for transmitters and distributors (OEB, 2017c). The new expectations required proof of evidence to the OEB that transmitters and distributors took security and privacy into account as system modernization occurs; however, the OEB did not develop a set of standards (OEB, 2017c). In 2015 the OEB's Smart Grid Advisory Agency assessed the current state of cyber security for non-bulk assets. The assessment demonstrated that many respondents had executive accountability in place; yet, few had fully developed response and recovery plans, and smaller transmitters and distributors were less developed in cyber security understanding and preparedness (OEB, 2017c). The assessment illustrated a causal security gap in Ontario's non-bulk assets that required action to protect critical infrastructure.

The Ontario Cyber Security Framework's Movement Through the Policy Cycle

The policy cycle is a model that represents the key stages in the policy process as a sequence of steps, from the initial identification of a problem to implementation and evaluation. While these steps will be analyzed separately and sequentially, aspects of the policy cycle often overlap, are not exclusive to one another, and rarely progress linearly. The following sections will examine the movement of the Framework through the policy cycle, including problem identification of a causal security gap, instrument choice, design of the policy, implementation into the *Transmission System Code* (TSC) and *Distribution System Code* (DSC), and the evaluation of the Framework.

Problem Identification for Non-Bulk Assets

The OEB acknowledged the importance of closing the security gap because of the severity and proximity of the problem to Ontario's critical infrastructure. A 2016 study completed by the Ponemon Institute showed that the energy and utility sector experienced an annualized loss of

$14.8 million per company due to cyber crime (Acumen Engineered Solutions International Inc., 2017), signalling that cyber threats represent a severe problem for the electricity sector. Ontario's electricity transmitters and distributors supply electricity to large industrial companies and millions of consumers throughout the province, with assets in the tens of billions (Acumen Engineered Solutions International Inc., 2017), illustrating the proximity to Ontarians' everyday lives. The severity and proximity of the security gap to the smart grid demonstrated the need for a common framework and reporting to ensure compliance. Thus, the Framework was created to provide transmitters and distributors evaluation and maturity development tools. Although the security gap is severe and close in proximity, the problem's scope and structure were simple for the OEB to identify.

The activity's scope identifies the number of people, activities, or organizations involved with a problem (Peters, 2005, as cited in Pal et al., 2020a, p. 151). If a problem is defined and relatively small, regulatory intervention is more likely to succeed (Peters, 2005, as cited in Pal et al., 2020a, p. 151). The OEB's regulatory intervention was accepted due to its limited nature and the number of organizations affected. Changes to the TSC and DSC focused on non-bulk distributors and transmitters rather than the entirety of Ontario's electricity system, refining the problem's scope.

A problem is well structured when few decision-makers and a small set of alternatives exist (Dunn, 2008, as cited in Pal et al., 2020a, p. 155). Aside from building a set of standards, few alternatives were available to the OEB to address the cyber security gap. Previously, transmitters and distributors selected standards that left larger companies with more sophisticated levels of cyber security, driving the need for the development of a set of standards to bring less sophisticated transmitters and distributors up to date. The OEB, transmitters, and distributors were the only decision-makers in the structuring of the problem. The assessment of transmitters and distributors in 2015 made it clear that a standard was required to fill the security gap. The acceptance of the Framework and accompanied amendments to the TSC and DSC are attributed to the OEB's instrument choice, stakeholder inclusion, and policy design.

Instrument Choice to Secure Non-Bulk Assets

Instrument choice and design are essential to the success of policy change. Vedung (1998) defined policy instruments as a set of techniques the government uses to ensure support and either effect or prevent change (as cited in Pal et al., 2020e, p. 173). The OEB chose to employ instruments that effect change in how transmitters and distributors ensure cyber security as the grid continues to modernize through indirect and direct action. The OEB used regulatory requirements as indirect action to enact change among transmitters and distributors; however, to assess cyber security capability and reporting, the OEB used direct action. The acceptance of such regulatory instruments is directly related to the inclusion of prominent stakeholders in the Framework's design.

Indirect Action

Indirect action entails pursuing objectives through an organizations' actions (Pal et al., 2020e, p. 175). For the OEB, indirect action included changing how transmitters and distributors ensure adequate steps are taken to protect cyber security during smart grid modernization. The OEB altered the behaviour of transmitters and distributors through regulatory instruments that stipulate rules and sanctions. The purpose of TSC and DSC amendments was to establish regulatory requirements for all licensed transmitters and distributors to provide the OEB with information to demonstrate appropriate action taken relative to security risks (OEB, 2017b). This indirect action, executed through amendments to the TSC and DSC, enabled the OEB to assess and monitor transmitters’ and distributors' cyber security capabilities.

Direct Action

Direct action entails the state using its resources to change conditions or provide services (Pal et al., 2020e, p. 176). Amendments to the TSC and DSC required transmitters and distributors to use the Framework to certify their cyber security capabilities against their inherent risks (OEB, 2017c). Amendments to Reporting and Record-Keeping Requirements required the OEB to use its organizational capacity to ensure compliance regarding implementing the Framework’s risk assessment and status of control objectives (OEB, 2018b). Further, during the creation of the Framework, establishing an independent oversight body, termed the Central Compliance Agency (CCA), was found to be of significant value to the sector. The role of CCA would be to receive additional information based on reports and to perform a level of independent auditing (OEB, 2017a).

Although the CCA has not been created, the province must provide a service to transmitters and distributors if the OEB takes responsibility for the CCA, a direct action. If the CCA is administered by a third-party, a contract will be required between the OEB and the third-party for the service, also considered a direct action.

Stakeholder Involvement

The success of a policy is directly related to the involvement of stakeholders. In Ontario's deregulated electricity market, engagement, consultation, and partnership are essential. Development of an anticipatory policy such as the Framework required engagement, consultation, and partnership between a policy network. A policy network is a subset of actors whose level of interest is higher and interacts with each other, often due to interdependencies (Compston, 2009; Sørensen & Torfing, 2007, as cited in Pal et al., 2020c, p. 265). The OEB recognized the interdependency between the development of the Framework and the interest of transmitters and distributors. The OEB acknowledged the importance of the policy network for non-bulk assets and engaged numerous sector stakeholders during the development of the Framework. The Cyber Security Steering Committee (CSSC) was formed to provide strategic direction during the Framework's development (OEB, 2017c). A list of stakeholders involved in the CSSC is noted in Table 1 below.

Table 1
Members of the Cyber Security Steering Committee

Member	Description
Electricity Distributors Association	A source for advocacy, insight, and information for Ontario's local distributors, municipality, and privately-owned companies (Electricity Distributors Association, n.d.)
Independent Electricity System Operator	Manages the power system in real-time (IESO, n.d.b)
Distributors' Senior Leadership	Hydro One, Toronto Hydro, Oshawa PUC, Hydro Ottawa, North Bay Hydro, Veridian, Alectra Utilities
Gas Distributor	Enbridge
Academia	The University of Toronto, Gowling WLG (Canada) LLP

Note. Adapted from *Ontario Cyber Security Framework*. https://www.oeb.ca/sites/default/files/Ontario-Cyber-Security-Framework-20171206.pdf. Copyright 2017 by the OEB.

A Cyber Security Working Group (CSWG) was also developed to evolve the Framework as it was presented. The CSWG leveraged industry standards, policy guidelines, and auditing requirements to build a framework that applied a distribution context, provided oversight, and validated the adequacy of cyber security measures for non-bulk assets (OEB, 2017a). A list of stakeholders involved in the CSWG is noted in Table 2 below.

Table 2

Members of the Cyber Security Working Group

Member	Description
Independent Electricity System Operator	Manages the power system in real-time (IESO, n.d.b)
Ministry of Energy, Northern Development and Mines	Works to develop a safe, reliable and affordable energy supply across the province (Government of Ontario, 2019)
Electricity Distributors Association	A source for advocacy, insight and information for Ontario's local distributors, municipality and privately-owned companies (Electricity Distributors Association, n.d.)
Electrical Safety Authority	Regulates and promotes safety in the electricity sector in Ontario (Electrical Safety Authority, n.d.)
Distributors' Senior Leadership	Alectra Utilities, Oakville Hydro, Oshawa PUC, Hydro One, Thunder Bay Hydro, EnergyPlus, London Hydro, Waterloo North, Toronto Hydro, Hydro Ottawa, Peterborough Hydro, Veridian, Burlington Hydro, Orangeville Hydro, Renfrew Hydro, Halton Hills Hydro
Gas Distributors	Union Gas, Enbridge

Member	Description
Transmitter's Senior Leadership	Entegrus

Note. Adapted from *Ontario Cyber Security Framework*. https://www.oeb.ca/sites/default/files/Ontario-Cyber-Security-Framework-20171206.pdf.

Finally, the OEB engaged three industry experts that developed the proposed Framework, with advice and guidance from the CSWG. The OEB engaged Acumen Engineered Solutions International, DLA Piper, and Richter, as these experts provide experience and knowledge of cyber security issues in the distribution sector, particularly in Ontario (OEB, 2017c). The inclusion of a diverse policy network of stakeholders and experts created a supportive base for the establishment of the Framework. The OEB received fifteen submissions in response to the draft Framework, whereby stakeholders were generally supportive and saw it as a positive policy initiative (OEB, 2017b). Support for the policy initiative was primarily due to the for industry, by industry approach taken by the OEB and the highly interactive and collaborative attitude with key industry stakeholders during policy design.

Policy Design of the Ontario Cyber Security Framework

Policy design involves choosing the most appropriate instrument to deal with the policy problem as it has been defined (Pal et al., 2020e, p. 203). As discussed, the OEB defined the policy problem as the lack of common cyber security standards for transmitters and distributors, and the appropriate instrument designed was the Framework. The Framework provides a methodology and toolset to assess transmitters' and distributors' inherent level of risk and define benchmarks, objectives, and progress management. Stakeholder support for the Framework is attributed mainly to the effectiveness, fairness, and efficiency of its design.

The Framework includes three instruments that support transmitters' and distributors' requirement to report their cyber security capabilities to the OEB. The first instrument, the Inherent Risk Profile Tool, assesses transmitters' and distributors' inherent risk level, which establishes forty-six weighted questions based on size, maturity and capability (OEB, 2017a; OEB, 2017c). The Risk Profile Tool produces a Risk Profile Number that categorizes a transmitter or distributor as high, medium, or low risk (OEB, 2017a; OEB, 2017c). The second tool, the National Institute of Standards and Technology Controls and Privacy Requirements, enables transmitters and distributors to map a set of suggested control objectives against their risk level (OEB, 2017a). The third instrument, the Self-Assessment Questionnaire (SAQ), helps transmitters and distributors identify cyber security gaps and their cyber maturity level (OEB, 2017a).

Effective

Design is considered effective if it is "getting the job done" (Pal et al., 2020e, p. 203). The Framework "gets the job done" because it leverages both authoritative security and privacy standards that safeguard the CIA Triad. The security aspect of the Framework represents the integrity and availability elements of the CIA Triad, whereby information and power delivery are protected and controlled through risk management.

Grid risk management is the process of identifying, assessing, and controlling cyber threats. The foundation of the Framework maintains the risk management process, which includes the National Institute of Standards and Technology's Cyber Security Framework (NIST-CFS) and the Department of Energy's Cyber Security Capability Model (C2M2). The NIST-CFS includes five core functions (identification, protection, detection, response, and recovery) (OEB, 2017c) that directly relate to a strategic view of cyber security risk management. The C2M2's description of maturity levels for various objectives, from not performed to managed, allows for the categorization of cyber risk management performance (OEB, 2017c). The integration of NIST-CFS and C2M2 allowed for the development of control objectives and the SAQ. The Framework is also scalable so that cyber maturity aligns with risks and proposes a set of benchmarks and control objectives for different risk levels (OEB, 2017c). The focus on transmitters and distributors, scalability and benchmarks create context-specific, scalable, and comparison tools that help build successful and secure cyber assets as modernization of the grid continues.

The NIST Framework does not include privacy guidelines, which disregards the CIA Triad's confidentiality aspect. To address this limitation, eleven Privacy by Design (PbD) principles were embedded in the NIST Framework. The inclusion of PbD principles requires entities to consider consumers' consent when deciding to collect, use, and disclose information (OEB, 2017c). PbD advances the view that future privacy is assured when it becomes an organization's default mode of operation (Cavoukian, 2011). The Framework, further, requires mandatory privacy compliance regardless of a transmitter or distributor's risk profile. While the OEB's for industry, by industry approach effectively garnered support for the Framework, an essential part of the policy network was overlooked. The OEB did not conduct public consultations despite the Framework's implications for Ontarians. Consumers have a high level of interest regarding the confidentiality, integrity, and availability of power delivery, particularly how distributors and transmitters handle sensitive personal data. While consumer privacy is at the heart of PbD principles, public consultations would provide additional perspectives and knowledge to build robust principles that are accepted by consumers. Moreover, public engagement involves interaction and listening, which provides consumers with a level of understanding and accountability regarding how increased connectivity impacts the grid's vulnerability.

Fair

Policy design is considered fair if the distribution of costs and benefits is not skewed towards one party (Winfield, 2016, as cited in Pal et al., 2020e, p. 203). Based on this definition, the Framework is considered fair because the TSC and DSC amendments result in benefits that exceed any additional costs and a better-informed electricity sector (OEB, 2018a). Transmitters' and distributors' abilities to protect the privacy of consumer's information and secure non-bulk assets outweigh the additional cost of cyber readiness. The cost to remediate a cyber attack on non-bulk assets outweighs the additional cost of preparedness.

The design of the Framework is truly fair due to the flexibility it provides transmitters and distributors. The Framework includes mapping for NIST-CSF guidelines and standards, allowing transmitters and distributors to identify if their cyber security approach already aligns with the outcomes expected (OEB, 2017c). Therefore, if a transmitter or distributor's cyber security approach already aligns with specific NIST-CSF guidelines, no adaptation is required. Flexibility is also provided during the initial evaluation of inherent cyber risk. The Inherent Risk Profile Tool offers a range of thresholds between Low to Medium Risk and Medium to High Risk that provides flexibility to determine a risk profile that best matches a transmitter or distributor's unique situation (OEB, 2017a). Risk is a spectrum instead of a specific number, allowing transmitters and distributors to define their appropriate level of risk and actions to addresses security and privacy gaps.

Efficient

Efficiency is understood as getting the job done with the least resources (Winfield, 2016, as cited in Pal et al., 2020e, p. 203). The Framework requires the least amount of government resources. Indeed, the OEB has indicated that they will review compliance with the Framework; the organization will not identify and assess transmitters' and distributors' risk management and privacy standards against the Framework's control objectives. Rather, the Framework focuses on changing the governance model of transmitters and distributors through self-certification. The SAQ is explicitly provided for internal use for transmitters and distributors and provides questions based on the determined risk profile with a set of choice responses that indicate each control and privacy requirements' status. The SAQ provides transmitters and distributors with the necessary tools to assess their cyber security status and maturity levels to set objectives to increase cyber security protection. SAQ results, compliant or non-compliant, support management certification to the OEB, ensuring that the appropriate attention was taken to determine compliance (OEB, 2017a). Resources from the province are required during reporting to assess if expectations of cyber security protection are being met. The design and purpose of the Framework ensured its successful implementation.

Implementation of Instruments for Non-Bulk Assets

Implementation of the Framework into the TSC and DSC was successful due to responsive regulation and the minimal number of clearances required to amend the codes. The implementation of the Framework for transmitters and distributors follows the principles of New Public Management (NPM); however, the continued success of the Framework relates to the OEB's stance that it is a living document that will be revised as circumstances evolve.

Implementation of the Ontario Cyber Security Framework into Amended Codes

The implementation of the Framework into the TSC and DSC was successful due to the nature of the Framework. Although the Framework is considered the most coercive form of indirect action, this type of regulation is what Ayers and Braithwaite (1992) term "enforced self-regulation" (as cited in Pal et al., 2020d, p. 236). The amended TSC and DSC enforce self-certification by the Chief Executive Officers of transmitters and distributors to ensure that the best practices and methodologies are in place to meet the Framework's defined control objectives. Self-certification and enforced annual reporting are provided to the OEB. Self-certification ensures the appropriate attention and focus is taken to address compliance and required remediation activities (OEB, 2017a). Due to the inclusion of transmitters and distributors in the Framework's development, it is highly unlikely that non-compliance will occur.

The success of the Framework's implementation is attributed to engagement and consultation during decision points that require clearances. Pressman and Wildavsky state that implementation requires "decision points" with "clearances" by multiple sets of actors (as cited in Pal et al., 2020d, p. 227). Amendments to the TSC and DSC required two "decision points," the implementation of the Framework and the implementation of Reporting and Record-Keeping Requirements (RRR). The "decision point" to amend the TSC and DSC with the Framework required two "clearance" points, as demonstrated in Figure 1.

Figure 1

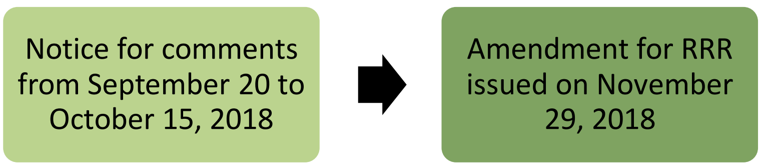
Decision and Clearance Points to Amend the Transmission System Code and Distribution System Code with the Ontario Cyber Security Framework

Note. The light green boxes illustrate clearance points, and the dark green box illustrates the decision point to amend the TSC and DSC. Adapted from *Protecting Privacy of Personal Information and the Reliable Operation of the Smart Grid in Ontario*. https://www.oeb.ca/industry/policy-initiatives-and-consultations/protecting-privacy-personal-information-and-reliable. Copyright 2019 by the OEB.

Few comments were received, which required two minor revisions to the proposed amendments regarding the definition of cyber security; however, no material changes were made to the Framework (Ontario Energy Board, 2018a).The amendment to include RRR only required one "clearance" point, as demonstrated in Figure 2.

Figure 2

Decision and Clearance Points to Amend the Transmission System Code and Distribution System Code with Reporting and Record Keeping Requirements



Note. The light green box illustrates the clearance point, and the dark green box illustrates the decision point to amend RRR. Adapted from *Protecting Privacy of Personal Information and the Reliable Operation of the Smart Grid in Ontario*. https://www.oeb.ca/industry/policy-initiatives-and-consultations/protecting-privacy-personal-information-and-reliable. Copyright 2019 by the OEB.

Again, few comments were received and focused mostly on clarification and guidance for reporting requirements (OEB, 2018b). The new sections of the RRR came into effect immediately, and transmitters and distributors were required to submit their first Cyber Report by April 30, 2019[5] (OEB, 2018b). Implementation success is demonstrated by the narrow problem structure and stakeholder inclusion in the Framework's development.

Implementation of the Ontario Cyber Security Framework

The implementation of the Framework for transmitters and distributors follows NPM as it focuses on outcomes and performance. NPM principels pay considerable attention to outcomes and performance, emphasizing clear service standards on which agencies can be held accountable (Pal et al., 2020d, p. 234). The Framework provides a methodology and toolset for assessing risk, defining benchmark objectives and measuring progress toward those objectives (OEB, 2017c). Transmitter and distributor accountability will be evaluated through the RRR's Cyber Reports. The continued success of the Framework will be attributed to adaptive management. Adaptive management builds flexibility and feedback into decision-making instances characterized by uncertainty (Government of Canada, 2016, as cited in Pal et al., 2020d, p. 247). The Framework is a living document that must be updated as best practices, methodologies, and industry experience and knowledge regarding cyber security expand.

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[5] The OEB acknowledged that cyber security reports from transmitters and distributors contain sensitive information and do not intend to disclose the self-certification status of transmitters and distributors as a part of public filing and will keep the reports confidential with limited access (OEB, 2018a). Therefore, an analysis of transmitter and distributor reporting on control objectives and benchmarks for maturity could not be completed for the purposes of this paper.

Evaluation of the Ontario Cyber Security Framework

The Framework does not build clear objectives for its evaluation; however, the CSWG and CSSC recommended that a Cyber Security Advisory Committee (CSAC) be established to evaluate the Framework's efficiency (OEB, 2017c). While no specific dates have been set for evaluation, the ever-evolving nature of cyber security suggests that formative evaluation is suited for the Framework's evolution. Formative evaluation focuses on policy improvement, typically working with program managers during implementation (Pal et al., 2020b, p. 314).

Evaluation of the Framework involves working with the proposed CSAC to improve the policy as transmitters and distributors identify and meet benchmark NIST control and PbD privacy requirements. Improvement to the Framework could be achieved in the short term by adding additional controls to suit the specific risk tolerance of a transmitter or distributor (OEB, 2017a). As cyber threats mature, the Framework’s security objectives and expectations must keep pace. In the long term, the Framework’s evolution must consider the adoption of increasing maturity levels associated with C2M2 (OEB, 2017a). Stage One of maturation is underway, ensuring that transmitters and distributors adopt baseline security controls aligned with their risk profile to have a maturity implementation level of 1 (MIL1) (OEB, 2017a). To evolve to a higher maturity stage, Stage Two involves evaluating transmitters’ and distributors' security controls, which indicates the status of reduced residual risk due to security control maturation (OEB, 2017a). This reporting will also help measure the NIST Control and Privacy Requirements' success in reducing the risks of cyber threats. However, a weakness is identified for the Framework's evolution, as no specified period is allocated to transmitters and distributors to attain the Initial Achievement Level of MIL1. The Framework will remain effective, efficient, and fair in the future as it evolves with the changing landscape of cyber security, deployment of smart grid applications, and the sophistication of cyber threats.

Conclusion

Ontario’s previous cyber security policies created a causal security gap that required cyber security standards for non-bulk assets. To address the security gap, the OEB, in collaboration with sector stakeholders, developed the Ontario Cyber Security Framework to provide standards for non-bulk assets. The analysis conducted above reveals that the Framework is a successful policy because of its quick and uncontested movement through the policy cycle.

Problem definition was straightforward for the OEB due to the narrow scope and well-structured nature of the issue, attributed to the small number of stakeholders in the policy network and already existing standards in transmitters’ and distributors' governance models. The problem remained to establish a standard for laggards to compare to, helping to ensure their cyber security. The OEB’s decision to mix both direct and indirect action for instrument choice enables a behaviour change through a regulatory response that requires reporting to the OEB and the proposed CCA. The OEB’s focus on a for industry, by industry framework that deployed a mix of NIST-CFS, C2M2, and PbD principles, allowed flexible mapping and ensured that the policy’s design was effective, fair, and efficient. This allowed for smooth implementation into the TSC and DSC and within transmission and distribution companies.

Although the Framework is a regulation, often considered the most coercive policy instrument, it is a responsive regulation that enables transmitters and distributors to self-certify that they are compliant through enforced reporting. The Framework utilizes a New Public Management structure that provides a methodology and toolset for assessing risk, defining benchmarks objectives, and progress management. Adaptive management and evaluation of the Framework will remain important for the future as the pace of the adoption of smart grid applications quickens, and cyber security threats evolve and gain sophistication. Complacency in the face of changing cyber threat landscapes will result in increased financial and reputational losses for transmitters and distributors, power interruptions that affect community safety and have the potential to cause human harm and damage to the grid.

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Overcoming Barriers for Adoption of Water Efficient Urban Agriculture: Exploring Policy Options in Water Stressed Regions

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Introduction

For countries in both the Global North and South, access to safe water is central to the health and well-being of populations, successful industries, and the environment. Despite this, water resources are distributed unequally around the globe, largely due to geographic features. This inequity can be seen along natural barriers, such as mountain ranges and drainage basins, and can also be traced through atmospheric currents and their interactions with oceans and landscape features. This imbalance is further compounded by settlement patterns and the various means by which societies consume water.

The scope of this problem extends beyond the physical availability of water resources. For example, in 2007, one-fifth of the global population lived in areas of physical water scarcity (Msangi, 2014). However, due to various other factors, between 1996 and 2005, approximately 4.3 billion people (71% of the global population) lived under conditions of moderate to severe water shortages at least one month of the year (Mekonnen & Hoekstra, 2016). Within this percentage, 66% experienced levels of extreme water stress at least one month per year, while between 1.8 and 2.9 billion people (23% to 37% of the global population) faced chronically low levels of water availability (Mekonnen & Hoekstra, 2016). By 2025, two-thirds of the global population could be living under water-stressed conditions (Msangi, 2014).

There are many contributing factors to this problem. However, agriculture is a key driver, as it often accounts for a majority of water usage, consuming more than two-thirds of total global withdrawals (Gan et al., 2013). Agricultural water use often represents up to 40% of water draws in countries in the Global North, and up to 90% in the Global South, such as those in Africa and Central and South America (Morison et al., 2008). At a global scale, agriculture, as a weighted average, accounts for approximately 80% to 90% of all freshwater used by humans (Morison et al., 2008). As a result, the rural agricultural industry is the single largest user, and often waster, of the world's water supply. This withdrawal is significant, especially for countries located in water-stressed regions.

Today, roughly 55% of the world's population, or 4.2 billion people, live in urban centres (Urban Development, 2020). By 2050, this number is expected to more than double to nearly seven out of ten people worldwide (Urban Development, 2020). The current situation presents both a problem and an opportunity. Since agriculture is predominantly rural by nature and represents a significant percentage of water use, the natural question is what can be done to alleviate agricultural water withdrawals within rural regions? What policy options could help transition to a water-efficient agricultural system?

In response to these questions, this research paper will explore how urban agriculture can help alleviate water scarcity in water-stressed regions by shifting production to urban spaces and increasing efficiencies. This paper will focus on the growing availability of efficient technologies, the growth of new investment opportunities, and the increased exposure to trade skills within urban environments. It will also explore potential policy alternatives to overcome the numerous challenges to implementing water-efficient urban agriculture systems in water-stressed regions.

This research, supported by literature, will open by describing and defining the scope of water scarcity and water stress throughout the world and present a case for how urban agriculture and various policy options can help address water stress. The paper will then discuss how agricultural water efficiency and clean technology options are being embraced, explore the barriers to adopting urban agriculture systems, and evaluate real-world policy options for adopting water-efficient agriculture in urban settings. As agricultural water efficiency has both technological and cultural elements, both will be featured when evaluating policy applications. Emphasis is given to small and medium enterprise technology adoption, where applicable, as these account for large segments of global agricultural systems.

Defining the scope of the problem

Water Stress

Understanding the inequitable distribution of water along geographic, economic, and social boundaries, and throughout time, is pivotal to understanding the issues at the heart of water stress and scarcity. Water stress occurs when demand exceeds current availability, or poor quality restricts its use, further depleting the usable supply (European Environmental Agency, 2019).

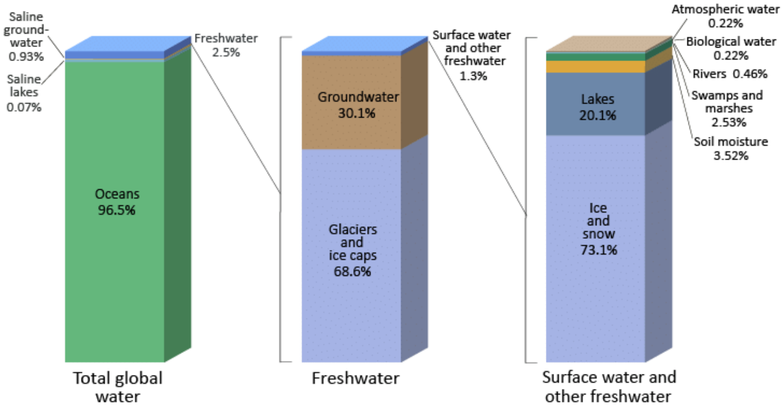
Water stress can arise from geographic and hydrographic limits where water availability is simply non-existent or not sustainable to the degree that society currently exploits the resource. These natural limitations are further compounded by socio-economic factors such as land-use patterns, urban and rural transformations, socio-spatial densification, and generally poor or inadequate water resource management frameworks.

The Distribution of Waters

As Shiklomanov (1993) has demonstrated (see Figure 1), saline and brackish waters constitute 97.5% of Earth's water sources, meaning that freshwater sources represent only 2.5% of total water availability. Of this freshwater, 68.6% is locked in glaciers and ice caps and is considered inaccessible, while 30.1% is stored in groundwater. Surface waters, which represent only 1.3% of the world's freshwater sources, are collected by means of lakes, rivers, seasonal ice and snow cover, swamps, marshes, and soil moisture (Shiklomanov, 1993). This means only approximately 0.75% of all water on earth is accessible and fit for consumption to use as freshwater. Of this accessible freshwater, the majority is overwhelmingly provided via groundwater sources.

Figure 1

Distribution of Earth's Water



Note. The usable portion of freshwater sources (not trapped in glaciers and ice caps) represent roughly 0.75% of the available water on earth. This availability does consider geographic, economic, demographic and social constraints to the distribution of water amongst the world populations. Adapted from "World Fresh Water Resources," by I. Shiklomanov, 1993, *Water in Crisis: A Guide to the World's Fresh Water Resources*. Copyright 1993 Oxford University Press.

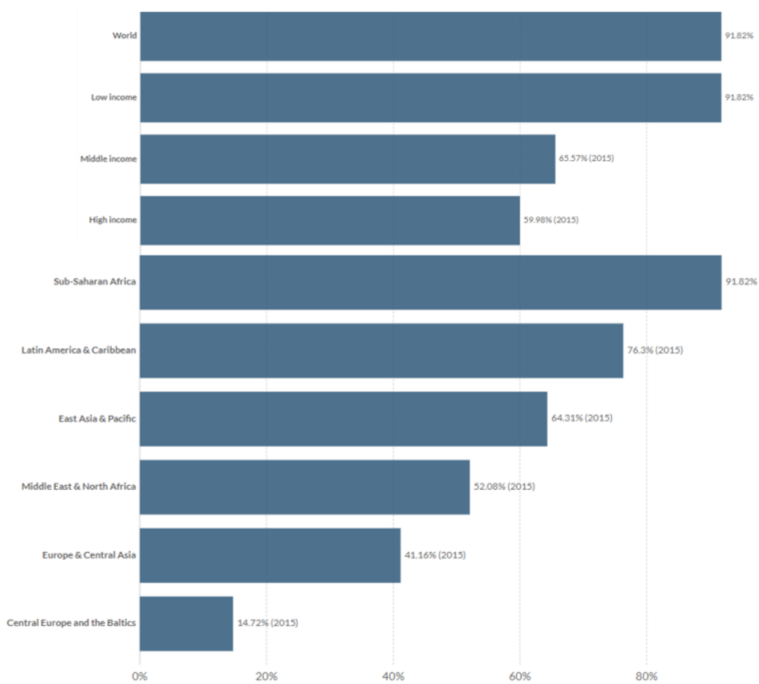
Typically, water precipitation and infiltration will not recharge groundwater sources. Only 10% to 20% of precipitation enters the water-bearing strata of aquifers; the balance of this water is stored in the soil zone and returned to the atmosphere through evaporation and plant transpiration (Alley, 2009). Aquifers have finite capacities and slow recharge mechanisms. By this nature, all land development based on their existence will become unsustainable without careful management (Groundwater Hydrology, 2019).

Water Withdrawals

When looking at water usage, a significant disparity is observed between agricultural water demands and other household and industrial water demands, as presented in Figure 2.

Figure 2

Agricultural Water Withdrawal as a Share of Total Water Withdrawals from 1956 to 2016



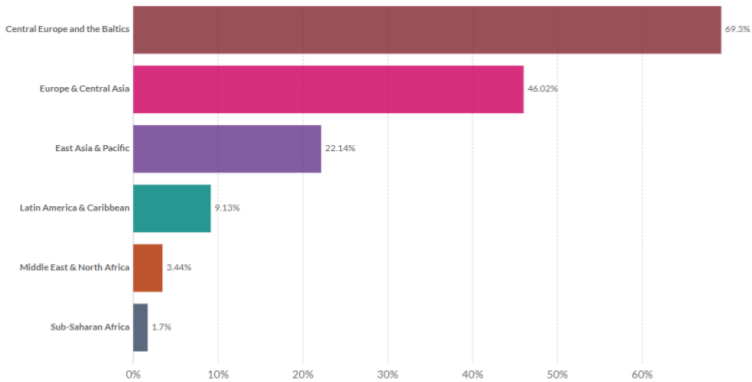
Note. This figure illustrates the agricultural water withdrawals as a percentage of total water withdrawals (that is, the sum of water used for agriculture, industry and domestic purposes). Adapted from *Water Use and Stress*, by R. Hannah, 2017, from https://ourworldindata.org/water-use-stress. Adapted with permission.

In countries in the Global South, such as central Asia, South East Asia, and Africa, agriculture can often account for 60% to 90% of total water draws, while withdrawals used in households and industry account for 2% to 40%, trending higher withdrawals towards household uses (Hannah, 2017). This inequality is further exacerbated by the high levels of water stress experienced in these parts of the world and can be attributed to a lack of water resources, inefficient or absent infrastructure, or geographic, social, and economic limitations.

Conversely, in Europe and North America, it is often industry that accounts for around 50% of total water consumption (see Figure 3), with the balance falling between households and agriculture (Hannah, 2017). By contrast, domestic or municipal water use rarely surpasses 20% of total water withdrawals, with a worldwide average of 13.74% in 2015 (Hannah, 2017). There are exceptions that see high domestic water share use in some African nations due to a lack of agricultural infrastructure and industry inputs, as well as in the UK and some very wet northern European states, which require negligible agricultural water inputs, thus skewing the results towards domestic water uses. Still, water use profiles facilitated by modern and more efficient distribution systems do not exclude the Global North from experiencing water stress. Instead, water stress in these countries can be attributed to prioritizing economic output and providing unbridled access for industry and domestic use, rather than limiting natural resource exploitation to promote longevity and sustainability.

Figure 3

Industrial Water as Share of Total Water Withdrawals 2015



Note. This figure shows industrial water withdrawals as a percentage of total water withdrawals (that is, the sum of water used for agriculture, industry and municipal purposes). Adapted from *Water Use and Stress*, by R. Hannah, 2017, from https://ourworldindata.org/water-use-stress. Adapted with permission.

Examining the water usage profiles and characteristics of the locations found in Figure 2, it is clear that regardless of water distribution, resource size, and whether a country is located in the Global North or South, agricultural water resource management plays a significant role in addressing water scarcity. To maintain limited water resources, sustainable water management policies focused on resource carrying capacity are required at all levels of government to address water scarcity and sustainable water use.

Urban Demand

Increasing urban demand for agricultural products, which have a significant water footprint, further intensifies water stress. While cities themselves often have more stringent water use regulations and programs to increase water efficiencies, agricultural products are often sourced from rural communities with more lenient water efficiency regulations. Furthermore, as urban centres rely heavily on surrounding rural hinterland regions for agricultural products and services, this creates pressure on rural regions to focus on generating greater economic output to supply the urban centres. The interactions of this urban-rural relationship often result in intensive landscape management practises and the subsequent loss of natural productivity, ecosystem services, and changes to landscape structures, including the natural hydrology of regions.

In order to meet the urban demand for agricultural products, rural regions depend largely on irrigation as a common and frequently used method of increasing agricultural production and yields. Most often, water from subsurface aquifers is pumped from groundwater sources and used in surface water irrigation networks. As previously discussed, precipitation and water infiltration do not recharge these groundwater aquifer sources, meaning that water introduced into the system through irrigation does not replenish groundwater aquifers, resulting in changes to the natural hydrology of the landscape. Instead, water introduced through irrigation schemes is typically transported as surface or subsurface runoff, becoming surface water, ultimately ending up in oceans. Unsustainable management of crucial groundwater aquifers is driven by urban and rural planning policies, which are predominantly concerned with the economic and social planning of settlements and communities and lack emphasis on the natural balance and size of these groundwater resources (Loucks & van Beek, 2017). Too often, these policies have led to the overdevelopment of regional rural landscapes, which lack the capacity to support the extent of resource exploitation required to meet human growth.

Therefore, the question is: how can planners and policymakers incentivize water efficiency within the agricultural sector? To combat these challenges, policymakers have put forth various policies to increase the efficiency of irrigation infrastructure. Many of these programs are incentivized cost-sharing programs that subsidize new investments towards more efficient water systems and equipment (British Columbia Ministry of Agriculture, 2017; Colby & Frisvold, 2012). While these programs have been extremely popular and widely publicized by governments, scientists, and international organizations, very few have been independently evaluated. When examined in detail, it becomes clear that these systems are not as efficient as once believed (Pfeiffer & Lin, 2014), leading many to debate whether the efficiency enhancements can make significant amounts of water available for other uses (Cooley et al., 2009).

Often overlooked are how changes in irrigation efficiency can impact a farmer's profit maximization and result in behavioural changes that increase their consumptive use (Pfeiffer & Lin, 2014). For example, in locations where water demand has a strong elastic response with higher marginal yields, increasing irrigation efficiency will increase irrigation demand (Pfeiffer & Lin, 2014). As a result, true water conservation occurs only with a decrease in actual net consumption rather than marginal consumption. Therefore, it is not enough to target water or crop efficiency as the primary performance metric. While water-efficient technologies can help reduce water consumption, it is essential to measure and regulate net water consumption based on the sustainability of the water sources' carrying capacity.

In addition to the above economic drivers, most hinterland regions do not have the population density and capital required to invest in the most water-efficient crop technologies, infrastructure or cultivation methods when developing agricultural products and services. With the exception of large industrial farming operations, which are primarily located in the Global North, small and medium-sized farms represent the dominant farming culture throughout most of the world (Lowder et al., 2016). It should come as no surprise that small and medium-sized rural enterprises often lack both the financial capacity and access to capital to invest in larger, capital-intensive water-efficient farming methods and technologies. This barrier creates an added incentive for small and medium agricultural providers to relocate or situate themselves near, or within, urban centres.

To come full circle, many of the planning and policy measures put in place to increase water efficiency have seen mixed success in decreasing behavioural water use. Generally speaking, groundwater aquifers continue to be depleted at unsustainable rates, far exceeding their capacity to recharge. Urban agriculture, however, represents a largely untapped value opportunity for both agricultural output, local businesses, and water conservation efforts.

Potential urban farming impacts on regional water conservation

Urban space and scale considerations

Various trends within the agricultural sector are driving more growers to establish and adapt their business models to better serve urban clienteles. The growing popularity and demand for local, organic, and sustainable foods have prompted a business response favouring urban farming solutions. As in most cases, demand is often counterbalanced by the availability of supply. Here, the demand for local urban farms is most often limited by land constraints, either due to land costs or simply the lack of available urban land plots required for conventional farming. The lack of urban land availability for traditional farming practices has led to the adoption of many alternative farming models, such as urban residential, land lot, rooftop, and an industrial model for urban food production, which is the most intensive production method.

Residential farms are small scale, often no larger than a well-tended and productive garden. These farms are designed to supplement small or large parts of domestic food demand and budgets with fruit and vegetable produce. Urban residential agriculture models are more prone to using water-efficient delivery and irrigation systems, like drip irrigation, than their rural counterparts. This difference can be traced to urban farmers benefiting from increased access to water-efficient technologies due to their proximity to urban markets, municipal and utility water conservation programs, and potentially higher water pricing schemes that, in turn, further incentivize water conservation. Water conservation programs often have targeted components addressing domestic water use, such as flow rates for sprinkler systems, fixtures, etc., and impact smaller scale, less capital-intensive equipment. However, the limits to suitable land and space within urban environments have predominantly pushed agricultural producers towards models of higher densification and efficiency to focus on higher product output, particularly at commercial scales.

Residential farmers, by contrast, consume their produce and are budget conscious for their scale of production. They are also more likely to use complementary crop management techniques, such as complementary crops themselves, use compost, and be more conscious about health impacts to reduce pesticide and herbicide use within their planting beds. Of course, these practices have positive reinforcing synergies by further promoting healthy, biologically active soils, which act as a moisture sponge to absorb and retain water. Residential models, due to their low capital requirements and ease of implementation, have been extensively developed in many locations throughout the world. For example, more than 38% of US households, representing 41 million people, grew vegetable gardens in 2010 (Lehrer & Dunne, 2011). In a more extreme example, food gardens in 2008 made up 8% of urban land in Havana, representing 3.4% of all urban land within Cuba (Brown, 2019). These food gardens produced 90% of all fruit and vegetables consumed (Brown, 2019).

In a similar fashion, vacant or underused urban land plots can be developed for community garden purposes. These land parcels, either owned by municipalities or other organizations, often represent underused assets within cities, which can be repurposed for community agriculture. Under this model, organizations and city land managers can designate parcels to be used for community garden projects. There are a variety of models, which range from member-based groups to individuals who enter into an agreement with the landowner to use a portion of their space for communal or personal farming activities. Using geospatial remote sensing satellite measurements, Clinton et al. (2018) estimate that there are approximately 7 to 11 million hectares (a low to intermediate estimate) of vacant and underused urban land plots that can feasibly be converted for urban farming uses worldwide.

Since access to land for a traditional farming practice is limited in urban environments, many growers have developed alternative growing techniques to take advantage of the widespread availability of unused rooftop spaces. Still, the potential for growing agricultural crops as part of a rooftop farming model is constrained but not precluded by structure, load challenges and the availability of drainage and water for irrigation. Here, rooftops are more likely to utilize a carefully designed and calibrated drip system for irrigation in planting beds and can be developed for open-air farming or include enclosed greenhouses, roof structure permitting. A variety of systems are also not uncommon and are selected based on a variety of considerations such as climate and pest control, insolation, nutrient control, crop variety, and availability of capital. For example, one farmer may utilize more traditional growing techniques such as raised beds or opt for a combination of several different growing techniques and systems, including hydroponic systems like drip, ebb and flow, water culture, or Dutch Bucket Systems. Overall, as a conservative estimate, globally, there are 1.3 million hectares of underused rooftop space that can be used for urban agriculture (Clinton et al., 2018).

By contrast, other urban farming applications follow the industrial model. These models are based on vertical, highly densified, and high production farming, often built in interior commercial spaces. These facilities are only limited by the availability of commercial infrastructure and energy. Industrial farming operations more closely resemble a modern industrial manufacturing facility over a traditional farm, and like any other manufacturing facility, they benefit from economies of scale. They can also use a variety of autonomous and semiautonomous controls to work in conjunction with everything from lighting power density, indoor climate control, irrigation, and other building and process automation systems. This model is best suited for hydroponic systems with the potential for densification, customization, reliable quality control, high output per cubic meter of space, and extreme water savings. However, due to the various climate control and lighting systems, these operations often present a high power demand (Barbosa et al., 2015). The demand for power can be problematic and even expensive, depending on the local grid conditions, particularly in the Global South, where access to reliable energy infrastructure is not as commonplace. Nevertheless, larger urban centres and port cities, as well as any location with good access to transportation and distribution hubs and special economic zones would be able to access the necessary infrastructure and equipment with relative ease.

These urban farming models have the potential to address water conservation in significant ways and can materially impact food availability. Clinton et al. (2008) estimated that in cities across the world, urban agriculture could produce up to 180 million metric tons of food per year, accounting for up to 10% of the global output of tubers, roots, legumes, and vegetable crops. The water conservation potential in providing 180 million metric tons of food per year through urban farming practices utilizing water-efficient irrigation and conservation techniques holds significant promise in reducing water demand on groundwater resources (Clinton et al., 2008). This topic will further be explored in the next section through a discussion of the various technologies widely used in urban agriculture systems.

Technological considerations

Technology selection for food production can have significant impacts on the quantity of resource inputs that are used and consumed in the production of agricultural goods. Though most rural field crops are irrigated using flooded field or overhead (spray) irrigation systems, urban farms often utilize water-efficient direct nutrient delivery systems and recycling options. Technologies such as drip irrigation and hydroponic systems have demonstrated the ability to significantly reduce water demand in farming applications. These systems utilize a method of water delivery and recycling that is timed and controlled, allowing drip irrigation systems to target root structures. On average, these systems can reduce water demand between 80% and 90%, with some systems capable of reducing water demand up to 95% from traditional methods (Barbosa et al., 2015; Stahl, 2019). However, these systems are also capital intensive and require specific technical knowledge to operate and maintain both climate controls and irrigation systems. Additionally, drip irrigation and hydroponic systems sometimes require technology-specific knowledge of external nutritional inputs, which is not always present in traditional farming culture. Direct or targeted nutrient delivery systems are also not adapted to industrial processing equipment for cultivation or harvesting. To a large extent, they rely heavily on human resources for cultivation in a similar fashion to fruit and vegetable farms. These systems are best adapted for vegetable crops, which have a high yield and are capable of multiple manual harvests annually.

Hydroponic and targeted nutrient delivery irrigation systems are also best suited for urban locations. These systems can be built in confined or limited spaces and designed to produce high yields by intensifying production, with tightly controlled resource inputs such as water, nutrients, and energy (Woodard, 2019). Such systems, which can range from rudimentary backyard setups to highly sophisticated commercial enterprises, are very versatile and can grow a number of specialty crops, including tomatoes, peppers, lettuce, eggplants, and strawberries. (Barbosa et al., 2015). Furthermore, they are capable of operating alongside, and in conjunction with, programmed controlled environments in industrial farming models, where heat, light, humidity, and airflow are managed to optimize crop output. Commercial or industrial urban farming operations are often built in larger, underused, commercial or industrial spaces to serve local markets, while community farming frameworks can easily be adapted to underused residential, rooftop, or public and private land lots for private use.

Barriers to urban agriculture transitions

Urban agriculture models vary significantly in potential scope, use, and operational frameworks. Small scale installations, such as residential and urban land plot models, can be developed with a simple drip or no irrigation system. Larger operational models, such as rooftop and commercial installations, usually require significant upfront capital investments and more intricate systems. Smaller, community-based residential or land plot models face stronger barriers regarding education and informational resources. Commercial-scale farms, however, may have difficulty gaining access to capital (including financing frameworks) and face a lack of land security. Urban farms, due to their higher financial requirements, as well as some technical and technological requirements, face a host of barriers similar to those of various energy efficiency and utility infrastructure industries. The following sections outline the most common barriers spanning all frameworks of urban agricultural adoption.

Information barriers

A lack of understanding concerning urban agriculture practices, in conjunction with indoor climate control and hydroponic systems, is rampant within the industry and is at par with barriers to accessing capital and land availability. Informational barriers can vary from inadequate understanding of the business case (resulting in insufficient income generation) to a lack of technical knowledge of the systems involved (which could halt operations and lead to system downtime). There are also issues associated with understanding the financial costs, savings, financing structures, and repayment mechanisms for water and energy efficiency upgrades through various financing programs, such as local improvement charges or programs that mimic property assessed clean energy (PACE) programs.

Furthermore, there remains a persistent lack of knowledge of the non-agricultural benefits specific to urban agriculture, such as social and ecological benefits, or how health and home values are impacted by residential and community agriculture. Outside of specific industry expertise, many of these non-output based values are often either unknown, overlooked, and in some cases severely undervalued across entire market segments. For example, while there is are studies that outline the potential mental health and social benefits of gardening, these analyses are usually qualitative rather than quantitative. Together, this constitutes a limited understanding of the business and domestic cases for urban agriculture.

Hidden costs

There are a range of cost considerations, outlined in Table 1, that are not widely considered by either urban or rural producers. These include general overhead costs, the costs involved for individual technology decisions, and the loss of utility associated with energy and water-efficient choices, as outlined in Table 1.

Table 1
Potential Hidden Costs Associated with Energy and Water-Efficient Equipment

Cost category	Examples
Hidden general overhead costs	• Costs of employing specialist workers (for example, energy managers and systems specialists) • Cost of information systems, gathering data, maintenance of submetering systems, data analysis, identification and correction of faults, etc.
Costs involved in individual	• Cost of: ○ identifying opportunities

Cost category	Examples
technology decisions	○ detailed investigation and design ○ formal investment appraisal • Cost of formal procedures for seeking approval for capital expenditures • Costs for specifications and tendering of capital works • Additional staff costs for maintenance • Cost of replacement, early retirement, or retraining of staff • Costs of disruptions and inconveniences
Loss of utility associated with energy and water-efficient choices	• Safety, noise, and working condition costs • Costs of extra maintenance and reliability

Note. Adapted from "Barriers to industrial energy efficiency: A literature review," by S. Sorrell, A. Mallet & S. Nye, 2011, *United Nations Industrial Development Organization*, p. 22, http://sro.sussex.ac.uk/id/eprint/53957/1/WP102011_Barriers_to_Industrial_Energy_Efficiency_-_A_Literature_Review.pdf. Copyright 2011 by United Nations Industrial Development Organization.

Rural communities may also not realize how closely water and energy are linked. A clean, reliable water source consumes energy, so water conservation ultimately leads to energy conservation and financial savings. This is because the price of freshwater is determined by the additional infrastructure required to supply, distribute, transport, treat, and ultimately recycle water for agricultural use

(Clark II, 2007). Those costs are in addition to rural communities' higher cost for product transportation to market, and potentially higher input costs, such as energy and fertilizer. Drawing groundwater to the surface and over land through high elevations is an energy-intensive and expensive process. For example, pumping 17,000 ft3 (480 m3) of water to a height of 330 ft (100 m) requires approximately 200 kilowatt-hours of electricity (Clark II, 2007). Additional energy is used to pump water to the wastewater treatment plant and to treat it with aeration and filtration. In California, it takes approximately 475 to 1,400 kWh of energy to treat 300,000 gallons of wastewater (Alliance for Water Efficiency, 2019). At a systems scale, water conservation provides savings, which, if ignored, can be a significant cost to rural municipalities. This is especially true given that many countries, in both the Global North and South, have average energy prices that exceed USD $0.20 per kWh (International Energy Agency, 2019). In contrast, urban farming models, characterized by water conservation methods, tend to have a smaller energy footprint for water consumption and provisioning per unit of produced goods. They also help in the adoption of new technologies and practices, which can permeate outward to rural communities.

Lack of land security

In urban environments, finding a quality location capable of supporting a farm can be complicated. In residential, municipal land lots, and industrial spaces, it is important for farm operators to ensure that their location is free of soil and site contamination. This can lead to high clean-up costs and, in many cases, renders the project unviable. Using closed-loop farming systems, such as hydroponics, provides a simple solution to this problem, though at a higher cost.

There are also potential costs associated with navigating property rights and legal principal-agent frameworks (owner/landlord vs. tenant), which can impact the operating frameworks of urban farms.

Difficulty accessing capital and affordability

Start-up and operating costs can be significant for commercial urban agriculture operations. Owners may seek to invest in more energy and water-efficient equipment or retrofits but may have difficulty accessing the upfront capital required for these expenses. A lack of affordable financing options (especially for low-income owners and owners with weaker credit) represents a significant barrier to adopting efficient water systems. Residential and urban land lot farming, however, requires little in the way of capital expenditures and can usually be accommodated on household budgets. Any community-based initiatives typically require some form of funding mechanism.

Bounded rationality

Owning to time constraints, lack of attention, and inability to process information, individual actors and decision-makers may make operational decisions that run contrary to those shown in economic models. They may not follow the best or optimal economic or investment decision making processes. As a result, they may neglect economic water-efficient policy options, even when informed and given adequate incentives (Sorrell et al., 2011). This is significant at both the individual farm level and the institutional and regulatory levels.

Bounded rationality constraints further lend to hydropolitics, where water resource management agreements are made between nations who rely on shared resources. Over-exploitation in one country or jurisdiction may have serious and detrimental outcomes for neighbouring jurisdictions and populations therein, restricting their access to both the quality and quantity of water. In hydropolitics, agreements are often drafted at national levels, which fails to address the concerns and reality of community stakeholders while focusing instead on macro concerns such as economic and political considerations.

Policy options and considerations for water-efficient urban agriculture adoption

Despite the fact that urban agriculture has existed throughout our history, there remains considerable unrealized potential to increase adoption rates and incentivize urban farming. As populations continue to migrate into cities, policy solutions present a practical means of addressing water scarcity within water-stressed regions and supporting the unrealized potential of urban farms.

Policy can simultaneously support the efficient use of resources and boost conservation by helping reduce stressors of regional water scarcity and promote sustainable aquifer management. Targeted policies can also be designed to directly address barriers to adopting urban agriculture for corporate, private, and civic interests. Enabling policies that can promote broader market adoption should take into consideration the wide range of policy options. Below is a list of potential policy interventions grouped by type that are worth considering.

Regulatory policy frameworks to implement groundwater, aquifer, and water basin planning frameworks at a national and state scale. Such policy frameworks would include legislated standards for measurement verification, reporting, and management of groundwater sources.Regulatory and legal policies can also help identify and overcome barriers faced by small scale urban farmers in selling their produce. Municipalities can provide progressive legal and regulatory frameworks for the operation of community food markets, food banks, and distribution hubs for urban agricultural producers and community-supported agriculture groups. Establishing policies for progressive tax incentives, addressing food safety and liability concerns, and food security by targeting farming co-ops, farming clusters, as well as small and medium-size businesses would support urban economies and empower urban farms.

Constituent policies such as the development and administration of water access rights and licenses, backed by behavioural and scientific data, can be used to manage aquifer and groundwater sources based on their natural carrying capacity. Where aquifers and water basins alone do not have the potential to address water demand, policies should promote the development of alternative water recycling methods and provide for the associated infrastructure to respond to the water demand needs. Conservation programs and campaigns to address consumer behaviour should also be included in these policies.

Distributive policies such as greening and urban farming programs for residential and community-based land plot initiatives can be drawn to provide educational information about how to plant and tend both public and private plots and garden farms. These programs can help establish educated urban farmers, reinforce community support groups, and provide mechanisms for urban farm development, including farming co-ops and community farming initiatives while driving sustained interest.

Urban planning and zoning policies to regulate zoning and planning policies to regulate community and residential gardens, urban greenhouses, and commercial farms provide another policy option. The review of zoning policies can increase land security and facilitate the development of brownfield sites for potential commercial, industrial-model farming solutions. Additionally, these reviews can help identify unused municipal land for farming. Zoning policies can also help support longer-term community master plans. Neighbourhood scale development plans can be drawn to help provide a holistic, long-term planning vision for city development and operations, spanning housing, infrastructure and water management plans.

Additionally, food policy councils and task forces at the municipal and city level can be developed to help engage stakeholders in addressing large-scale production and distribution barriers. Food councils can work with urban and municipal planners to help develop long-term community projects. These projects can be achieved with the identification and provision of municipal and community land plots, through the strengthening of urban-rural community relationships, and the administration of food security, pesticide, water, and land management frameworks. Task forces can help guide citywide efforts to identify, catalogue, and develop urban landscapes suitable for agriculture, as well as to help incentivize and access water collection and storage technologies for urban use, such as cisterns and rain collectors.

Economic, financial and redistributive policies such as legislating capital financing frameworks for urban commercial farms should also be considered. Financing programs enable building and business owners to access a host of options to invest in infrastructure and equipment, such as water and energy efficiency initiatives that would otherwise be considered a barrier to investment. These include reasonable financing rates, appropriate and varied loan repayment mechanisms and timeframes, as well as loan transferability so the owner can recover the cost of the investment should they move and sell. Financing schemes should also be mirrored from existing lending frameworks widely used within other industries. These could be modelled based on infrastructure upgrades provided through local improvement charges (LICs) or following property assessed clean energy (PACE) frameworks for water and energy efficiency upgrades.

Policymakers can also establish credit enhancement tools specifically designed to leverage private capital. These tools help close the gap to accessible financing by de-risking the investment terms on which private investors would be willing to lend and those by which building owners would be willing to borrow (The Atmospheric Fund, 2017). This de-risking can be accomplished through loan loss reserves, interest rate buydowns, loan guarantees, and the use of soft loans.

Capacity building policies represent another option for policymakers. They can help strengthen institutional capacity to respond to industry needs, as well as to develop job training and skills development programs, and help staff urban agricultural industries. These policies can include industry training programs for accountants, lawyers, and bankers to strengthen professional services within the urban farming industry. They would also include supporting skilled technical programs for water, energy efficiency, and systems technicians to operate and maintain large commercial urban farming operations. Institutions can also play a large role in identifying funding opportunities and service providers for technical and professional business support.

Finally, **strengthening international water access and cooperation policies** to combine the efforts and attention of hydropolitics at the international scale with hydropsychology policies at the community and domestic scale as both can have deep impacts on water scarcity (Elhance, 2000). Since failures of hydropolitics have been demonstrated through past and present water conflicts between nations, utilizing a holistic approach that pairs hydropolitics and hydrospsychology (the use of water at the micro, or individual level (Sivakumar, 2014)) can assist decision-makers in addressing and determining water access rights for national-scale water-sharing agreements. Decision-makers at the international level pay little attention to local concerns, and vice versa, because both have significant knowledge within their respective scopes, combining the two fields of policy study can complement each other's blind spots.

While no one policy direction should be followed above others, it is important to consider the added value of each of these policy considerations. Each has a role within a comprehensive framework of enabling features and can ultimately help respond to water stress and reduce water strain within vulnerable regions.

Conclusion

Access to safe water is central to the health and well-being of populations around the world, as well as for the success of industry and the integrity of the environment. Given the current number of people living with some degree of water stress, and taking into account the trends modelled for population growth in various regions, the topic of water resource management is becoming a significant area of concern at all levels of government and will only become more prominent in the coming decades.

Due to changing market dynamics and the increasing availability of efficient technologies, urban agriculture can play a significant role in addressing water conservation. These applications have particular value in mitigating water scarcity in water-stressed regions, while small-scale initiatives within urban communities can have a far-reaching, positive effect on regional water management efforts. Cumulatively, these small-scale projects can have a deep impact on water quantity, quality, and access within their respective watersheds and aquifers and can ultimately influence hydropolitics between nations. However, when addressing agriculture within the context of water scarcity, decision-makers should take a whole-system approach to understanding and responding to the drivers, impacts, barriers, and potential interventions within the industry. Piecemeal solutions can have significant value in and of themselves, but individual policies, programs, and projects should be undertaken within a larger comprehensive framework for regional water management.

Addressing the success and failures of past water management challenges provides a window of opportunity to evaluate new and innovative ideas that question existing frameworks while acknowledging the complexity of modern water management challenges. In examining how to best use underutilized urban spaces to maximize social, economic, and environmental benefits, small, medium, and commercial farms can capitalize on market incentives provided within urban centers while diversifying the industry and providing added value to their clientele. These opportunities can be deemed “low hanging fruit” opportunities since most urban farming models and methods, with the exception of hydroponic and industrial urban farming models, lend to low cost, low barrier implementation strategies.

Though this paper emphasizes the efficient use of resources facilitated by market opportunities, namely within urban centres, many of the proposed concepts would work well in rural settings, should the various barriers to water-efficient technology adoption be addressed. Still, the enabling policies discussed in this paper are generally universal in their applicability and are by no means exhaustive. Developing governing frameworks, facilitating efficient water use policies, and promoting and strengthening resiliency within the agricultural industry are all considered effective measures in mitigating the ongoing effects of water stress.

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The Importance of Governance Structures in Protected Area Management: A Comparative Analysis Between Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park

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Written for: Natural Resource Management

Please note that the following article was written by a non-Indigenous voice and, therefore, does not represent the thoughts, opinions, or views of the Tla-o-qui-aht First Nation or Nuu-chah-nulth First Nation.

Introduction

Global biological diversity (biodiversity) is declining at an unprecedented rate. Biodiversity faces a multitude of threats from habitat loss, the impacts of invasive species, and climate change. These threats have forced species to the brink of extinction, with some scientists stating that biodiversity loss represents Earth's sixth mass extinction and the first humanmade extinction (Gómez-Baggethun & Martín-López, 2010). Indeed, current estimates suggest that one million species are currently at risk of extinction, and unless immediate action is taken, by the end of the century, they will likely be lost forever (United Nations, 2019).

In an effort to protect biodiversity, Canada adopted the *2020 Biodiversity Goals and Targets for Canada* in 2015, a five-year strategy that included a set of four goals and 19 targets focused on addressing biodiversity issues unique to

Canada (Biodivcanada, n.d.). Target One states that "[by] 2020, at least 17% of terrestrial areas and inland water, and 10% of marine and coastal areas of Canada are conserved through networks of protected areas and other effective area-based measures" (Zurba et al., 2019).

Protected Areas (PAs) are renowned for their ability to protect the natural environment. There are many different types of PAs, including national parks, nature reserves, and tribal parks (International Union for Conservation of Nature [IUCN], n.d.). These PAs, whilst all serving the same goal of preserving biodiversity, have drastically different management structures. Some PAs are governed by federal or provincial governments, while others are governed by Indigenous governments or communities, which undoubtedly have stark differences in management and governance structures. The epistemologies of these governance structures also differ, with federal and provincial governments favouring Western science and Indigenous peoples favouring Indigenous Traditional Knowledge (ITK).

Given these considerations, the purpose of this paper is to conduct a comparative analysis between a tribal park and a national park, with particular attention given to the governance structure of each. The PAs considered are the Pacific Rim National Park Reserve (PRNPR) and the Tla-o-qui-aht Tribal Park, both located on Vancouver Island, British Columbia. The PRNPR is managed by Parks Canada, whereas the Tla-o-qui-aht First Nation manages the Tla-o-qui-aht Tribal Park. The analysis conducted in this paper will center on which governance structure is more conducive to enhanced ecological integrity and biodiversity, arguing that ultimately incorporating ITK allows for a richer assessment of biodiversity.

This paper will begin by outlining the importance of biodiversity and explore the need for PAs to preserve ecosystems. It will then explore the different types of governance structures in PA management before analyzing the biodiversity of PRNPR and the Tla-o-qui-aht Tribal Park. Finally, a comparative analysis of the two regions will explore how the epistemologies of each governance structure interact with biodiversity, how the different epistemologies shape perceptions and definitions of biodiversity, and its ultimate objectives. The paper concludes by exploring the implications these definitions have for Canada as it seeks to meet both national and international biodiversity targets.

The Importance of Protected Areas for Biodiversity Conservation

Biodiversity refers to the variety and richness of species in a particular region or ecosystem and considers the interaction between genes, species, communities, and ecosystems (Carrington, 2018; National Geographic, n.d.). The interactions amongst these groups have formed the foundation on which all life depends and has made the "earth habitable for billions of years" (Carrington, 2018).

Biodiversity plays a critical role in the overall well-being of humanity. Indeed, there are many services essential for our survival that are derived from rich ecosystems. Specifically, many medicines are harvested from rainforests, which may hold the cure to humanity's deadliest diseases, including cancer or Alzheimer's (Carrington, 2018). Rich ecosystems also contribute positively to our global economy, as ecosystem services are “worth trillions of dollars” (Carrington, 2018). For example, in a 2001 economic valuation of mangrove ecosystems, Santhirathai and Barbier found that these ecosystems are worth an estimated US$4000[6] per hectare due to their ability to protect against extreme weather events, act as fish reserves, and the forestry products that can be derived from mangroves (Gómez-Baggethun & Martín-López, 2010).

Additionally, Indigenous cultures worldwide are dependent on ecosystems for sustenance and food security, developing and maintaining language, and sharing and participating in cultural practices and rituals (Assembly of First Nations & David Suzuki Foundation, 2013; Leech et al., 2016). Biodiversity also plays an essential role in the fight against climate change, operating as an essential carbon sink through temperate and tropical forests, mangroves, and oceans (Friedel, 2017; Erickson-Davis, 2018; Riebeek, 2008). Finally, biodiversity protects humanity from natural threats or disasters. For example, coral reefs and mangroves act as natural barriers that help protect people living in coastal regions from tropical storms and tsunamis (Carrington, 2018).

However, humanity’s impact on Earth has had devasting effects on global species, ecosystems, and biodiversity. Global biodiversity is declining at an unprecedented rate, with roughly one million species on the brink of extinction (United Nations, 2019). Further, estimates have suggested that 75% of the land-based environment and 66% of the

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[6] It is important to note that in 2020, these monetary values are likely to be significantly higher due to inflation.

marine environment have been “significantly altered by human actions” (United Nations, 2019). Our profound impact on the planet has led to speculation that the world has entered its sixth mass extinction, the consequences of which will be devasting because “without biodiversity, there is no future for humanity” (Carrington, 2018).

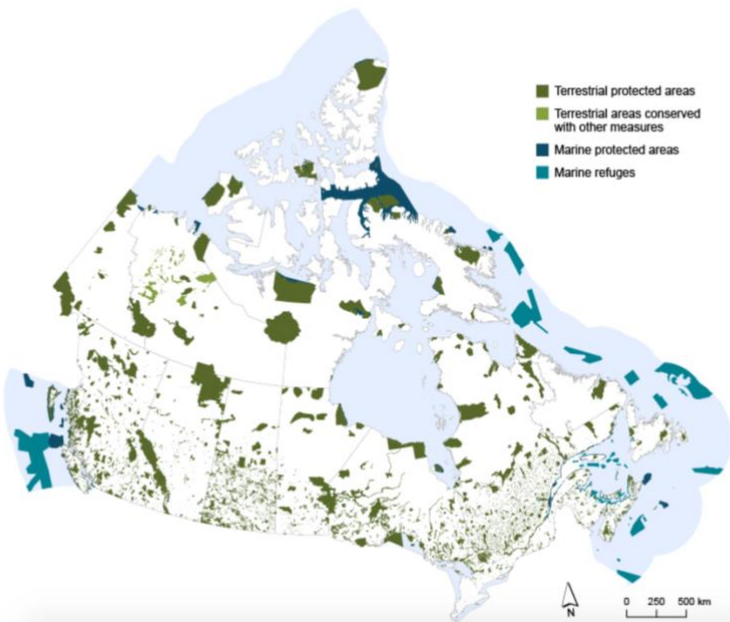
This terrifying reality has resulted in a global movement to protect biodiversity, most notably through the adoption of two global commitments: the 2020 Aichi Biodiversity Targets and the 2030 Sustainable Development Goals (SDGs). Both the Aichi Targets and the SDGs state the importance of PAs in conservation management. PAs are a “clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (IUCN, n.d.). They protect both marine and terrestrial ecosystems and are vital for sustainable fisheries management and the production of agriculture and forestry products (United Nations Environment Programme-World Conservation Monitoring Centre & IUCN, 2016). PAs have been hailed as a cornerstone of global conservation efforts as they are essential for protecting biodiversity, the restoration of degraded landscapes, and for providing places for people to reconnect with nature (IUCN, n.d.b). Further, PAs are essential in the fight against climate change. Estimates suggest that these areas can store at least 15% of global terrestrial carbon annually through forest and marine carbon sinks (IUCN, n.d.a). According to the World Database on Protected Areas, as of 2017, there were an estimated 200,000 protected areas worldwide (Protected Planet, 2017).

Canada is home to 3.75% of total global PAs, with over 7,500 marine and terrestrial PAs across the country, covering approximately 11.5% of its landmass in 2017 (Walker, 2017). Canada has long recognized the importance of PAs for the protection of species. The first PA in Canada, Banff National Park, was established in 1885. While the initial intent of the park was to create a tourist destination, it established the precedent for the 1930 *National Parks Act*, which placed ecological integrity at the forefront of national park creation (Walker, 2017).

Today, PAs are located across every province and territory in Canada. British Columbia has the highest proportion of PAs at 15.3% of its landmass. The map in Figure 1 provides an overview of the number and types of PAs across Canada. Terrestrial PAs work to conserve land and freshwater areas, while marine PAs conserve Canada's oceans (Government of Canada, 2018). Within these PA classifications, various subsets exist: terrestrial and marine protected areas are officially designated PAs, whereas terrestrial areas are conserved by other means, and marine refuges are areas that use other governance mechanisms to conserve land, freshwater, and marine environments (Government of Canada, 2018). Collectively, these PAs serve as a mechanism for the conservation and protection of species and habitat for generations to come (Government of Canada, 2018).

Figure 1

Map of Canada's Protected Areas



Note. From *Canada's conserved areas*. https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/conserved-areas.html#summary-details0. Copyright 2018 by the Government of Canada.

Governance Structures in Protected Area Management: IPCAs vs. National Parks

A vital component of PAs for conservation management is their various governance structure. Indeed, the governance structure of PAs has the greatest potential to affect both the success and efficiency of an area in ecosystem conservation (Borrini-Feyerabend et al., 2013). The International Union for Conservation of Nature (IUCN) defines governance as the "interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken and how citizens and other stakeholders have their say" (Borrini-Feyerabend et al., 2013).

The IUCN identifies four main types of governance structures (Borrini-Feyerabend et al., 2013):

- Governance by government
- Shared governance by diverse rights holders and stakeholders together
- Governance by private entities
- Governance by Indigenous peoples and/or local communities

This paper will focus on two of the IUCN's identified governance types: governance by government and governance by Indigenous peoples or communities. The other governance structures identified by the IUCN are beyond the scope of this paper, as they do not represent the governance structures employed by the PAs considered in this case study.

In the Canadian context, PAs managed through a "governance by government" structure are overseen by a federal, provincial, or territorial body who has full "authority, responsibility and accountability for managing the protected area, determine[s] its conservation objectives and develop[s] and enforce[s] its management plan" (Borrini-Feyerabend et al., 2013). In Canada, this governance system accounts for 98% of all PAs, including some of the most well-known national parks, such as Banff, Jasper, and PRNPR (Benidickson, 2011).

The second governance structure considered involves PAs that are managed by Indigenous peoples or local communities. This structure is loosely defined as “protected areas where the management authority and responsibility rest with Indigenous peoples and/or local communities through various forms of customary or legal, formal or informal, institutions and rules” (Borrini-Feyerabend et al., 2013). These types of PAs are created under a wide range of circumstances and conditions due to the varying rights of Indigenous peoples and communities globally (Bhattacharyya & Whittaker, 2016).

In Canada, there are several types of Indigenous-governed PAs, including Tribal Parks, Indigenous Cultural Landscapes, Indigenous Protected Areas, and Indigenous Conserved Areas. The term Indigenous Protected and Conserved Areas (IPCAs) has been adopted as an all-encompassing term (Indigenous Circle of Experts, 2018). IPCAs in Canada emerged out of Indigenous peoples’ desire to protect their ancestral land from unsustainable land management practices, such as logging and mining (Plotkin, 2018). Today, IPCAs represent an opportunity for self-determination in the governance of traditional lands and act as an important step towards advancing the 2016 mandate for reconciliation between the Government of Canada and Indigenous peoples. There are currently ten IPCAs across Canada. Notable parks include the Haida Gwaii Protected Area, Dasiqox Tribal Park, and Tla-o-qui-aht Tribal Park (Indigenous Circle of Experts, 2018).

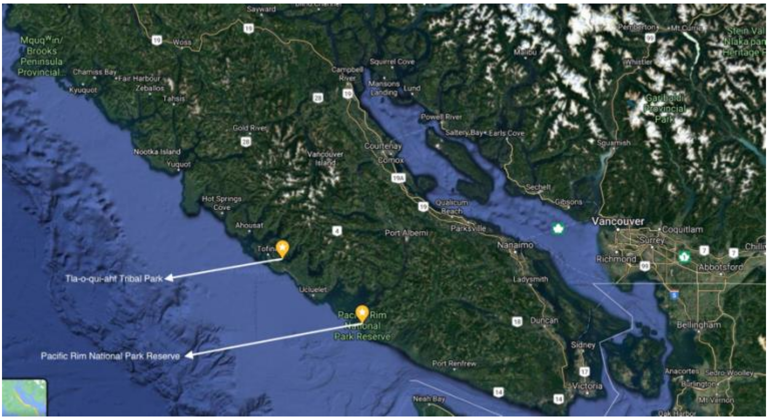
IPCAs are inherently different from national parks due to their inclusion of ITK. ITK is characterized as the “wealth of wisdom and experience of nature gained over millennia from direct observations, and transmitted – most often orally – over generations" (Mazzocchi, 2006). In comparison, Western science, used under government-managed PAs, is based on the scientific method and is objective and quantitative (Mazzocchi, 2006). Increasingly, ITK is seen as an essential complement to Western science in conservation management, as it helps to "unveil valuable information about the intricacies of environmental systems" and can provide historical data that is not readily available to scientists (Parks Canada, 2019c; Rundle, 2019). This historical data acts as a baseline for conservation efforts and provides a more complete understanding of the biological value of an area.

Pacific Rim National Park Reserve vs. Tla-o-qui-aht Tribal Parks

Pacific Rim National Park Reserve (PRNPR) and the Tla-o-qui-aht Tribal Parks are two examples of PAs managed under the previously discussed governance structures. Tla-o-qui-aht is an IPCA governed by the Tla-o-qui-aht First Nation. PRNPR is managed by Parks Canada (Murray & King, 2012; Parks Canada, 2020). Both PAs are located on Vancouver Island, British Columbia (BC), and are roughly 61.5 km apart, sharing a border (see Figure 2). As such, these PAs have near-identical ecological, environmental, and physical characteristics. Specifically, both regions are characterized by rugged coastlines with temperate coastal rainforests and are dominated by tree species such as the Douglas Fir and Western Hemlock (Noss et al., n.d.; United Nations Educational Scientific Cultural Organization [UNESCO], 2015). Further, both regions are home to iconic species such as the cougar, wolf, and black bear (Parks Canada, 2020).

Figure 2

Map of Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park



Note. The yellow points on this map indicate the location of the Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park on Vancouver Island, British Columbia. Adapted from *Google Map of Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park*. https://www.google.com/maps/d/edit?hl=en&mid=1CAaQYcq_jSh2-2248cRnBfxGRbsWdl6R&ll=49.395186930570986%2C-125.675587430518&z=8. Copyright 2020 by Google.

Pacific Rim National Park Reserve

PRNPR, established by the Government of Canada in 1970, was the first national park on Canada's west coast (Murray & King, 2012). Originally created for recreational purposes, PRNPR encompasses 525 km^2, including 125 km of coastal lowland forest and marine portions of the Vancouver Island Shelf (Murray & King, 2012; Indigenous Circle of Experts, 2018). PRNPR is also located on the traditional territory of several First Nations, collectively known as the Nuu-chah-nulth people, who were not consulted on the creation of the national park (Murray & King, 2012). The Government of Canada felt that the Nuu-chah-nulth people were an "Indian problem" and told them to settle outside the boundaries of the park, seeing them as a detriment to the enjoyment of visitors for whom the park was intended (Murray & King, 2012; Indigenous Circle of Experts, 2018).

PRNPR is home to six ecosystems: subtidal, intertidal, shoreline, stream, lakes and wetlands, and temperate rainforest (Parks Canada, 2009). Plant and animal species inhabiting these ecosystems include large kelp forests (subtidal ecosystem), eelgrass beds (intertidal ecosystem), pink and yellow sand-verbena (shoreline ecosystem), salmon (stream ecosystem), ducks (lakes and wetlands), and old-growth Sitka spruce and western red-cedar trees (forest ecosystem), among others (Parks Canada, 2009).

Since its inception, PRNPR has been managed by the *Canada National Parks Act*. However, the park's management priorities have changed considerably from 1970 to 2000. When the park was first established, it was intended to serve primarily as a recreational area. However, in the early 2000s, Parks Canada shifted the park's priority to preserving ecological integrity (Gilpin, 2020). Parks Canada's definition of ecological integrity is closely linked to the concept of biodiversity, defining it as "a condition that is determined to be characteristic of its natural region […]" (Parks Canada, 2019a). Given this change in priorities, Parks Canada now conducts regular monitoring of species and primarily uses Western scientific methods to inform decisions about the park's ecological integrity.

Tla-o-qui-aht Tribal Park

Established in 1984, the Tla-o-qui-aht Tribal Park and its regions are one of the largest, nearly intact temperate rainforests on Vancouver Island (Tindall & Robinson, 2017).

The area's biodiversity is characterized by a large contiguous canopy of old-growth forests, containing large tree species and "approximately 300 vertebrae" (UNESCO, 2015).

The Tribal Park's establishment marked Canada's first official IPCA and symbolized an important victory for Indigenous peoples. The need for a tribal park was driven by the Tla-o-qui-aht First Nation, who saw it as the only way to protect their traditional, unceded territory from unsustainable logging practices that were devastating local forests (Indigenous Circle of Experts, 2018). At the height of industrial logging practices in the 1980s, roughly one million cubic meters of old-growth forest disappeared annually, resulting in the destruction of species habitat and profoundly impacting local ecosystems (Raygorodetsky, 2014a). Following a lengthy legal dispute and a series of peaceful protests, the Tla-o-qui-aht First Nation reached an agreement with the Crown in October 1984 (Murray & King, 2012). Hereditary Chiefs of the First Nation subsequently declared the area a Tribal Park,[7] forever changing the approach to conservation in Canada (Murray & King, 2012; Gilpin 2020). The Tribal Park was the first of its kind, representing both a method for protecting and enhancing biodiversity and a significant step towards self-determination for the First Nation, allowing them to use their ITK practices to care for their land.

[7] A tribal park is "a land or watershed governance area that is developed, governed and managed by Indigenous Peoples and allows for traditional ways of life and ecologically sound commercial activities, but not industrial activities" (Indigenous Circle of Experts, 2018).

Since 1984, the Tla-o-qui-aht First Nation has expanded the Tribal Park to include four sub-parks, known collectively as the Tla-o-qui-aht Tribal Parks (Indigenous Circle of Experts, 2018). The vision of these parks is to "re-establish a healthy integration of economy and environment in which there is a balance of creation and consumption and a continual investment in biological and economic diversity" (Indigenous Circle of Experts, 2018).

The Tla-o-qui-aht Tribal Parks are managed through zoning and are based on their traditional teachings of *qwa siin hap* and *uuya thluk nish*. The first teaching, *qwa siin hap*, which translates to "leave as it is," promotes the conservation of resources for future generations. These zones are characterized by old-growth forests, rare species (such as the California Condor and the Hoary Elfin Butterfly), and represent areas of cultural significance to the Tla-o-qui-aht People (Tla-o-qui-aht Tribal Parks & Tla-o-qui-aht Tribal Wilderness Committee 2013; Noss et al., n.d.). Other zones are managed under the second philosophy, *uuya thluk nish*, or "we take care of" (Tla-o-qui-aht Tribal Parks & Tla-o-qui-aht Tribal Wilderness Committee, 2013). Under this teaching, resources within the Tribal Parks are harvested sustainably, focusing on ecological restoration (Tla-o-qui-aht Tribal Parks & Tla-o-qui-aht Tribal Wilderness Committee, 2013). Further, many of these areas were previous sites of unsustainable logging and industrial practices (Tla-o-qui-aht Tribal Parks & Tla-o-qui-aht Tribal Wilderness Committee, 2013). As such, there has been an attempt to "integrate economic development and ecosystem restoration, such as salmon habitat restoration" in *uuya thluk nish* zones (Tla-o-qui-aht Tribal Parks & Tla-o-qui-aht Tribal Wilderness Committee, 2013).

Biodiversity Levels in Pacific Rim National Park Reserve and Tla-o-qui-aht Tribal Park

PRNPR and the Tla-o-qui-aht Tribal Park represent two PAs with seemingly opposing land management practices. Given these differences, it seems pertinent to explore which governance structure is more conducive to enhanced biodiversity and ecological integrity.

Pacific Rim National Park Reserve

PRNPR published its most recent comprehensive biodiversity data in a 2009 *State of the Park* report[8]. This report focuses on biodiversity from a purely ecological sense, assessing ecological integrity by examining five indicators comprised of 21 measures. The indicators used in the report are based on the six ecosystems found in PRNPR; however, due to lack of data for the lakes and wetlands, an indicator was not created for these ecosystems (Parks Canada, 2009). The 21 measures used to evaluate these ecosystem indicators are primarily quantitative. They include measures such as evaluating species populations, the density or cover of plant species, and the overall extent of invasive species (Parks Canada, 2009). Upon evaluation, each measure is characterized as good, fair, poor, or undetermined, and assigned a trend (improving, stable,

[8] The 2009 *State of the Park Report* represents the most recent data available. Understandably, in the eleven years since the publication of the report, it is possible that the state of PRNPR's biodiversity has changed considerably. However, in the absence of more current data, this report serves as the basis for analysis in this paper.

declining, or undetermined) (Parks Canada, 2009). Parks Canada employs five methods[9] to determine the thresholds for each status.

According to the *Status of the Park* report, PRNPR has seen overall positive trends in ecological integrity in its shoreline and forest ecosystems, whereas ecological integrity is declining in the subtidal ecosystem (Government of Canada, 2018). The positive trends observed for the shoreline ecosystem reflect the area's continued ability to support "healthy populations of breeding shorebirds" (Parks Canada, 2009). Specifically, this area has seen a 30% increase in the blackoyster catcher shorebird over the past 30 years, and a 25% increase in the nesting population of glaucous-winged gulls over the past ten years (Parks Canada, 2009). These population increases are indicative of a healthy and rich ecosystem.

Similarly, the forest ecosystem continues to support healthy wildlife populations such as black bears, cougars, and wolves, and the extent of old-growth forest in the park has remained relatively stable since the 1990s[10] (Parks Canada, 2009). However, the biggest challenge facing the forest ecosystem is the extent of invasive alien species, such as English Ivy and Scotch Broom, which have impacted 80% of the forest ecosystem (Parks Canada, 2009). While the report states that the forest ecosystem is 'healthy,' this

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[9] The methods employed include adopting and modifying previously established thresholds and applying IUCN threshold criteria for slowly changing population numbers, along with other statistical procedures and manipulations for ecosystems prone to broad fluctuations, organisms with declining populations, and cases that do not fit the previous scenarios (Parks Canada, 2009). To determine general trends, Parks Canada conducts regression analyses (Parks Canada, 2009).

[10] 1990 acts as the report's base year for comparison.

region is undoubtedly facing considerable challenges attributable to the threat caused by invasive species. This threat will continue to place pressure on the ecosystem, becoming more pervasive as climate change impacts the region. Therefore, it is argued that the forest ecosystem may see declining trends in ecological integrity in the future, if this is not already the case.

Conversely, the declining ecological integrity of PRNPR's subtidal ecosystem is attributed to the changing climate placing pressure on marine life (Parks Canada, 2009). Most notably, the Pacific herring's biomass has dropped below the sustainable threshold of 18,000 tonnes and has been steadily declining since 1991 (Parks Canada, 2009). Furthermore, 44% of the 21 measures evaluated are considered to be either in poor or fair status (Parks Canada, 2009). Notably, salmon and marbled murrelet populations are 50% below the long-term average (Parks Canada, 2009). These species are impacted by the warming ocean, altering where they can nest and feed (Parks Canada, 2009).

The information presented in the *State of the Park* report paints an opaque picture of the overall biodiversity of PRNPR. While the shoreline ecosystem is likely seeing positive trends in biodiversity, as inferred by the positive trends in ecological integrity, PRNPR's forest ecosystem is suffering from the threat of invasive species, which is undoubtedly impacting the ecosystem's biodiversity levels. Alternatively, the subtidal ecosystem is experiencing an overall decline in ecological integrity, and hence it is understood that biodiversity has also decreased. Finally, the status of a significant portion (44%) of the 21 measures evaluated in the report were identified as either fair or poor, indicating that ecosystem integrity, and therefore, biodiversity, across PRNPR is experiencing significant challenges. Given these considerations, it is clear that while PRNPR has witnessed some positive trends in biodiversity, the area is facing significant overall threats to biodiversity.

Tla-o-qui-aht Tribal Park

Biodiversity levels in the Tla-o-qui-aht Tribal Park were assessed by exploring accounts given by the Tla-o-qui-aht First Nation, who inhabit the land and have witnessed variations in species diversity over time either through firsthand experience or through testimonies given by older community members. Further, it would appear that under the governance structure employed by the First Nation, ecological integrity is not evaluated using a series of indicators and measures. Rather, reports on biodiversity in the Tribal Parks note whether there has been a general increase or decrease in observed species. The following information detailing the state of biodiversity in the Tla-o-qui-aht Tribal Parks was collected using the *2018 Tribal Parks Annual Report*, published by the Tla-o-qui-aht First Nation, the Central West Coast Forestry Society, and a series of articles published by the United Nations University.

As discussed in previous sections, the Tla-o-qui-aht Tribal parks are managed through a series of zones, specifically the *qwa siin hap* (leave as it is) and the *uuya thluk nish* (we take care of) zones. Within the *qwa siin hap* zones of the Tla-o-qui-aht Tribal Parks, it can be inferred that biodiversity has likely seen overall positive trends, as the defining feature of these regions is pristine old-growth forests with diverse populations of flora and fauna (Raygorodetsky, 2014a). Notably, one Tla-o-qui-aht First Nation member stated: “Just look at it – our garden is still here!" (Raygorodetsky, 2014a), demonstrating the fundamental principle of the *qwa siin hap* philosophy – to leave the area the way it is, allowing natural processes to flourish. Whereas, if the region were suffering ecologically, then it would be a designated *uuya thluk nish* zone, where the First Nation people would attempt to restore the region. Therefore, by virtue of the *qwa siin hap* zone existing, it can be inferred that overall biodiversity is being sustained.

By this argument, it is then understood that the areas of the Tribal Parks governed by *uuya thluk nish* may be experiencing similar biodiversity challenges to PRNPR. Notably, the Tribal Parks have also seen a reduction in wild salmon populations, with one resident noting that while the area used to be abundant in fish, today one "needs to travel 3 to 5 miles away from the shore, out into the open ocean" to catch salmon (Raygorodetsky, 2014b). However, the *2018 Tribal Parks Annual Report* notes evidence that salmon populations are slowly starting to recover in some of the Tribal Parks' watersheds; in particular, the restored Kennedy watershed may have seen up to three times the amount of fish than other areas (Tla-o-qui-aht Tribal Park Allies, 2018; Central Westcoast Forest Society, 2015). Further, the Centennial Creek watershed has also noted healthy freshwater systems and salmon populations (Central Westcoast Forest Society, n.d.). These observations are particularly significant because salmon populations have been steadily declining in PRNPR, with stocks 50% below long-term averages. However, despite these promising trends for salmon, the Tla-o-quit-aht people have stated that "[…] it is unlikely to ever be as abundant as before" (Raygorodetsky, 2014a).

There is also evidence that within *uuya thluk nish* zones, which were the sites of intense logging practices, the forest ecosystem has started to recover to a younger secondary-growth forest characterized by trees with “a lighter, almost fluorescent shade of chartreuse, unlike the darker emerald hues of the old growth forest” (Raygorodetsky, 2014a). Although these regions still have significantly fewer and less diverse populations of flora and fauna, the resurgence in tree species is indicative that this zoning model has helped a disturbed area begin to recover (Raygorodetsky, 2014a). Furthermore, as time passes and the region continues to develop, more species will be encouraged to return to the area, resulting in improved biodiversity and ecological integrity. However, the continued recovery of forests in *uuya thluk nish* zones is dependent on what impacts climate change will have on the region.

Interestingly, the *2018 Tribal Parks Report*’s biodiversity assessment included a human component that emphasized how cultural and economic practices were being sustained in the Tribal Park. For example, the Tla-o-qui-aht First Nation plans to construct a Long House Community Centre for the Tla-o-qui-aht people to act as a space for cultural and community gatherings (Tla-o-qui-aht Tribal Park Allies, 2018). There are also several sustainable development activities unfolding in the Tribal Parks, including three run-of-river hydro facilities within the Park’s watersheds, which will provide green energy and are “[…] mindful of fish habitat” (Tla-o-qui-aht Tribal Park Allies, 2018). The inclusion of cultural and economic practices within the Parks’ biodiversity assessment presents important considerations for how biodiversity is defined. Indeed, biodiversity definitions can be expanded to incorporate the role of humans. In particular, this view of biodiversity considers that both people and place are intrinsically connected, as humans influence ecological systems, yet ecological systems also influence humans (American Museum of Natural History Center for Biodiversity and Conservation, n.d.).

Specifically, the rich ecosystems native to the Tla-o-qui-aht Tribal Parks have supported the Tla-o-qui-aht First Nation for thousands of years; over these years, they have interacted with species to form a vibrant web of relationships (Raygorodetsky, 2017). For example, salmon is a vital species to the region, supporting more than 190 plant and animal species that depend on it for food. More importantly, salmon carry marine nitrogen as they spawn upriver, which is essential for the overall development of the forest ecosystem (Raygorodetsky, 2017). For thousands of years, the Tla-o-qui-aht First Nation has been reliant on salmon as a food source and for the benefits they provide to the entire ecosystem. These benefits allow species such as berries, ducks, and clams to thrive and be used by Indigenous people as sustenance (Raygorodetsky, 2017). Thus, the restoration of salmon populations within the Tribal Parks is a cultural and ecological priority, as the Tla-o-qui-aht people have depended on the resources and benefits provided by the land to sustain themselves and their livelihoods. In fact, Eli Enns stated: “This isn’t about protecting nature per se. It’s about creating better relationships with our ecosystems. […] This is about the wise and prudent management of the house” (Galloway, 2019).

Based on the assessment of biodiversity in the Tla-o-qui-aht Tribal Parks, it is argued that ecologically, the Park is most likely seeing positive biodiversity trends in the *qwa siin hap* zones. Within the *uuya thluk nish* zones, evidence suggests that while this area may be experiencing some ecological loss, an increase in salmon populations in certain watersheds suggests that this region may recover. The inclusion of cultural and economic sustainability within biodiversity assessments in the Tla-o-qui-aht Tribal Parks suggests that an alternative approach to the definition of biodiversity is warranted.

Discussion of Parks

The above overview of biodiversity in PRNPR and the Tla-o-qui-aht Tribal Parks demonstrates that there are subtle differences in biodiversity levels between the two PAs. However, these differences depend on the definitions of biodiversity employed during evaluation. Using an ecological definition, which focuses entirely on the health of ecological systems, the variations in biodiversity between the two parks are negligible; both parks appear to have regions that are thriving and others that are suffering. However, one might consider the differences in salmon populations between the two parks as an indication that the Tla-o-qui-aht model for conservation is superior.

Alternatively, when comparing the PAs using a socio-ecological definition that considers the relationships between humans and ecosystems, the Tla-o-qui-aht Tribal Parks appear to be more diverse, as humans are considered in the biodiversity conversation. This is particularly prudent as the intent of the Tribal Parks is to conserve both ecological and cultural diversity. Further, by considering the interaction between humans and nature and incorporating this into traditional practices, the Tla-o-qui-aht First Nation enables a series of practices that facilitate achieving strong biodiversity and ecological integrity without compromising cultural sustainability. Whereas, in PRNPR's biodiversity assessment, Parks Canada does not consider the interactions between humans and nature.

Thus, it would appear that the differences in biodiversity analyzed above are ultimately the result of how biodiversity is defined. As will be examined, these differing definitions are driven by the epistemologies of the two governance structures analyzed.

Comparative Analysis

The variations in biodiversity between PRNPR and Tla-o-qui-aht Tribal Parks indicate that governance structures of PAs play an important role in influencing overall biodiversity. These variances can be attributed to the different knowledge systems that each governance type adheres to. There are also important differences in how these epistemologies interact with ecosystems, which ultimately factor into biodiversity levels.

As used by Parks Canada, Western science is based on objective reason and relies on observation and experimentation to inform results. In biodiversity management, this knowledge system dictates that species are monitored under strict observation, and their vitality tends to be considered independent from other species. This Western view of biodiversity management can be illustrated by Parks Canada's use of a set of indicators to monitor ecosystem richness. By monitoring ecosystems through a set of indicators, overall ecological integrity is considered through a narrow viewpoint, and some of the intricacies between species interactions are lost. For example, in the *State of the Park Report*, the importance of salmon to the entire ecosystem is stated as an aside, and the report fails to mention the impacts of declining salmon populations on the region. In contrast, the Tla-o-qui-aht Tribal Parks report emphasizes the ecological and cultural importance of salmon on the broader socio-ecological ecosystem, stressing the need to restore salmon populations.

Further, the classification of ecosystems into four thresholds for each indicator (good, fair, poor, undetermined) raises concerns regarding data accuracy. Specifically, what happens if an indicator falls on the boundary between fair and poor? These labels may profoundly impact actual species conservation efforts because areas that are labelled as “poor” will garner more attention from conservationists than those labelled as “fair.” In reality, species in both areas may be experiencing similar levels of decline, so the actual differences between “poor” and “fair” areas are minuscule. As such, these categories for determining ecosystem health could be misleading, which could have implications for the assessment results of overall park health.

On the other hand, traditional knowledge, used by the Tla-o-qui-aht First Nation, interacts with biodiversity differently. Rooted in ancestral teachings passed down through generations, traditional knowledge emphasizes the symbiosis between humans and nature. By incorporating humans into the biodiversity conversation, this epistemology allows for a richer understanding of the inherent complexities in a region. For the Tla-o-qui-aht Tribal Parks, this can be seen through the *qwa siin hap* philosophy, which protects areas of cultural significance and states that resources need to be preserved for future generations. Specifically, this area has protected the sacred site where the Tla-o-qui-aht people originated, as well as their sacred burial grounds (Murray & King, 2012).

Based on the interactions of Western science and ITK with biodiversity, it is clear that there is an emergent issue. It appears that these interactions not only define approaches to biodiversity but its overall objectives as well. With its focus on data and indicators, Western science suggests that biodiversity can only be considered through an ecological lens because the epistemology does not factor in cultural or human dimensions. This failure to recognize these elements, in turn, means that the overall objectives of biodiversity are simply to monitor species to evaluate how they have fared in comparison to existing data. Conversely, because ITK inherently considers the interactions between humans and species, biodiversity must be examined from a socio-ecological perspective that highlights the interconnectedness of Indigenous peoples and their land (American Museum of Natural History Center for Biodiversity and Conservation, n.d.). Thus, under this definition of biodiversity, measures of ecosystem vitality differ from those in Western science because ITK incorporates both ecological components and human interactions.

While both definitions have their merits in determining overall biodiversity objectives and outcomes, considering the socio-ecological perspective allows for an overall deeper assessment of biodiversity, as it benefits from knowledge that is thousands of years old. This ancestral knowledge allows conservationists to analyze trends in species over a significantly longer time-period than what is considered under Western science. Further, humans play an inherent role in affecting ecosystems by virtue of simply existing in an area, and so they must be considered within biodiversity definitions. In reality, Parks Canada and the Tla-o-qui-aht First Nation both incorporate elements of each other's epistemologies in their assessments of biodiversity in the studied PAs (Parks Canada, 2009).

Notably, Parks Canada has made efforts to increase collaboration with the Tla-o-qui-aht First Nation, and the First Nation has also expressed a desire to include some of the benefits of modern science in park management (Murray & King, 2012). To achieve this, Parks Canada has attempted to provide cultural awareness training to PRNPR staff, increasing employment opportunities for First Nation members, commemorating historical aboriginal sites, and creating a cultural resource management working group between PRNPR and the Tribal Parks (Murray & King, 2012; Parks Canada, 2009). For the Tla-o-qui-aht First Nation, incorporating modern science into park management involves expanding traditional teachings to include quantitative species monitoring practises (Murray & King, 2012). Incorporating each other's epistemologies presents an opportunity for knowledge co-evolution between the two management regimes, as both Parks Canada and the Tla-o-qui-aht First Nation would benefit considerably from the knowledge provided by Western science and ITK.

Implications

The impacts of Western science and ITK on definitions of biodiversity influence the objective for PA biodiversity under the analyzed governance structures and offer important lessons for Canada as it seeks to meet the 2020 Aichi Targets and the 2030 SDGs.

As Canada increases the network of PAs as mandated under the 2020 Aichi Targets, attention must be given to the role governance structures play in shaping biodiversity levels, and more importantly, how they impact biodiversity objectives and outcomes. As has been examined, PAs under Indigenous governance lead to a greater understanding of the interactions between species and their surroundings. This ultimately means that species in these areas are more protected because park managers have a greater understanding of prevailing threats and are more equipped to deal with them. In the current global biodiversity landscape, which is experiencing unprecedented declines, a governance structure that enhances species protection is ideal. IPCAs can thus play a crucial role in helping Canada meet biodiversity targets and greater sustainability goals.

In order to meet international biodiversity targets, Canada will need to report on progress. Thus, attention must be given to what definition of biodiversity reporting mechanisms are designed for. For example, if reporting mechanisms are tailored to incorporate Western science's interactions with biodiversity, then an incomplete image of the biodiversity story will be depicted, as it overlooks the socio-ecological element. Further, the institutions collecting data will simply continue to perpetuate a colonial power dynamic, whereby only a specific, Western narrative of biodiversity is told. Thus, it is imperative that consideration be given to ensure Indigenous communities do not report through an imposed colonial understanding of biodiversity (Zurba et al., 2019). Biodiversity reporting then needs to find a way to incorporate both definitions but remain mindful that the choice to report biodiversity levels in IPCAs remains with the Indigenous peoples. This is noteworthy because reporting ultimately determines Canada's overall biodiversity performance, and so it must remain mindful as to who is being represented in these reporting mechanisms, both locally and globally.

Conclusion

The importance of governance structures in the management of protected areas cannot be understated. In Canada, these governance structures include PAs managed by Parks Canada (PRNPR) and those managed by Indigenous communities (Tla-o-qui-aht Tribal Parks). The comparison of PRNPR and the Tla-o-qui-aht Tribal Parks showcases how different governance structures approach biodiversity management. In PRNPR, Parks Canada conducts biodiversity evaluations through the monitoring of species, under Western science practices; whereas, the Tla-o-qui-aht First Nation, through their traditional teachings, uses two philosophies that determine land-use.

The above analysis reveals that under an ecological definition of biodiversity, both parks have regions with overall positive trends and others with diminishing trends of biodiversity. However, under the socio-ecological definition of biodiversity, the Tribal Parks saw high levels of ecosystem vitality attributed to the relationships between people and nature. These relationships were omitted from Parks Canada's analysis of biodiversity in PRNPR. It was determined in the analysis that the two epistemological systems, which interacted with biodiversity in different ways, impact biodiversity definitions and objectives differently. Ultimately, it is concluded that adopting a socio-ecological definition of biodiversity that incorporates ITK and Western science allows for a more robust understanding of regional ecosystems, meaning that species are better protected against prominent threats such as invasive species that will inevitably be exacerbated by persistent and worsening climate change.

As Canada seeks to expand its network of PAs to meet biodiversity and sustainability targets, consideration needs to be given to how these areas are managed. It is imperative that attention is given to how the epistemologies of different bodies define and ultimately shape biodiversity objectives and outcomes. Further, as Canada seeks to advance reconciliation efforts with Indigenous people, it must consider that IPCAs are essential for Indigenous well-being and cultural sustainability. The expansion of IPCAs will thus be vital for biodiversity conservation in Canada.

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