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Climate Change Vulnerability, Water, and Extreme Weather: Perspectives from Graduate Environment Students

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Abstract: The experience and impacts of climate change are uneven across generations, income classes, cultural groups, and geographical locations. Efforts to document and understand such experiences and related perspectives are increasing. Particularly among student groups, there is much attention on understanding how children and teenagers perceive climate change. However, until now, such perspectives of graduate students have not been represented in the literature. We, thus, surveyed and spoke with graduate students from a Geography, Planning and Environment Program at Concordia University in Montreal / Tiohtià:ke, Quebec, Canada. As a sample of next-generation decision makers, they shared fears, concerns, and recommendations consisting of both bio-physical and socio-political scientific dimensions. They expressed interdisciplinary perspectives related to climate change vulnerability, mitigation, and adaptation as they relate to water and extreme weather. Their fears included uncertainties pertaining to climate and human behaviors, and the possibility of surpassing global carrying capacities that could result in irreversible and lethal disasters. Considerations involved recognizing the vulnerability of the climate system and of humans, with a focus on socio-political injustices. Students placed a strong focus on emerging opportunities, such as fostering community development and investing in innovative technologies. They recommended power shifts, through paradigm awareness and reformed policies, where currently vulnerable populations access more decision-making power. They suggested fostering interdisciplinary and international cooperation to integrate climate science, involving age-appropriate modelling programs, into school curricula, and learning about human positionality and from resilient populations. We consider wicked problems, psychological distancing, and climate literacy as influential concerns in shaping climate change contexts and literacy. Our methodology allowed research participants to guide the study's questions and foci with the use of a survey, collectively-generated word collages, and a focus group. The activities prompted space for the group to practice roleplaying as decision makers. As gentle form of Participatory Action Research, the methods could guide other groups to reflect upon and document their perspectives.

Keywords: climate change mitigation and adaptation, climate vulnerability, extreme weather, student perspectives, water, interdisciplinary climate literacy.

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Introduction: Wicked Problems and Next-Generation Decision Makers

Next-generation decision makers are recognizing the need to address the array of challenges facing humanity and the planet as it relates to climate change and climate vulnerability. This *climate change generation* (Wachholz *et al.* 2014), which constitutes many young adults in graduate school, has grown up amidst a context of *wicked problems* (Bastien & Holmarsdottir 2015; Bielawski, 2020) including threatened water systems and increased frequency of weather extremes. These upcoming leaders and policymakers are already facing unprecedented global challenges. Having a well-informed knowledge base and well-equipped toolkit, complete with scientific modeling skills and sociopolitical awareness, could increase their chances of being future-ready to make sound and sustainable decisions.

On and around the island of Montreal / Tiohtià:ke, Canada, where we spoke with graduate students, residents have been experiencing increasingly intensive rainfall over recent years. In Spring 2020, water levels remained higher than normal along the Riviere-Des-Prairies waterway (bordering the island's North shore) and extending into the Ottawa River, which led to flood watches and minor inundation along shorelines. A particularly significant flooding event occurred in April 2019, affecting thousands of people near the waterway. Similarly, two years earlier, in April 2017, the island experienced intense flooding that resulted from virtually double the average/normal rainfall (~160 millimeters). This Spring 2017 event would typically be considered an event that happens once every 50 years, and yet similar levels of flooding returned only two years later. Since the noted 2017 flood, the area has also endured two extreme weather events, specifically the microburst events of August 22nd, 2017 and August 29th, 2018. Additional extreme weather includes heat waves, most recently those in late-May to end-July 2020, and the Summer 2018 event which took the lives of over 90 people across Southern Quebec, with about 50 fatalities reported on the island alone.

Increasing frequencies of extreme weather, coupled with water issues, such as water insecurity and sea level rise, are particularly hazardous for already vulnerable regions. Moreover, such water issues and weather events are likely to increase in both frequency and/or intensity with future global warming. This is especially evident for coastal regions that are often affected by the damaging winds of tropical cyclones, and heavy precipitation and flooding. Furthermore, populations vulnerable due to sociopolitical injustices, such as environmental racism and systemic barriers to adequate health care, are notably at risk.

As a result, it is becoming increasingly crucial for policymakers and communities to develop mitigation and adaptation strategies to better prepare at-risk areas and populations for future climate changes, particularly with regards to water and extreme weather. Thus, a greater understanding of insight from future decision makers from the climate change generation could contribute to developing better informed sustainability education and climate policies.

We present here findings from a survey, a collection of word collages, and a focus group that we conducted with a group of university graduate students (Masters and PhD level) from the Geography, Planning and Environment Program at Concordia University in Montreal / Tiohtià:ke, Quebec, Canada. There are differences among the specific degrees featured by the program in which ten students were registered in the Master of Environmental Assessment (EA)

Program, four in the Master of Science in Geography, Planning and Environment (GPE) Program, and one in the Master's of Sustainable Practice. However, despite these variations, the students were brought together by a shared concern for humanity and the state of the climate. The group shared commonalities that contribute to their realities of how they experience and perceive climate change, given their similar age group, income status, privilege to pursue graduate school, and geographical location of living in Montreal. Characteristic to many large urban centers today, the group reflected some cultural diversity, originating from six different countries and four Canadian provinces.

We stress the importance of hearing from these graduate students because of the lack of representation to date in the literature on graduate student perspectives related to climate change. They could be considered a proxy for a larger group holding interdisciplinary perspectives, including awareness of how such changes affect the interconnectedness and fragility of the climate and people in a plethora of ways. Plus, the domains of Geography, Planning and Environment, of which the students represent, can offer integrated understandings of both global geo-physical processes and human socio-cultural-political phenomena. Insights from these interdisciplinary domains, encompassing both physical and social sciences, could contribute to constructive exchanges of ideas and guidance related to climate change mitigation and adaptation.

Background: Student Perspectives and Climate Change Curriculum

Student Perspectives

Perspectives on climate change have received considerable attention in scholarly literature. This is particularly focused on views held by students and youth aged 12-25, which includes middle school up to undergraduate college-age (Corner *et al.* 2015). More specifically, studies to-date have employed empirical analyses to research perspectives and knowledge related to climate change science. For example, Chandra (2016) investigated the experiences and understanding of climate change among 300 youth aged 12-17 in India. In the Midwest United States (U.S.), Shepardson et al. (2009) worked with 91 seventh graders to document their conceptions of global warming and climate change. A case study from the United Kingdom shared the research agendas of young climate change activists to promote understanding of their perspectives on international climate negotiations (Harriet 2016). The Landon Pearson Research Center (2017) runs workshops at universities across Canada where youth explain their perspectives on how climate change and water concerns impact their rights, and then offer recommendations to local politicians.

Student groups are visibly activating around the world, sharing their perspectives. Notably, the recent movement inspired by high-school student and striker Greta Thunberg (in Belam, 2019) who states, "Being young is a great advantage, since we see the world from a new perspective and we are not afraid to make radical changes". Similarly, an international group composed of students between the ages of 15 and 20 declared at the 2019 United Nations World Water Week convention that "We want interdisciplinary curriculums in schools to increase educational efforts on climate-change related knowledge to the general public and instill this

knowledge bringing it to the core of the young generation" (National winners of the Stockholm Junior Water Prize, 2019, p. 2).

Although we see an increase in academic studies, news stories, and policy documents related to students' perspectives on climate change, we were unable to find coverage on university graduate students. Graduate students, especially those in Geography, Planning and Environment studies, hold well-informed perspectives on sustainability issues and geo-physical processes. Such knowledge enables them with insight related to climate vulnerability, mitigation, and adaptation concerning water and extreme weather, making them and their perspectives relevant to our study.

Considering that "building a richer understanding of international youth perspectives on climate change should be an important priority for future research" (Corner et al., 2015, p.530), this study is a fitting contribution to the literature related to climate policy and sustainability awareness, as it pertains to university graduate-level youth. In addition to addressing the gap in demographics, this study also contributes perspectives focused on vulnerability, and mitigation and adaptation in relation to water and extreme weather.

Psychological Distancing and Climate Science Literacy

Before describing the graduate students' perspectives, we present two noteworthy ideas from Sustainability-related literature in efforts to frame relevant context of what it means to be part of *the climate change generation*. Factors include the notion of *psychological distancing* (Corner *et al.* 2015), and the observation that many students lack climate science literacy (Wachholz *et al.* 2014).

Psychological distancing explains the phenomena of individuals and communities lacking awareness related to the gravity of climate vulnerability due to being physically distanced from serious impacts. Since such people remain directly unaffected by remarkable impacts and, consequently, do not consider them in their daily routines, they do not realize the severity of the threats. Other contributing drivers of psychological distancing include shorter-term concerns of economic well-being, education, and health care, which often push longer-term priorities to the margins (Corner *et al.* 2015).

Psychological distancing may also be linked with students' lack of accurate knowledge about climate science. For example, Wachholz *et al.* (2014) showed misconceptions among most American college students as to the causes and consequences of climate change, including a lack of knowledge in regional and global impacts that had occurred in recent decades. Seventh grade students from the Midwestern U.S. stated that although they believed that global warming would impact temperature and precipitation regimes, they did not consider how changes in frequency/ severity/variability of weather extremes, such as tornadoes, drought, and tropical cyclones, would also respond to this warming (Shepardson *et al.* 2009).

The general lack of climate science literacy has been linked to "education that is unbalanced, over-specialized, and mono-disciplinary" (Watson *et al.* 2013, p.107). Subsequently, "students need opportunities to develop climate literacy" (CLEAN, 2019 in Lally, 2020, p. 1). In addition to Earth Science studies and sociopolitical awareness, climate literacy can be built using age-appropriate computer-based simulated modeling programs. One such program that teaches

about water and climate change is the focus of a recent study by Lally et al. (2020), which examines the impact of using modeling with undergraduate students.

Curricula

Studies show that climate science is increasingly being integrated into primary and secondary school curricula, particularly in the physical sciences and covered in interdisciplinary contexts (Corner *et al.* 2015), as well as across an array of university programs (Watson *et al.* 2013). Studies from Finland and the U.S. indicate that students learning about climate change science at school tend to be more likely to engage themselves, personally and politically, in actions of climate change mitigation (Corner *et al.* 2015).

Existing climate science education literature recommends detailed curriculum that includes the following topics: The Carbon Cycle and the Greenhouse Effect; Global Warming and Climate Change; and Climate Change Impacts (Shepardson *et al.* 2009). Such curricula and programs intend to familiarize students with the concept of climate change and its broad connections to global atmospheric processes and impact(s) on ecosystems, such as freshwater systems. Notably, these recommendations focus on bio-physical systems, yet oftentimes have little inclusion of the roles and implications for humans.

Similarly, results from a curricula assessment of sustainability education programs at Georgia Tech University showed that the curriculum focuses on environmental factors while bearing significantly less attention to social dimensions, concluding that the depth of environmental content lacks holistic and interdisciplinary elements (Watson *et al.* 2013). Subsequently, Corner *et al.* (2015) conducted studies in Australia that "have suggested broadening the scope of environmental- and climate-related education to introduce a more interdisciplinary approach that includes the economics and politics of climate change as well as negotiation, analytical, and scientific skills" (p. 528). Recent literature poses the question, "At this critical junction in our history, during severe climate and ecological breakdown, what are the ways we can challenge students to learn and be aware of the environmental injustices impacting marginalized communities?" (Vaughan-Lee & Dorman, 2020, p. 1).

To broaden the scope of climate education, and to contribute to the collective understanding of perspectives held by people on climate change and how to cope with it, we invited graduate students to participate in our research study.

Participatory Methodology as Impactful Action

The research methodology, whereby participants were active in guiding the questions and foci, prompted an evolving space for collective reflection on climate change vulnerability and climate change-related education. They were able to imagine how they might behave as policymakers by determining the priority areas of the focus group. The opportunity simulated a simplified process of policy-making (in a less-politicized arena than actual policymakers might find themselves), including deliberation about facts AND values related to current and future wicked problems. So, in a sense, these emerging leaders from the climate change generation were practicing for future roles they could likely assume. We, thus, consider the methodology a gentle form of

Participatory Action Research (Bradbury, 2015; Schmuck, 2006), as it made a positive difference to the group involved in creating scenarios for them to practice expressing their perspectives while knowing their comments would be synthesized and published.

Once the group was gathered, we conducted an online survey using *Pollev.com*, where responses were shared in real time with the group. We first collected demographic information (including age, geographic origin, and academic program). Of the 15 participating graduate students, 67% ranged in age from 23 to 28, and 33% were over 32 years old. 50% of the class represented four Canadian provinces (Quebec, Ontario, BC and Alberta), and the remaining students were from France, Australia, Moldova, Belgium, and the U.S. One research participant described the participants as a "group of graduate students from different backgrounds with different perceptions", and another wrote "a group of critical graduate students". Although backgrounds varied, we reiterate that the students were brought together by common concerns and interest for the sustainability of the planet and its systems and members, including humans.

The participants were all students in an Advanced Environmental Science graduate course at Concordia University in Montreal / Tiohtià:ke, a course offered by their Geography, Planning and Environment Program. They each consented to participate in this study as a component of the class. Prior to research activities, participants read four preparatory documents, including the Intergovernmental Panel on Climate Change (IPCC) Executive Summary Report on Climate Change and Water, case studies on climate change adaptation and mitigation, and literature on climate vulnerability as it relates to Atlantic hurricanes.

To acquire a general sense of the students' collective knowledge, we asked them on a survey to write the first word that came to their mind after hearing certain words or questions about climate change and respective concerns and opportunities. With the survey program, we were able to generate word collages (visible in Figures 1, 2, 3, and 4 in this article), which we then used as visual catalysts to further explore their perspectives.

With the word collages on display, we conducted a loosely-structured focus group (to allow the students the opportunity to guide it) centered on the following research question: *"In the context of climate vulnerability, and climate change mitigation and adaptation, what do future leaders from the current 'climate change generation' suggest for our relationship with water and extreme weather?"*

Findings and Discussion: Environment Graduate Students' Questions and Reflections

In this section, we discuss the graduate students' fears, considerations, opportunities, and recommendations related to climate change. We show word collages that illustrate the results of survey responses, and we summarize points and quotes from the focus group. Note that the size of the word in word collages indicates the frequency it was submitted. Thus, the larger the word, the more frequently it appeared in the students' survey results. Within and throughout the presentation of findings, we have integrated points of discussion to elaborate on key themes.

General Perspectives of Environment Graduate Students

The first word collage grew from asking the students to write the first word that came to mind after hearing the term 'climate change'. Their responses are displayed in the word collage below, shown in *Figure 1*.

Figure 1: Word relations to climate change

These words illustrate a collective awareness of large-scale global systems, both geo-physical and anthropogenic, such as ecological functions and capitalism, respectively. 'Global' was the word noted the most, by three students, with 'flood' being mentioned by two individuals, and the remaining words in the map were each listed by one student. The students acknowledged the phenomenon of climate change and, furthermore, expressed their familiarity with its capacity to impact trends and cycles of global systems, particularly with respect to water and extreme weather. From their previous course work and experiences, they were able to articulate various social and physical factors that they believe significantly drive climatic changes. They described both long-term geologically-driven processes and human-induced intensification of climate changes. The specific anthropogenic drivers of climate change mentioned included: the industrial revolution, resource overexploitation, consumer capitalism, greenhouse gas emissions, political short-sightedness, and a general lack of accountability. In addition, they recognized El Niño and La Niña, and their impacts on recent weather patterns.

Collectively, the students acknowledged that the problems we face are complex and include current and future uncertainties. They discussed the paradox of needing to act immediately in order to address pressing predicaments of water changes and weather extremes while calling for the precautionary principle in designing, planning, and implementing mitigation and adaptation strategies. It is interesting to note the climate literacy among the group, visible from their familiarity with the precautionary principle and other climate change-related concepts, which many said they learned about while in high school and undergraduate courses.

In discussing the concept of climate vulnerability, some students requested clarification from their colleagues on who or what in particular was vulnerable, whether it was us as humans or the climate in its entirety. According to the climate science community, vulnerability focuses on *human vulnerability* as a direct result of the current and potential future impacts of climate change. However, recognizing that humans are dependent on climate and water systems, one student suggested that it was interesting to draw a distinction between the two (between humans and the climate), and that he saw both, together, as being vulnerable. We, therefore, acknowledge

that climate vulnerability can be interpreted as either the state of the global (or regional) climate itself being vulnerable and/or humans becoming more susceptible to a changing climate. Although not the focus of this study, the group also acknowledged the importance of considering the vulnerability of non-human lifeforms.

Similarly, students described the integrative natures of water and extreme weather and recognized that weather extremes can **"**affect the amount [of water], the distribution, and the access to it". Another student explained, "I have a very hard time separating climate change from the water itself". He proceeded to tell us about his mother in Peru whose source of water is rain collection; she collects it independently using a household rain catchment system and then stores it in a cistern. So, for her, interacting with water (specifically rainwater) is synonymous with interacting with the climate. Thus, students shared the perspective that the multiple entities and systems mentioned are intimately connected and are tied into each other's vulnerabilities.

The group also raised points about relevant social justice implications. According to one student, "vulnerabilities are not simply vulnerabilities related to climate but also vulnerabilities related to social inequality". Injustices, uncertainties, and irreversible actions are all concerns held by the students, as elaborated upon below.

Fears and Concerns: Uncertainty, Vulnerability, Modelling projections, Sociopolitical Conflicts

Discussing vulnerability prompted students to express their fears and concerns related to climate change, first by each stating a relevant word, and next by elaborating on it during the focus group. The results are presented in *Figure 2*.

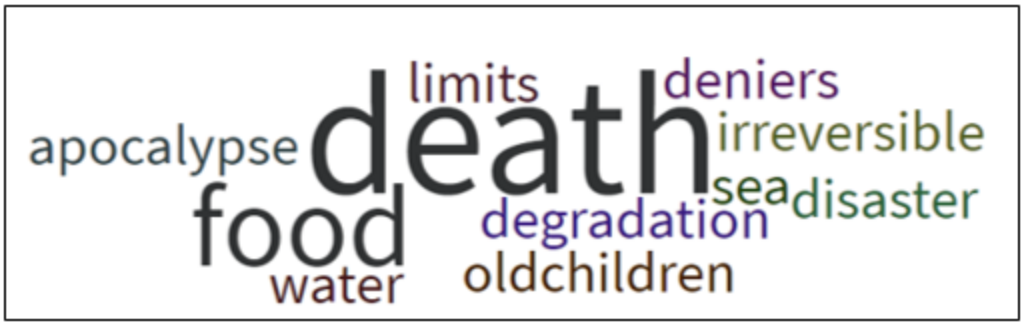

Figure 2: Fears related to climate change

Our findings show that uncertainty was a prevalent theme throughout the focus group. Students expressed their fears and concerns about uncertainty relating to: climate behavior; the validity of climate models; human behavior, and how it impacts our collective human relationship with the planet; and the unpredictability of increased storms and floods. Notably, students spoke about the possibility of surpassing global carrying capacities which could result in irreversible and lethal disasters. Pending catastrophes, such as large-scale environmental degradation and/or potential ecosystem collapse (initially referred to as 'apocalypse' in the word collage), arose as deep-seeded fears among the group.

The students further expressed their fears of tangible risks, like the vulnerability of global food and water systems, and the subsequent dependency of humans on these vulnerable systems. They spoke about human dependency on grocery stores and mass-industrial food systems, and the vulnerability of relying on respective neo-liberal systems to feed much of the global population. They worry that the larger systems may collapse, and that smaller ones may not be widespread or strong enough to meet the extensive demand. The combination of the many threats to global ecosystems and food chains, with current and projected human consumption habits, were expressed as dangerous.

In planning future policies and practices to address the many threats, the students discussed the relevance of global and regional climate model projections. These model projections provide estimates of the climate system response to prescribed perturbations, such as to scenarios of greenhouse gas emissions. Drawing on their experiences and reflections from undergraduate and graduate course work involving environmental modelling, they acknowledged the controversy surrounding the applications of such model projections. They expressed this as a central consideration because of the degree of uncertainty that occurs when attempting to project trends over extended periods of time (i.e. decades to centuries). This uncertainty contributes to the lack of trust held by some students when considering projections presented by climate modeling research and, thus, the students claimed, climate modeling projections should be treated with caution. The lesser degree of confidence expressed by the students is likely linked to the idea that climate models are not capable of fully representing the realistically complex nature of the climate system because of the assumptions made to describe physical processes, especially at finer spatial scales. However, although they suggested that model projections may not be fully accurate with longer-term trends, "they are better than nothing", and they are improving with time. Therefore, students see these models as valuable tools that can assist policymakers in preparing for a global climate that is likely to experience increased occurrences of extreme weather.

Beyond physical challenges of resource quantities and qualities, students were fearful of socio-political conflicts and potential tension building in ways that exasperate inter-human competition, hierarchies of power, and oppressive injustices. Students were particularly concerned about people positioned at higher-risk degrees of climate vulnerability, such as children, the elderly, impoverished and/or marginalized people, and those living at sea-level and in drought-ridden areas.

Positionality was an important consideration implicitly reflected upon by the students. They expressed concern that those in highly vulnerable situations (whether because of socio-political standings and/or geographical locations) are not the people who generally hold positions of power or who have influence in government policymaking (compared to well-funded lobby groups, for example). Those in higher-level positions of power are comparatively less at risk for climate vulnerability and, thus, do not possess respective capacities to accurately assess the gravity of climate injustices. Oftentimes, these decision makers, according to students, respond inadequately, make unsuitable decisions, and reinforce unsustainable behaviors and habits.

We also found from our focus group that psychology in relation to climate change is a very important dimension. The students conveyed apprehension related to seeing 'the frog effect' happening among politicians and populations at large, whereby climate change impacts

may be increasing so gradually that we simultaneously adapt to the new realities without recognizing the magnitude of risk and without trying to mitigate it. More specifically, one student in our focus group metaphorically expressed this notion as "It's the frog boiling", referring to the tale that when a frog jumps into boiling water, the response is to react quickly. However, if the frog jumps into water that heats up slowly, the response is slower and puts the frog at risk of growing weak as the water gradually boils him/her/they/it to the point of death or reacting later. Similarly, another student already has fears that:

> we'll just keep on saying '*oh that's just the way the world is now... like put on more sunscreen and don't worry about it'*. That's what I'm worried about, is that we'll just sort of adapt to it, by like saying '*I just gotta get home and watch my Netflix and not worry about it'*.

Students also expressed concern about climate change deniers and the influence they have in activities contributing to climate change. Specifically, in relation to North American political stances and approvals of resource extraction expansion projects, students worry that by denying the relationship between such activities and increasing carbon emissions, impacts will accelerate the fostering of conditions unfavorable to human well-being. Such political decisions, once in place, are difficult to change; students expressed their fears that these legal systems and structures may be incapable of adapting rapidly enough to effectively mitigate climate change impacts and can, thus, further global climate vulnerabilities.

Considerations: Evolving Conversations, Varying Interpretations, Contexts and Positionality

The students presented a panoply of considerations in what they see as important to include in conversations and decisions related to climate change mitigation and adaptation. Word representations are displayed below, in *Figure 3*.

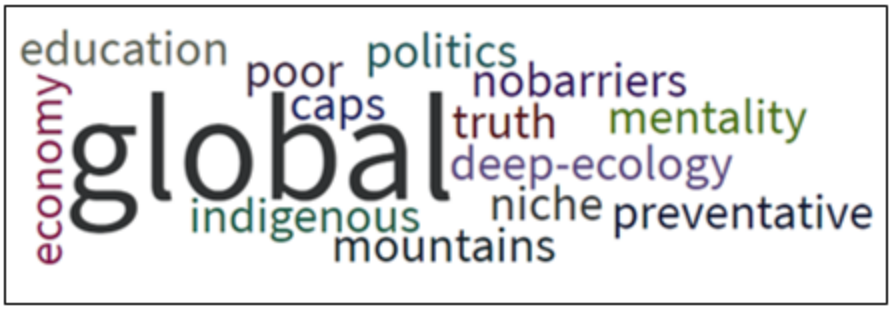

Figure 3: Considerations related to climate change mitigation and adaptation

They explained that climate change is changing conversations, particularly discourse on how to strategically proceed in educational, political, and managerial arenas on local, regional, and global scales. One student explained:

> We don't even have to consider if climate change is a pro or con, or is it damaging or is it beneficial. We don't even need to look at that evaluation. Just climate change is a topic right now that is changing the discussion, very much politically... we can see how it's changing our perspective and our approach to these issues.

Multiple interpretations of the concept of mitigation were discussed, wondering if policy efforts should be more focused on reducing vulnerability to a degree where people are not detrimentally affected by extreme weather, or whether humanity should collectively strive to increase the resiliency of people to be better equipped to deal with impending changes. Although the students did not explicitly mention Donella Meadows' (1999) theory related to leverage points in a system, we include it here, as their recommendations align with several of the levers, or entry points, that she identifies.

Some students were particularly passionate about considering geo-engineering as a tactic to reduce the rate of global warming, or even to offset long-term global warming. Geo-engineering, which is also known as climate engineering, is a mode of intervention that directly attempts to modify the climate system to reduce global warming and mitigate its effects. It resonates with several of Meadows' (1999) leverage points including: #7. Reduce the gain around positive feedback loops; #8. Increase the strength of negative feedback loops relative to the impacts they try to correct against; #9. Change the length of delays, relative to rate of system change; #10. Change the structure of material stocks and flows; #11. Change the sizes of buffers and stocks relative to their flows; and #12 Changes in constants, parameters, numbers.

Students gave examples of cloud seeding (to generate more low-altitude clouds, as their more reflective nature can deflect incoming solar radiation back to space) and reforestation projects to sequester carbon (to modify carbon sources and sinks). They were adamant about making the distinction between large-scale geo-engineering and small-scale geo-engineering.

They also recognized a need for both top-down policies (i.e. income redistribution, pollution penalties, monetary incentives) and simultaneous bottom-up mitigation efforts (i.e. gardening at home, developing local community sharing networks). We can link approaches related to policy to Meadows' (1999) points of: #4. Power to add, change, evolve, or self-organize system structure; and #5. Rules of the system (such as incentives, punishment, constraints).

Differing contexts were also included as a considerable factor, particularly the intersection of geo-physical surroundings as they relate to our worldviews, principles, and policies. For example, "in some areas you have no [water] supply and other areas you have lots of supply. That definitely changes your politics on how you interact with water". One student from Australia told the class what it was like growing up with regular water restrictions where actions like taking very short showers and refraining from washing cars were embedded into their daily lives. He noticed that people in Canada tend to use water more abundantly.

Building on the fear mentioned previously related to positionality (whereby those in decision-making power are generally those less affected by climate change impacts), students reiterated the importance of acknowledging the sociopolitical players and their respective dynamics. One student explained, "There are some places controlling the water up to the point where other countries aren't getting enough supply". They spoke of water access injustices, colonialism, and the power of human dynamics in shaping the contexts of other humans. They

recognized that water security is not necessarily about physical proximity to water, and that vulnerability does not solely depend on one's physical geographic location.

They also noted the relevancy of global economic systems, and their influence in equating dollar values to ecosystem services, and to occurrences like hurricane damage. One student stated that, "Economics are a huge issue" and followed up his concern contemplating that through an economic lens, and with economic tools, we may comprehend problems and threats but might not be able to do anything about them. He said, "the economy is a human construct... I think it's important to keep in mind that it's a very artificial metric that is a little bit unrelated and only allows us to locate that vulnerability, rather than deal with the actual issues". To elaborate, if the problems and threats are resulting from impacts of traditional economic systems (from which many global injustices do), then we cannot use traditional economic measures to fix them. It is similar to the famous quote from Albert Einstein that, "We cannot solve our problems with the same thinking we used when we created them".

We also found that students reminded each other to remain cognizant that human population is growing exponentially, and that areas of high growth include financially-disadvantaged areas and urban centers. They said that it is important to consider that these areas of high human population growth are also areas more susceptible to climate vulnerability.

Recognizing that certain people are more vulnerable than others, the students considered the idea that "the best people in the city to deal with that sort of situation are those who have the best resiliency in emergency situations". They suggested that we learn from refugees who have lived in dire situations and/or in refugee camps where their abilities to adapt, ration food and water, and live from low-power subsistence, are well-practiced skills. Although we may view these individuals and groups as being the most vulnerable, they may also be well placed to offer important guidance to larger communities about resiliency. Here, we can apply Meadows' (1999) levers that she identifies as being higher in effectiveness, such as: #2. Change the mindset or paradigm out of which the system arises; #3. Change the goal of the system; #4. Nurture the power to add, change, evolve or self-organize system structure; #5. Change the rules of the system (incentives, punishments, constraints); and #6. Change the structure of information flows, to alter who does (or does not) have access to information.

Furthermore, the students also spoke of learning from Indigenous Peoples and respective knowledge systems and abilities to build human resiliency in the face of climate change impacts. One student explained that Indigenous knowledge related to living with and directly from the land, and how that sense of reciprocity of giving back to the land, could teach us about resiliency and, in turn, about mitigation and adaptation. She elaborated by explaining that mitigation practices may be interchangeable with sustainability practices, such as reducing our carbon emissions and ecological footprints. She referred to a talk she had attended by an Indigenous woman speaking about Indigenous law. The focus was to understand that it is not just about decreasing humanity's negative impacts on the planet, but also about asking how we can give back. So, rather than holding a limited mindset of quantitatively calculating our impacts, include a qualitative awareness of reciprocity and stewardship to nourish sustainable and respectful relations with the non-human world. Other students agreed that the angle or worldview from which we view a problem or possible solution is significant to consider.

As a final consideration, the research participants questioned the assumptions that they hold as a group of environment students. This point aligns with Meadows' (1999) lever of #1. The power to transcend paradigms. The students acknowledged that their general understanding of the world is through a Western Science lens which, thus, inadvertently excludes other types of ideologies, knowledges, and practices in their collective thinking. They questioned notions that their collective conceptual framework might take for granted in ways that are different from other collective paradigms. They recognized that they believe, individually and as a group, that climate change is happening and is a real threat, and that not everyone around the world agrees. They realized that they share the belief that there are political and/or technological solutions to the climate challenges we face; however, they expressed their fear that there might not be.

Opportunities: Cognitive Shifts, Innovation, Righting Injustices

In addition to current and predicted harmful impacts of climate change and relative fears, growing awareness of such issues is lined with opportunities. Students were asked to contribute one word to describe opportunities arising from climate change. The visual description is below, in *Figure 4*.

Figure 4: Opportunities of climate change

The students explained that they see a shift happening. One older student stated that, "I see a big difference in some of the students in this program who are younger than my group of friends... I feel like that is a very positive development". They described the evolving collective mentality held by young adults (as compared to older adults) as resulting from growing up in different times, environments, and education systems. They explained that collective priorities have shifted to now include an awareness of environmental issues. For example, they have grown up hearing about the hole in the ozone layer, endangered species, carbon emissions and other impacts on the planet. Two students explained that they gain hope from David Suzuki's *Blue Dot Project*, which engages Canadian municipalities and provinces (and is also working to engage federal government departments) to adopt legislation that supports the lawful right to have a clean environment.

Students spoke about how awareness of climate change offers opportunities to better ourselves. One student said, "I hope that we do do something about it and that the change we

make as a society is greater than predicted... ...to better ourselves and our society, and to shine the light on injustices that exist". He claimed that "we have more potential than we think". Technologically, we can communicate more efficiently than ever before, and we can build innovative structures to assist us. For instance, one student spoke about plans in New York City to build a hurricane wall that doubles as green space to capture water and transfer it to the underlying water table. He explained how these more-sustainable building practices are influencing the relationships we have with our local and built environments. Another example he cited was the use of concrete designed to simultaneously be permeable to and filter water, thereby contributing to improved water quality and safety.

Finally, the students discussed the opportunity that awareness and discourse related to climate change can contribute to righting injustices by shedding light on social inequalities. By seeing how climate vulnerability impacts those in disadvantaged positions, we can take steps to address the issues and effectuate appropriate behavioral change. Students mentioned that climate injustices have begun to act as a catalyst for discussion about classism, colonialism, systemic and structural powers and privileges, environmental racism, hierarchies of knowledge, and hegemonic values promoting Western ideologies at the subsequent exclusion of other ways of knowing and ethics. Opportunities of becoming more aware of such phenomena include opening ourselves to other ways of thinking about, and enacting upon, our intentions.

Empathy was suggested as a practice that could be fostered widely as a lens to develop respect for the Earth and our global and local environments while collaborating in ways that care for fellow human beings. Thus, students expressed their hopes for a vision where both sustainable technological fixes, as well as empathetic social change, are affected in a manner that addresses both immediate and long-term well-being.

Recommendations: Education, Power Shifts, Precautionary Principle

We found that the importance of education, particularly interdisciplinary climate literacy, was a subject that emerged several times throughout the focus group. The students insisted that instead of education affirming fears related to climate change, lessons could instead promote avenues highlighting the interconnectedness of everything on the planet and fostering respect for such interdependencies. They furthermore suggested learning from non-Western pedagogies and/or land-based worldviews like Indigenous and Traditional Ecological Knowledge, Nature-based Solutions, and Deep Ecology which honor interconnectivities of all living beings and life-supporting systems. Recommendations also included that a sense of reciprocity be incorporated into mainstream education curriculums to encourage thinking along the lines of 'what can we give back to the earth', rather than just a relationship of one-way taking for human consumption.

The students envisioned a shift in power whereby marginalized communities gain more decision-making access and capacities. In other words, they envisioned power being decentralized from the top-down to address the wicked problems at local levels. Specifically, they suggested that we learn from those who are most vulnerable (for example, refugees), and who might hold capacities to be more resilient. They see this as one approach to reducing the lack of action due to the gap resulting from psychological distancing.

The group suggested fostering a worldview and corresponding governance structure that is more in line with nature, particularly with natural systems. In effect, they explained, actions

that are in better balance with nature's need to function in healthy ways will intrinsically be more sustainable and, therefore, contribute to mitigation measures. They suggested ecological economics and the *Degrowth* (Martínez-Alier *et al.* 2010) movement and its principles as models to learn from.

The group expressed their collective aspiration for a global population where "everyone is on the same page and values a diversity of knowledges". One student described it as "perspective accessibility", or in other words, maximizing the sharing of knowledges to be able to make decisions from a place of more thorough perspectives and well-informed climate literacy. This way, students claim, we can better understand the whole system to make better informed decisions for the welfare of all life, and subsequently for the well-being of human life and systems.

About half of the students passionately recommended adopting Strategic Regional Environmental Assessments (rather than case-by-case project assessments) as a widespread practice. As explained by one student, in relation to water governance,

> For example, Quebec has a lot of water. So, let's look at watershed management, ok, we have a lot of water, but maybe we should go to the city-scale and see how we use up water and then make policies at that level... there needs to be better connection between local and global, by using the sea as the final sector.

The precautionary principle was promoted amongst the group in ways that suggest obtaining more research and learning more about ourselves and our systems, as well as the planet and its systems (of which we are a part). One student exclaimed, "It's important that we try to understand the world as much as possible before jumping to conclusions because what we're going to do is eventually cause a problem so large that we won't be able to solve it".

The students advised caution specifically for actions related to large-scale geo-engineering. Small-scale geo-engineering, however, they deliberated, could contribute to mitigation and adaption for climate change risks. They acknowledged that climate vulnerability can be addressed both socially and technologically, and they categorized technical fixes as possibly offering short-term solutions, while long-term solutions require addressing broader social concerns.

With respect to scale, we found that students also highlighted the approach of 'thinking globally and acting locally' and applied it to community building opportunities. They advocated for both top-down and bottom-up action (simultaneously) to come together to strategically organize climate change mitigation and adaptation efforts. They recognized the need for passionate leaders who both understand the pending risks and who rally optimism to encourage people to contribute to effective collective change. In other words, they endorse leaders who show less embodiment of psychologically distancing and more endeavors to promote realistic hope.

They suggested that renowned Scientist and Environmental Activist David Suzuki could potentially administer top-down governance while concurrently promoting and supporting grass-roots community projects. For, as recommended by the students, we need community building at local, regional, and global scales. "By making stronger community ties, that's how you actually enact social change".

Students further suggested that we reflect on connections and disconnections, and in doing so, foster local communities. One student explained how being disconnected from your neighbors and residential community is a microcosm of being disconnected from larger systems, and particularly a sense of being disconnected from complex ecological communities. They spoke about how it is also important to try to understand other people as much as possible and to "conduct ourselves with empathy... prioritizing vulnerable populations, and also considering what we know and how we can use it to empathize with people who are most vulnerable".

The students recognized that we are inherently a part of global communities (human and larger eco-communities), yet that many people conceptually situate themselves apart from these broader integrated communities. Therefore, they recommended connecting on local scales to better understand ourselves in relation to the people around us, and also to be able to better understand ourselves as humans in relation to larger inter-connected and inter-dependent eco-communities. Ultimately, this way, connecting on local scales can transfer patterns and awareness of connection to larger-scale thinking and decision-making to affect better-informed mitigation and adaptation strategies.

Summary and Further Reflections

Our sample of graduate environment students showed that the current climate change conversations have evolved to explicitly include interdisciplinary considerations. As future leaders from the climate change generation, they suggest that to effectively mitigate and adapt to water changes and extreme weather, we need to invest in improving interdisciplinary climate literacy.

More specifically, the group showed that their knowledge base is composed of links between the physical and social sciences, including learning from non-Western knowledge systems. We, therefore, look to these students as being well equipped with balanced perspectives to inspire and inform development and/or improvement of climate change curricula for younger students. We learned from them that, in addition to standard Earth Sciences, climate literacy should include an interdisciplinary approach composed of learning from and about the following: modeling projections, techno-scientific innovations, community building, socio-political dynamics and reform, and paradigm awareness and shifts. Their recommendations naturally aligned with all of Meadows' (1999) 12 leverage points.

A significant finding highlights the point that climate change mitigation and adaptation to address vulnerability opens a great opportunity for innovation development. Climate modeling programs are quickly evolving as a technical tool to represent atmospheric processes that show how weather events may collectively change in response to warmer temperatures. Creating age-appropriate modeling programs, especially by using virtual reality (VR) technologies and integrating them into school curricula, could engage students to learn experientially about water, weather, climate features and projections.

Being able to draw distinctions in the time scales in which weather and climate occur is crucial for understanding climate science. It is frequently these terms that cause confusion and ultimately the debate as to whether climate change exists. It is also important to recognize the difference between annual and monthly variability in weather patterns versus climatic change

that occurs over decades or centuries. By using simple climate models, students can also experiment with climate scenarios to visually gain a broad sense of future climate trends.

In turn, this can build awareness and potentially help students and non-students to later contribute to short- and long-term solutions that may mitigate some of the current and longer-term effects of climate change, such as through more potentially effective and careful implementations of small-scale geo-engineering. Furthermore, and beyond the classroom, model projections can be conveyed to the general public and to policymakers in efforts to inform sound decisions related to a warmer global climate, more extreme weather, and water scarcity.

However, we pose ethical questions wondering whether climate models might encourage reliance on human-designed systems in ways that reinforce human-centric thinking and inclinations to dominate nature. That being said, climate models are perceived as valuable tools, and as our level of understanding increases further, the assumptions made by models in describing the physics of the atmosphere will also increase.

Based on reliable data, small-scale geo-engineering projects that strive to directly reduce impacts of climate change could offer technological solutions to some impacts of climate change, according to the students. However, they strongly expressed that caution should be taken with any large-scale geo-engineering that may cause unexpected and irreversible consequences.

Another important consideration is that using geo-engineering as a means to mitigate warmer global temperatures may also inadvertently reduce political and/or public pressure to directly cut greenhouse gas emissions to prescribed targets specified by international agreements. Because of the complexity of atmospheric processes, it is further unclear how climate modification and, ultimately, weather modification, will resonate to broader atmospheric circulation features, which has generated controversy in the effectiveness of their applications. In general, these and closely related works draw on the precautionary principle, as environmental scientists often study the complexities of natural systems but also face the pressures from those who seek environmental protection (Kriebel et al., 2001).

Of utmost importance here is to reiterate the precautionary principle and integrate a discussion on impacts and values. This principle can act as a guiding framework for science and technology to offer great developments in mitigation and adaptation while regulating decisions to implement projects only after having interdisciplinary and intercultural consensus on possible consequences being accounted for and accepted. Discussions working for consensus could intentionally focus on priorities of justice, reciprocity, stewardship, and being mindful of interdependent global communities composed of human and non-human lifeforms and life supporting systems.

Although the students advocated for the precautionary principle, they also admittedly recognized their fears of humanity's potential to surpass global carrying capacities, thereby intensifying the dilemma to need to act immediately versus their aspiration to proceed attentively and slowly. This point is integral in the complexity, or the messiness, of climate change conversations, amplified by fears rooted in uncertainties related to the unpredictability of human and climate behaviors.

In particular, foci like climate injustice, colonial awareness, and positionality were key to the conversation. Observations were consistent with other studies that indicate, "People are saying we need to make our communities more climate resilient, but it needs to be a resilience

that cuts across race, class, and geography" (Dr. Robert Bullard in Rysavy & Floyd, n.d. in Vaughan-Lee & Dorman, 2020, p.7). We, thus, emphasize here that the wicked problems are not based in 'the climate problem' but rather in human socio-political problems with geo-physical problems manifesting as symptoms.

To better understand such points, conceptual frameworks for thinking about climate vulnerability should include a critical understanding of power and privilege structures and global climate injustice (encompassing social, political, and environmental injustices and how they are entrenched together). Skills can be fostered, such as learning relevant age-appropriate language to be able to understand and articulate thoughts related to classism, colonialism, capitalism, hierarchies of knowledge, and hegemonic values.

Community building, according to the students, is imperative to dealing with wicked problems, and respective uncertainties and dilemmas. Awareness and physical impacts of climate change can bring people together at local scales to understand their relationships with broader communities and, ultimately, their role in fighting climate change as part of a global effort. Practicing positive, small-scale community-building can provide microcosms upon which to enhance global community-building and interdisciplinary cooperation.

The students seemed to emit a general lack of trust for top-down systems, yet also promoted them as necessary in conjunction with bottom-up actions. They further explained that current hegemonic socio-political systems of positionality reinforce power imbalances that cause some human populations to inevitably become more vulnerable than others to water change and extreme weather events. To reiterate the words of one student, "vulnerabilities are not simply vulnerabilities related to climate but also vulnerabilities related to social inequality".

Oftentimes, those most vulnerable are also those with the least global decision-making power; such inequalities reinforce psychological distancing amongst higher-level decision makers who are not necessarily qualified individuals to accurately assess existing climate injustices or make suitable decisions with respect to the state of the climate.

The students, thus, advocated for a power shift whereby those who are the most vulnerable, and those who hold experience with resiliency, acquire greater access to decision-making power and curricula input. Particular populations proposed for such roles include refugees and Indigenous communities. Furthermore, integrating ethical frameworks that align with respecting and caring for natural systems could contribute to shifting power to more sustainably-minded worldviews.

Our sample group, although representing six countries and four Canadian provinces, is limited in the sense of being privileged, coming from developed countries and enrolled in graduate university programs. At risk of speaking from 'an ivory tower', their perspectives specifically about learning from marginalized and/or more vulnerable communities may be romanticized. An interesting corresponding article would be to document the perspectives of members of these communities based on that recommendation.

To further document perspectives, we can recommend the methodology presented here, and/or an adapted version of it. It showed effective in prompting space, in an engaging way, for participants to guide the focus and have a shared space for reflecting on complex topics. If access to online programs is limited (and *poll.com* cannot be used), the survey and word collages could be done physically using paper and pens.

With additional baseline studies on student perspectives, we could collectively be better equipped to gauge the evolution of climate change-related conversations. Such insight could then be transferred into interdisciplinary climate literacy curricula to respond to evolving realities and perceptions. Subsequently then, more responsive and nuanced climate education would reduce psychological distancing. Educators could intentionally design curricula to help reduce fears related to climate change in ways that instead manifest as fascination and passion. Understanding the fragility of the climate system, coupled with being equipped to play responsive roles, could be a valuable contribution to upcoming climate change generation students.

In summary, as these students have illustrated, an interdisciplinary approach and drawing on an integrated balance of education strategies, climate modeling projections, technological fixes, community-building, and socio-political awareness and reform, could offer an ample toolkit from which to address climate vulnerability and to nourish climate change mitigation and adaptation.

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References

Bastien, S., & Holmarsdottir, H. B. (2015). *Youth 'At the Margins'*. Rotterdam: Sense Publishers.

Belam, M. & Guardian Staff. (2019, Sept 26). Greta Thunberg: teenager on a global mission to 'make a difference'. *The Guardian.* Retrieved Jan 6, 2021 from, https://www.theguardian.com/environment/2019/sep/26/greta-thunberg-teenager-on-a-global-mission-to-make-a-difference

Bielawski, A. (2020). Educating for Water Resilience in the Context of Climate Crisis. *Journal of Sustainability Education, Special Issue on Water Resilience, March 2020.*

Bradbury, H. (Ed.). (2015). *The Sage handbook of action research*. Sage.

Chandra, V. (2016). Young People's Experience and Understanding of Climate Change and Natural Disasters in India. In *Third ISA Forum of Sociology (July 10-14, 2016)*. Isaconf. Accessed September 3, 2020 from, https://isaconf.confex.com/isaconf/forum2016/webprogram/Paper75337.html

Corner, A., Roberts, O., Chiari, S., Völler, S., Mayrhuber, E. S., Mandl, S., & Monson, K. (2015). How do young people engage with climate change? The role of knowledge, values, message framing, and trusted communicators. *Wiley Interdisciplinary Reviews: Climate Change*, *6*(5), 523-534.

Harriet, T. (2016). UK Youth Participation in Climate Change Decision-Making: Perceptions of the International Climate Negotiations. In *Third ISA Forum of Sociology (July 10-14, 2016)*. Isaconf. Accessed September 3, 2020 from, https://isaconf.confex.com/isaconf/forum2016/webprogram/Paper76206.html

Kriebel, D., Tickner, J., Epstein, P., Lemons, J., Levins, R., Loechler, E. L., ... & Stoto, M. (2001). The precautionary principle in environmental science. *Environmental health perspectives*, *109*(9), 871.

Lally, D., Franz, T.E. & Forbes, C. T. (2020). Undergraduate Education about Water and Climate Change: Students' Use of a Water Balance Model. *Journal of Sustainability Education, Special Issue on Water Resilience, March 2020.*

Landon Pearson Research Center. (2017). Brasser les décideurs au Québec, Les droits des jeunes et l'environnement: Rapport final de l'atelier. Accessed August 8, 2020 from, https://carleton.ca/landonpearsoncentre/wp-content/uploads/Rapport_conference_STM20Montreal202017.pdf

Martínez-Alier, J., Pascual, U., Vivien, F. D., & Zaccai, E. (2010). Sustainable de-growth: Mapping the context, criticisms and future prospects of an emergent paradigm. *Ecological economics*, *69*(9), 1741-1747.

Meadows, D. H. (1999). Leverage points: Places to intervene in a system. Accessed May 28, 2021 from, http://www.scrummaster.dk/lib/AgileLeanLibrary/People/DonellaMeadows/donellameadows.org-Leverage%20Points%20Places%20to%20Intervene%20in%20a%20System.pdf

National winners of the Stockholm Junior Water Prize 2019. (2019). *Statement from the Stockholm Junior Water Prize winners 2019 to the United Nations General Assembly.* Retrieved Jan 6, 2021 from, https://www.siwi.org/wp-content/uploads/2019/09/SJWP_Youth-statement_v3.pdf

Schmuck, R. (2006). *Practical research for change, 2nd edition.* Thousand Oaks, CA: Corwin Press, SAGE Publications.

Shepardson, D. P., Niyogi, D., Choi, S., & Charusombat, U. (2009). Seventh grade students' conceptions of global warming and climate change. *Environmental Education Research*, *15*(5), 549-570.

Vaughan-Lee, C. & Dorman, S. (2020). Learning and Teaching About Environmental Justice and the Right to Clean Water: From Flint to the Dakota Access Pipeline. *Journal of Sustainability Education, Special Issue on Water Resilience, March 2020.*

Wachholz, S., Artz, N., & Chene, D. (2014). Warming to the idea: university students' knowledge and attitudes about climate change. *International Journal of Sustainability in higher education*, *15*(2), 128-141.

Watson, M. K., Lozano, R., Noyes, C., & Rodgers, M. (2013). Assessing curricula contribution to sustainability more holistically: Experiences from the integration of curricula assessment and students' perceptions at the Georgia Institute of Technology. *Journal of Cleaner Production*, *61,* 106-116.

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