Drought Disaster Planning and Adaptation in Rural British Columbia

by

Evan Lloyd

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Supervisor: Professor Ann Dale

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COMMITTEE APPROVAL

The members of Evan Lloyd's Thesis Committee certify that they have read the thesis titled Drought Disaster Planning and Adaptation in Rural British Columbia and recommend that it be accepted as fulfilling the thesis requirements for the Degree of Master of Arts in Disaster and Emergency Management:

Dr. Ross Pink [signature on file]

Dr. Julie Drolet [signature on file]

Final approval and acceptance of this thesis is contingent upon submission of the final copy of the thesis to Royal Roads University. The thesis supervisor confirms to have read this thesis and recommends that it be accepted as fulfilling the thesis requirements:

Dr. Ann Dale [signature on file]

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Abstract

Drought is one of the more devastating climate-driven hazards across the world. Its impacts have long term impacts and can lead to degradation of access to sufficient water, food and other necessities for human life. British Columbia experiences drought on a regular basis and given the increasing impacts of global climate change on the province, it is crucial to understand how small municipalities are prepared for this hazard in the present, as well as how they intend to address the hazard in the future. This project is a multiple-case study applied methods examination of current drought preparedness and adaptation planning in the BC communities of Tofino, Merritt and Dawson Creek. Findings show that there are significant gaps in disaster and emergency plans to currently address this hazard at the municipal government level, with minimal adaptation plans for the future. Case study sites rely heavily on water restriction adherence by residents and commercial users to reduce demand in drought season. There is a universal expectation and reliance on the Provincial government to 'save the day' in the event of any major drought event, despite the Emergency Program Act which states that it is the responsibility of municipalities to identify and address their own hazards.

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Glossary of Disaster Management Terms

Adaptation: Efforts to reduce severity of climate change impacts (Burch, 2010). The adjustment of a system to changing climatic conditions and their effects, in order to alleviate adverse impacts (Papadaskalopoulou, et al., 2015, p.2; United Nations International Strategy for Disaster Reduction, 2009, pp.4).

Disaster: Any event (natural or human caused) that produces adverse impacts on a population that exceeds that populations ability to respond and recover without external aid. A disaster event may cause immediate physical harm, and/or may significantly reduce quality of life over a long period (Coppola, 2011).

Drought Disaster: Any drought driven event impacting on a population that exceeds local response capacity and requires said population to acquire external aid to sustain itself.

Drought event: Any sustained period where water levels are low but does not exceed the capacity of local response resources and thereby does not constitute a disaster. However, eventually may lead to a drought disaster.

Exposure: The vulnerability of a human population adjacent to or within the impact area of a Hazard, and the degree of severity an impact from this hazard would affect said population (Coppola, 2011).

Hazard: A natural or man-made threat whose impacts on a population may lead to a disaster (Coppola, 2011).

Hazard Level: Expressed as the function of Risk (how likely or often a hazard will occur), multiplied by Exposure (how vulnerable a population is or how severely a hazard would affect them) to determine hazard level (Coppola, 2011).

Mitigation: The lessening or limitation of the adverse impacts of hazards and related disasters. (UNISDR, 2009, pp.19)

Risk: The likelihood that a hazard will impact a population. This is often expressed in terms of percentage over a given time period, i.e. “a one in a hundred-year flood”, or “there is a 35% chance that an 8.0 earthquake will happen in the next fifty years” (Coppola, 2011).

Vulnerability: The sensitivity of a system or community to a hazard and the degree of adaptive capacity it contains to cope with adverse impacts (Adager, 2006).

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Introduction

Drought is a very complex hazard type that is driven by climate and is common in British Columbia (BC) (Etkin, 2010). In BC there are several unique geo-climactic regions that experience seasonal drought events to varying degrees. A severe drought that significantly reduces or eliminates a community's water supply would constitute a disaster if that community was unprepared to deal with such a scenario. Also, this region is not immune to the consequences of global climate change and there are numerous scientific studies that predict significant changes to BC's climate over the next century, which could increase drought hazard (Allen, Stahl, Whitfield & Moore, 2014; Cohen & Koshida, 2015; Maurer, 2010; Shanley, et al., 2015; Stewart, Cayan & Dettinger, 2004; Schnorbus, Werner & Bennett, 2012; Stahl, Moore, Shea, Hutchinson & Cannon, 2008). Understanding how BC communities prepare for and adapt to climate-driven hazards such as drought is important, if disasters from such hazards are to be avoided in the future.

There are several factors that contribute to the situation in which drought poses a hazard risk to BC communities. A recent drought event in 2015 saw several communities in BC come within several days of completely depleting their water resources due to drought and there is evidence that these conditions could become the new normal for this province (Cameron, 2016; Schnorbus, 2016). Additionally, the degree to which BC communities have integrated adaptation strategies and disaster management planning to address vulnerability to drought is not well known (Cameron, 2016). In BC it is the responsibility of municipal governments, not the provincial or federal government, to create and implement emergency management plans (Emergency Management British Columbia [EMBC], 1996). Communities can also be vulnerable to drought due to poor adaptive capacity, as a result of insufficient social, human, institutional, economic or natural resources (Wall & Marzall, 2006). For these reasons, it is important to better understand the extent to which communities use adaptive strategies to address drought in their strategic planning and disaster management plans. Understanding how prepared and adaptive BC communities are is crucial if drought disasters are to be avoided in the future.

This is a multiple case study applied research project that examines the attitudes of selected staff from the municipal governments of Tofino, Merritt and Dawson Creek in BC to the hazard of drought and analyses the extant disaster and emergency management plans that currently address this hazard, as well as adaptation capacity and planning to account for possible drought events in the future.

After preliminary research, evident gaps in knowledge led to the following primary research questions for this project:

- To what extent are small communities in British Columbia formally prepared for current drought hazard?
- What adaptive strategies do BC communities have in place to deal with drought conditions in the future?

Secondary questions include:

- Are current disaster management plans in place to account for drought, and are these plans robust or cursory?
- What adaptive capacity do communities display in their long-term strategic planning to deal with future drought hazard?
- Do communities perceive drought as a hazard that requires attention and adaptation, and is this issue a priority?
- What social, financial or physical attributes constrain, or aid, in implementing adaptation planning?

Examining both current preparedness and long term adaptation planning is necessary because drought poses both a contemporary, seasonal threat, and a potentially growing future hazard due to the possible consequences of global climate change on the region.

In this mixed methods applied research approach data was collected from primary source interviews along with a detailed review of planning documents that are publicly available from each of

the case study sites. Municipal government employees were the subjects of the qualitative interviews that explored attitudes in their community to this hazard as well as official plans to address drought events in the present and future. In addition, emergency management plans, and long term growth strategies, community planning documents and other municipal government documents were reviewed for strategies that address drought hazard in the present and future.

This project was developed based on the researcher's past experience in professional, voluntary, and academic fields, with topics directly related to drought and water security. Professional experience primarily involved dealing with one of the consequences of this hazard in a forest firefighting role with the Province of BC Wildfire Management Branch for six seasons, and often involved calculating weather conditions and different drought codes to determine fire hazard. Volunteer experience took place in Central America working with non-government organizations (NGOs), one of which involved upgrading local water infrastructure with small communities to improve the availability and quality of local water sources. Another volunteer position was a research position for an NGO advocating on behalf of sugarcane field workers in northwestern Nicaragua who are oppressed by monoculture and corporate domination of the region: these workers have suffered in shocking numbers from a mortal kidney disease that has taken the lives of the majority of the working age population in some communities, the disease linked to working conditions and specifically to insufficient access to fresh water. All of these experiences fed concern for drought hazard while broadly studying disaster and emergency management. That concern has led to a greater understanding of the immense complexity of drought hazard through the vast variety of experiences and consequences of drought that have occurred globally. This project was formed within the context of these experiences, with the knowledge that communities in BC are responsible to address and create disaster management and climate adaptation plans.

In BC the Emergency Program Act defines a bottom-up approach to disaster management, where communities are responsible for identifying, mitigating and preparing for their own hazards, be they natural or man-made (EMBC, 1996). The Provincial government holds a supporting and advising role in the creation of local hazard and disaster management plans to aid in mitigation and preparedness

initiatives and fulfills this by providing information and in some cases with funding. The federal government of Canada supports the provincial government with information on hazards through various agencies, and funding and resources when a disaster scenario exceeds the resources and capabilities of provincial governments. These roles are flexible depending on the scale of a disaster, but generally the local community authority will handle a situation if they are able, but will seek out assistance from the next level of government when they cannot, and then other relevant government levels will work to coordinate a disaster event between them. If the provincial government cannot handle a disaster then they will seek federal aid, which in turn may include requests for international, non-governmental, and private sector assistance, as the scale of the disaster increases.

The bottom-up approach places a great deal of responsibility on small communities to manage their own hazards. This situation results in a wide variety of strategies and capabilities for different communities to address their hazards. A benefit of this approach is that it allows variation in strategies to match variation in hazard, and also local solutions for local hazards are created to match the needs of distinct communities. However, one of the problems with this approach is that there is also wide variability in the capacity of communities to identify and address their hazards and adapt to new hazard conditions. It is the goal of this project to examine the extent to which the case study communities are prepared for a somewhat obscure, yet potentially devastating hazard.

My first chapter reviews both international and domestic literature to understand the scope and scale of the hazard. The next section describes my methodology and explains site selection, participant selection, as well as limitations. Chapter 4 provides a detailed introduction to each case site to provide context, along with an exploration of current drought disaster management plans and adaptation plans. This is followed by a discussion chapter to explore the implications of the data findings. Finally, Chapter 6 is the Conclusion, where remarks and recommendations are made.

Context

This chapter offers clarification on the highly complex topic of drought. It is important to review international examples of drought hazard and drought disasters to comprehend that this is a widespread hazard, and to create heightened awareness of the consequences of inaction. On this issue we must also examine scientific data and climate predictions for the world, Canada, and BC, as this slow-onset hazard is driven by climate (Coppola, 2011). Finally, it is important to have an understanding of disaster management and adaptation planning in small municipalities, and why best practices in these fields are critical for hazard reduction. This will provide useful context for more detailed examination of the case study communities in later chapters.

2.1 Drought Context on the Global Scale

Drought is a highly insidious hazard, and compared to other types of natural hazards drought is very difficult to recognize and address because it has a long-term impact phase (Coppola, 2011; Zamani, Gorgievsky-Duijvesteijn & Zarafshani, 2006). A drought disaster is known as a slow-onset disaster because it does not have the sudden and recognizable impact of other well-known fast-onset disasters, such as earthquakes or forest fires; and drought impacts are often drawn out over long periods of time and across large regions, unlike tornadoes or industrial accidents (Coppola, 2011; Zamani, Gorgievsky-Duijvesteijn & Zarafshani, 2006). The process by which a drought event becomes a disaster is long and extremely complex. Due to the large temporal and spatial scale of this hazard, victims may not immediately recognize the onset or full impact on their region and therefore, drought can have a degrading impact on quality of life over very long periods, including many months, years or even decades (Coppola, 2011; Gutiérrez, Engle, De Nys, Molejón & Martins, 2014; McNeely, 2014). The slow onset and lack of recognition by drought victims can lead to the degradation of the social, economic and cultural fabric of a society and these impacts can be extremely challenging to reverse (Zamani, Gorgievsky-Duijvesteijn & Zarafshani, 2006). Severe or long-term drought may also result in

disintegration of social order and conflict over access to basic amenities such as food and water (Femia & Werrell, 2012; Zamani, Gorgievsky-Duijvesteijn & Zarafshani, 2006).

Drought disasters are some of, if not the most devastating climatological disasters anywhere in the world (Guha-Sapir, Hoyois & Below, 2014). The World Economic Forum's Global Risks report stated that "global water crises – from drought in the world's most productive farmlands to the hundreds of millions of people without access to safe drinking water – are the biggest threat facing the planet over the next decade" (2015). Many of the most significant international drought disasters have caused secondary, or cascading disasters. These include cases of irreversible desertification, widespread famine, and mass population migration leading to civil conflict (Bandyopadhyay & Shiva, 1986; Coppola, 2011; Couttenier & Soubeyran, 2014). There is probably no more significant example of civil strife in the modern world than the Syrian Civil War. There is clear evidence that one of the main social stressors that lead to the conflict included major droughts in Syrian agricultural areas which forced large population movements in to urban areas, and exacerbated tensions in the urban setting in the period preceding the Arab Spring demonstrations (Femia & Werrell, 2012; Gleick, 2014). The drought event was exacerbated by government mismanagement of water resources, which also contributed to social unrest (Femia & Werrell, 2012).

These are examples of worst-case scenarios, but other contemporary examples of significant drought events in the developed world can be found in the United States, Cyprus and Australia (Papadaskalopoulou, et al., 2015; Hunter, Grey & Edwards, 2013; Cook, Seager, Cane & Stahle 2007; McNeeley, 2014).

2.2 Scientific Context of Drought in Canada and BC

There is a large body of scientific research that suggests droughts and water scarcity are becoming more common and severe worldwide as a result of climate change (Mekonnen & Hoekstra, 2016; Schnorbus, Werner & Bennett, 2012; Engle, 2013; Gutierrez et al., 2014; McNeely, 2014).

Droughts have occurred regularly across the vast geographic region of Canada throughout recorded history (Bonsal et al., 2011). In modern times, the vulnerability of this nation to this disaster type has not waned. Canada's most recent significant drought event occurred between 1999-2005 (Bonsal et al., 2011; Stewart, Pomeroy & Lawford, 2011; Wheaton, Kulshreshtha, Wittrock & Koshida, 2008) and produced some of the driest conditions on the Canadian Prairies since records have been kept. As with the most recent national scale drought (1999-2005) significant drought in any area of the country can have devastating consequences for the entire nation (Bonsal et al., 2011; Stewart, Pomeroy & Lawford, 2011; Wheaton, et al., 2008; Wilhite, Svoboda & Hayes, 2007). Drought in Canada may result in reduced agricultural production, environmental damage, increases in wildfire scale and intensity and a variety of health issues for vulnerable communities, amongst other risks (Macias Fauria, & Johnson, 2008; Stewart, Pomeroy & Lawford, 2011; Wheaton et al., 2008; Wilhite, Svoboda & Hayes, 2007). Other trends include changes to the amount, timing and distribution of water due to climate variability (Cohen, Koshida & Mortsch, 2015). It is impossible to fully predict future weather events but most scientific models dealing with further climate changes predict increases in the weather scenarios that lead to drought across Canada (Bonsal et al., 2011). The risk of drought is high in Canada because the likelihood of droughts is common and the consequences are significant (Stewart, Pomeroy & Lawford, 2011).

The province of BC is not immune to this trend and a considerable amount of data indicates that over the next 50 years meteorological and hydrological sources of water could shrink in this region (Schnorbus, Werner & Bennett, 2012). There are indications that precipitation may increase on an annual scale in certain regions, but become more seasonally extreme, with winter months seeing large increases in precipitation and summer months seeing decreases from current averages (Lerner, 2011). Peak streamflow timings are moving earlier in the year in many locations across BC (Stewart, Cayan & Dettinger, 2004) and precipitation in the near future is more likely to fall as rain instead of snow, meaning reduced summer snow packs and subsequent reductions in summer stream flows (Etkin, 2010). Glacier runoff has already passed the initial phase of increased runoff due to the warming climate (Stahl & Moore, 2006) and even evaporation is increasing to significant degrees (Fernandes, Korolevych & Wang,

2007; Cohen, Koshida & Mortsch, 2015). All climate data for future trends in BC indicates significant changes from present average conditions, and this will have a direct impact on hydrological systems and drought hazard (Lerner, 2011; Shanley, et al., 2016; Allen, et al., 2014; Fernandes, Korolevych & Wang, 2007; Stahl & Moore, 2006).

There is a significant amount of accumulated data for the Clayquot Sound region surrounding Tofino and the future of its water sources, that is unambiguous regarding drought hazard. Lerner (2011) estimates that summer drought frequency will increase in the Clayoquot Sound region between 15% and 46% over the next century. Coulthard, Smith & Meko (2016) found the dendrochronology record measuring climate variations using tree-core sampling showed 'worst-case' drought scenarios for south-coastal BC to be more severe than those previously predicted by hydrology low-flow models for the last 350 years. Other sources indicate that summer stream flows for the coastal BC region will decline over the coming years, and that despite predictions of increased annual precipitation that precipitation will more often fall as rain in winter than it has in the past or does currently (Shanley, et al., 2016).

Merritt has related but variant issues. A number of academic sources offer significant insight into likely future scenarios for climate change and drought in BC, southern BC in particular. Allen, et al. conducted a review of groundwater trends for approximately thirty years up until 1999, results showing that groundwater levels appear to be decreasing both in Merritt and province-wide (2014).

> Over the longer term, climate change is expected to have major regional effects on air temperature, precipitation, evapotranspiration and, ultimately, runoff. Changes to these key hydrologic variables can also be expected to influence groundwater recharge (Allen et al., 2014, pp.3).

Predictions such as these hold significant implications for communities relying exclusively on groundwater sources like Merritt. Another factor that could influence future trends in Merritt arises from

the type of aquifer utilized. The primary aquifer for Merritt is quite shallow, four of the total of five city wells drawing from it at about 100 feet below ground. Alley, Reilly and Franke pointed out that shallow "surficial aquifers… are likely to be the part of the groundwater system most sensitive to climate change" (1999, pp.21).

2.3 Adaptation vs Mitigation

One main objective of this project is to discover the degree of adaptive capacity displayed by the case study communities to account for the drought hazard that they currently face. Adaptive capacity is defined as the demonstrated or planned for capability of a community to plan for possible changes in climate and to respond to the impacts of such changes (Papadaskalopoulou, et al., 2015). Discovering the extent of adaptive capacity to drought hazard in the case study communities is important because it provides a clear indicator of the potential for these communities to overcome impacts of drought hazard.

Adaptation is defined as "the adjustment of a system to changing climatic conditions and their effects, in order to alleviate adverse impacts" (Papadaskalopoulou, et al., 2015, p.2). To account for the potential future growth of drought hazard and the hurdle this presents to community viability in the decades to come, sound adaptation planning is required (Picketts, et al., 2012). The National Municipal Adaptation Project (NMAP) survey found that concern amongst small communities was very high but that they also had the lowest rates of adaptation planning, compared to larger communities (Hanna et al., 2013, p.10). Adaptive strategies are often viewed as disruptive and expensive, so strategies considered mitigative are preferred. The definition of mitigation is provided by the UNISDR as "the lessening or limitation of the adverse impacts of hazards and related disasters" (2009, pp.19). Examining the extent of adaptation planning compared to mitigation strategies is necessary to fill gaps in knowledge regarding current plans and actual capacity of communities to adjust to a changing climate, and through this adjustment reduce their vulnerability to the hazards that such change presents.

To deal with the contemporary or present hazard, the common approach in many small Canadian municipalities involves mitigation tactics that stave off severe hazard impacts (Hanna, et al., 2014).

Mitigation tactics are characterised by their low cost, easy implementation and low impact on day to day life (Coppola, 2011). Mitigation tactics may also be preferred when a hazard is not considered to be significant, or a community does not think it is highly vulnerable, as is sometimes the case with drought due to the insidious nature of the hazard. Despite this mitigation bias, adaptation strategies should be considered in their place as best practice for reducing vulnerability to climate-driven hazards for reasons that will be explored below.

The focus on adaptation, instead of mitigation is important because although the two concepts are closely linked, there are important differences between them (Hanna, et al., 2013; Picketts, et al., 2012). The main difference between the concepts is the mindset towards the active agent, which in this case is drought hazard. Mitigation describes actions that are taken to lessen the ability of the hazard to reach its full potential of impact, while allowing the affected community to continue functioning with its status quo of activities, plans and infrastructure. While this approach seems sound, it should only be acceptable if a hazard is legitimately manageable and impacts are reversible, with no significant increases in future condition of the hazard anticipated. Mitigation is particularly appropriate for fast-onset hazards (Coppola, 2011), but not as appropriate for climate-induced slow-onset hazards, as these hazards indicate long-term or permanent change in standard conditions. Adaptation, especially in the context of climate change-related hazards such as drought, is a more mature and sound policy because it requires consideration and acceptance of new conditions and a reconsideration of the old plans and strategies.

But what are adaptation actions and how are they different from mitigation actions? A hypothetical example of the difference between mitigation and adaptation can be found by considering communities who build dykes to mitigate flooding versus communities with houses on stilts that have adapted to flooding. The difference between the two examples may seem slight but it is important and can be explored by asking ourselves what happens to the community behind the dykes if the floodwaters breakthrough or overcome the dykes? The answer is that a flooding disaster will almost certainly occur because the houses themselves are not built to handle floodwaters. Those same floodwaters may not impact the community with houses on stilts to the same degree, although smaller losses might be incurred

regardless. Therefore, with the adaptive approach a flood-induced disaster can be avoided. In short, mitigation defines short-term strategy to prevent change to the status quo, while adaptation defines long-term strategy that accepts new realities.

Measham, et al., discovered five core constraints to adaptation planning at the municipal government level: leadership, competing priorities, planning process, lack of information, institutional limitations, and resource constraints (2011). These constraints were examined in the context of climate change adaptation emerging as a local responsibility in municipalities in Australia, due to the realisation that climate impacts are experienced at the local level (Measham, et al., 2011). Each of these constraints was echoed in some way in the research gathered for this project, either directly stated or indirectly implied in the interview data, or evident in the literature on planning processes. The most significant constraints involved a combination of lack of information, competing priorities, and resource constraints. Another observable constraint is a lack of coordination between those responsible for strategic planning, land use planning, and disaster management planning (Measham, et al., 2011). Adaptation occurs when communities overcome these constraints and perceive new circumstances in which hazards are real and present, and they take action to allow the coexistence of community and hazard agents by reducing risk and exposure.

Methodology

3.1 Research Design

This qualitative research used a multiple case study approach to analyse municipal government policy and literature to answer the above research questions. Sherman and Welb (1988) point out that qualitative researchers seek to understand the meanings people construct. "In contrast to quantitative research, which takes apart a phenomenon to examine component parts (which become the variables of the study), qualitative research can reveal how all the parts work together to form a whole." (Sherman & Welb, 1988, p.6).

Qualitative research uses a variety of interpretive research methodologies and is based on the phenomenological paradigm (Merriam, 1998). To support the of use a case study approach, Merriam (1988, p.19) states, "A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation." Yin (1994) states that case study is particularly suited to projects in which separating context and the phenomenon's variables is impossible. Cohen & Manion also support the advantages of case study research and point out that "their particular strength lies in their attention to the subtlety and complexity of the case in its own right" (1994, p. 123). Case studies provide researchers with the ability to understand the inherent complexity of social truths. Cohen & Manion (1994) also state that case studies are a 'step to action' as their insights may be directly interpreted and put to use as they allow readers to judge the implications of a study for themselves. This makes case studies particularly valuable to applied research projects such as this one.

Interviews were structured to be standardized, open-ended interviews, which means that all interviewees were asked the same open-ended questions and then themes and discussions were explored covering both facts and meanings (Kvale, 1996). This enabled comparison between the interviews to be conducted and interpreted which was useful in the multiple-case study approach, where similar themes were explored in different contexts (Kvale, 1996).

Document analysis was conducted on the literature gathered for each site. "As a research method, document analysis is particularly applicable to qualitative case studies" (Bowen, 2009, pp.3). This is a qualitative method that requires data to be examined and interpreted in order to elicit meaning (Bowen, 2009). This approach was important for the type of documents under review, which were municipal plans for drought response and adaptation. This approach is commonly used as a method of triangulating qualitative data to ensure credibility of the findings, which makes it a suitable method to pair with the interview method used here (Bowen, 2009).

3.2 Limitations

The identification of communities that were suitable research sites was complicated and challenging. There are several communities in B.C. that have very recent exposure to drought and who came within weeks of completely running out of water in the most recent drought of 2015 (Cameron, personal communication, February 17, 2016). The identity of communities who experienced this is not publicly available and so selecting possible case study communities and determining their suitability as research locations presented some challenges. For example, extended contact and discussions were held with a community that ultimately did not wish to engage in this research, due to what appears to be an absence of official consideration of the topic in spite of recent direct experience with drought hazard. This reluctance was discovered through extensive communication with various members of the municipal government who were sought out as possible research participants. The statements explaining this were that the community had no contingencies for the topic hazard and so had nothing to offer this project.

Other possible research sites were contacted, but no response was received to inquiries or requests for participation in this project. A simple conclusion to be drawn from this is that these communities have no plans in place or consideration for drought. If this is accurate, this presents a serious and negative implication for these communities if faced with severe drought in the present and future.

A further constraint is the small sample size of the interview data. This was due to the small number of individuals in each case study site that were able to speak on the topic. This issue was alleviated by combining this data with available literature produced by the case study communities on the topic and closely analyzing this literature to corroborate interview data and to expand that narrative of each site on the topic. It was not within the scope of this project to include more case study sites, and this directly limited the number of possible interview participants.

One inherent constraint of the document analysis method is that there is potential for low volumes of retrievable data due to intentional blocking (Bowen, 2009). This project may have been subject to this, as the target documents for data collection were drawn from publicly accessible sources. This constraint was intended to be alleviated by discussing the topic with participants who would have knowledge of

documentation not publicly available, but the researcher was not made aware of any such documents by participants.

3.3 Research Sites

The case study communities that agreed to participate had established municipal government structures and this resulted in exploring the suitability of communities with a population between 2,000 and 10,000 residents. It was assumed that communities of this size could provide interview participants that had the ability to observe impacts of drought hazard at the societal level, and not just the household or neighborhood level (Keshavarz, Karami & Vanclay, 2013). Although understanding drought impacts at various scales is important, a goal of this research project was to understand how adaptation and drought preparedness interact in small self-determining municipalities, and so communities of a minimum size were of interest. Research was conducted to identify appropriate communities and then contact was made with the relevant municipal governments to identify participants.

The towns of Dawson Creek, Merritt and Tofino provide a geographic cross-section of BC and provided a variety of drought impacts and planning methods to be studied. Preliminary research suggested that these were suitable research locations due to their experience with drought hazard and their level of community organization regarding water management. However, further research was required to study the suitability of these sites and the success of making research contacts was a significant determining factor in site suitability.

3.4 Participant Selection

Within the identified communities purposive or selective sampling was used to identify key actors for the interview phase (Coyne, 1997). This identified research participants who fit "a preconceived, but reasonable initial set of criteria" (Coyne, 1997, pp.628). The intent in this research was to select participants with professional knowledge of municipal drought preparedness planning. This type of sampling is very common in qualitative research, and further can be argued to be crucial to the success

of qualitative study (Coyne, 1997). Snowball sampling (Noy, 2008) was then used to identify additional potential interviewees who should be sampled. These sampling methods were sufficient to provide a small, yet appropriate set of research participants for data collection. Ultimately, each research site yielded two interview participants, six in total, which was deemed a sufficient number due to the very specific topic and the small staffing sizes of the municipal governments involved.

3.5 Methods and Analysis

The theoretical framework for this research project is based on the social constructivist approach. With this approach, "individuals develop subjective meanings of their experiences" which in this case is how prepared for drought is their municipality (Creswell, 2014, pp.6). This approach allowed for the examination and interrogation about how subjects give meaning to their lived experience with the interaction with drought as a central component of this (Denzin & Lincoln, 2011).

The research incorporated three phases. The first phase involved a literature review and document analysis into the current drought and emergency plans for the three municipal case studies in rural BC, as well as an examination of current and future climate trends for the region of BC in which they are situated. The second phase involved semi-structured, open--ended interviews with civil planners and municipal government officials for each case study site. The third phase involved data transcription, theme coding and analysis to illuminate common themes and findings. This last phase revealed some similarities and differences between the case study sites, and the essential data for answering the research questions. It is intended that the research findings will provide valuable information for other drought-vulnerable communities in the province and elsewhere.

As mentioned, the first phase focused on research into publicly accessible data from the local governments regarding drought management and disaster preparedness planning, along with an examination of the regional climate trends. This information provided an initial picture of current planning and adaptive capacity across the different case study sites. The data from this phase was then used to inform the creation of interview questions for the second phase of research.

In the second phase, interviews were conducted with civic officials responsible for water management and emergency planning in their community. Ethical approval for these interviews was obtained from Royal Roads University based on an approved Request for Ethical Review for Research Involving Humans. Half of the interviews were conducted face-to-face, while distance required the others to be conducted via telephone. These interviews explored participant views on drought preparedness in their municipal government, the adaptive nature of this preparedness and the social attributes of the community that helped or hindered adaptive capacity. Interviews were open-ended with standardized questions, in order to draw out understandings and to explore them in depth. This was done by transcribing the interview recordings and then conducting cross-comparison of the transcriptions for topics and themes. The intent was to gain a clear picture of the current consideration and preparedness for the hazard across BC, in order to inform a report that describes and explains this state.

Document analysis was the focus of the third phase of research. The interview data was transcribed from audio recordings and along with notes from the interviews, was analyzed for relevant patterns, themes and discrepancies. Themes were drawn out from the transcripts and notes to provide the analysis of the data with clarity and structure. Data from the first phase of literature review was then compared with that from the second phase of interview data and analyzed to reveal significant findings. Despite the complexity of the topic and the uniqueness of each case study site and situation, a specific narrative was clearly evident in the data from the research sites. The importance of these findings is discussed in subsequent sections.

Case study description

4.1 Case Study Introduction

Three case communities were selected Tofino, Merritt, and Dawson Creek, situated respectively in the South Coast, Central Interior, and the Northeast regions of the province. Due to the wide geographic separation, each community has a unique outlook in predicted climate models and each

community has unique experience and vulnerability to drought hazard. This provides a limited cross-section of drought-affected municipalities in BC.

4.1.1 Tofino

The first case study site is Tofino, BC, a town of approximately 1,930 residents located in Clayoquot Sound on the western shore of Vancouver Island (Statistics Canada, 2017). This coastal community is adjacent to Pacific Rim National Park and experiences a large influx of seasonal residents and tourists each summer visiting the town and the surrounding area.

Potable water for the town of Tofino is supplied by four streams on nearby Meares Island, across a short marine channel from Tofino. Water is transported to Tofino by underwater piping from reservoirs on the island. This surface water source is exclusively based on precipitation, as there is no annual snow pack accumulation on Meares Island to feed the system in warm months. Tofino's water source therefore is inherently vulnerable to seasonal drought, as summer months often see extended periods without rainfall (Lerner, 2011).

Tofino's recent experience with drought conditions includes the summer of 2006, when severe water restrictions were required and potable water had to be trucked into the community from external providers to meet local demand and to keep businesses open (Dodds, 2012). The data shows that as a result of that experience there is high public awareness of drought concerns and strong adherence to water restrictions by community members. This is driven in part by the community's reliance on tourism to drive the local economy, and the fact that this industry is severely impacted by water restrictions and sustained drought (McDougall, 2016).

Drought hazard in Tofino is driven by seasonal hydrological change, resulting from multiple consecutive days without precipitation in summer months in conjunction with sharp increases in local water demand during the driest part of the year.

4.1.2 Merritt

The second case study site is the city of Merritt, located in the Southern Cariboo region of south-central BC in the Nicola Valley, with a population of approximately 7,140 (Statistics Canada, 2017). Merritt is located directly to the east of the Coast Mountain Range within its rain shadow. The Official Community Plan (OCP) states that the town has a dry semi-arid desert climate with minor snowfalls in winter and hot temperatures in summer.

Merritt is positioned at the confluence of the Coldwater and Nicola rivers, but the city's primary water source is a shallow subsurface aquifer drawn by four wells, with a secondary deep aquifer with one well serving as a back-up source. The surrounding area is predominantly agricultural range land, with several private wells drilled in to the local groundwater sources. Merritt's reliance on groundwater aquifers is unique in this study and, offers an opportunity to examine issues for groundwater-reliant communities and drought hazard.

Drought hazard in Merritt is driven by the aridity and low annual precipitation of the surrounding environment, in conjunction with demonstrated high water usage and limited adherence to water restrictions by many residents, which is evident in the data. Recent experience with drought in Merritt occurred in 2012, when the Coldwater River ran so low "you could walk across and not get your ankles wet", although this event did not significantly impact daily life due to the high storage capacity of the local aquifers.

4.1.3 Dawson Creek

The third case study community is the City of Dawson Creek in northeastern BC, a community of approximately 12,180 residents (Statistics Canada, 2017). Dawson Creek procures potable water from the Kiskatinaw River watershed, a tributary of the Peace River gathering water from territory covering roughly 2800 square kilometers. The headwaters of the Kiskatinaw at Bearhole Lake are about 170 kilometers from Dawson Creek, while intake pumping stations are about 20 kilometers from the city, with several raw water reservoirs and a treatment plant involved in the system.

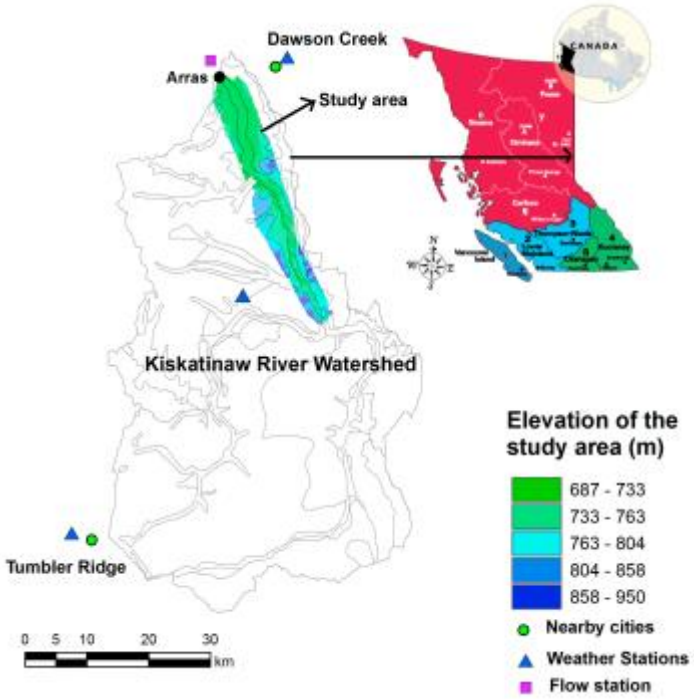

Figure 1. "Digital elevation map of the study area and its location in the Kiskatinaw River Watershed as well as in the Peace Region of British Columbia, Canada." By Saha, 2015 is licensed under CC BY 4.0

Dawson Creek is a community with extensive and recent experience with drought hazard. The data indicates that there were significant drought events in each of the past three decades, including two recent events this decade in 2012 and 2015, with an earlier very severe event occurring in the early 1990s. These events are considered severe due to the range of actions required to address and mitigate the hazard impacts. The well-known presence of drought hazard, has led to substantive initiatives by the municipality to address water quality and quantity concerns. The local government deals with three key stakeholders in the region regarding water: the public, a prominent oil and gas sector, and the provincial government. The data shows that issues of water quality and quantity are a serious concern for all three.

The data indicates that drought hazard in Dawson Creek is driven by hydrological drought that creates low water levels in the Kiskatinaw River, along with poor adherence to water restrictions by residents. In addition, the oil and gas industry uses very large amounts of water for its operations, putting added pressure on local water supplies.

4.2 Current Drought Disaster Management Plans and Analysis

The first of two primary focuses of this study is on *municipal planning and adaptive capacity to address current drought hazards.* All three case study sites have had recent experience with drought events, and based on climate models will experience them again. How these communities have thus far planned to address the hazard is an important question. There was a notable drought event in 2015 that raised widespread concerns about municipal preparation and future planning for drought in the provincial government, as some communities came very close to running out of water at that time. This event brought into sharp relief the strong presence of drought risk in many areas of BC, and assorted degrees of preparedness. Three case study sites were selected to serve as a snapshot of that heterogeneity.

4.2.1 Tofino

The District of Tofino "Water Shortage Response Plan" outlines responses to drought conditions with a focus on mitigative conservation of supply strategies, to be enacted at each stage of water restriction. There are brief but fairly thorough descriptions of municipal-level responses at each water use restriction stage, and mandatory water use strategies for residents and businesses in order to reduce water demand by users. This document is the most significant source of current information on drought response, its content formed through Tofino's experience with drought impacts, and provides a clear indication that this municipality is reliant on mitigation strategies to handle drought hazard.

The main concern that arises about the "Response Plan," is that it has not been exercised or updated since its creation in 2009. In the absence of exercises, municipal employees may not be thoroughly clear on roles and responsibilities during drought events, and this issue could be compounded by employee turnover since the last drought event in Tofino when actions outlined by the plan were last used. Regular updating and exercise are basic principles of sound disaster management and evidence in the data for these practices in support of this Plan is lacking. The plan includes contact information for

various water suppliers, but these contact numbers may or may not be current and the data shows that this status is unknown.

A second hazard response-oriented document for Tofino is the District's "Emergency Response and Recovery Plan", which lists various hazards including terrorism, public disturbances, and hazardous materials exposure events, but does not include drought despite the fact that this is a hazard that the community has actually been exposed to, unlike some of the other hazards listed. This plan comprehensively details incident command roles and responsibilities in the event of a fast-onset disaster, and would be a useful framework for event management if drought impacts were to lead to a disaster scenario. However, the interview data indicates that if a major drought were to occur, the municipality would quickly declare a State of Emergency and request the Provincial Government to step in and take management of the situation, thereby negating the usefulness of this plan in a drought scenario. This admission defies the legislated roles and responsibilities outlined in the BC Emergency Program Act, but also implies an understanding of the devastating potential of a full drought disaster to overwhelm the community.

Another relevant document is the "District of Tofino Water Systems Emergency Response Plan," last updated in 2012. This plan primarily includes contact information for various stakeholders and private water purveyors in the region, and a brief list of actions to be taken in loss of water supply scenarios. Yet again, interview data revealed that these contacts have not been updated or verified recently, and doing so is not high on the local emergency management priority list.

One major municipality-led initiative that indicates adaptive capacity to drought risk in Tofino has been the installation of stream-level measuring instruments on Meares Island to monitor stream flows that feed the town's reservoirs. The data is collected daily, in low-flow months, and the system has been in place for about four years. Streamflow data is collected to provide the municipality with a better understanding of water supply levels and demand in various climate conditions, and for a data set of variations over longer periods of time. Stream level monitoring also serves as an early-warning tool, influencing the enactment of water restriction regulations imposed by the municipality to address water

shortages in the summer months. These restrictions are also enacted as advised by the provincial government when it communicates measured drought levels to municipalities. The municipality closely follows provincial government recommendations for drought stage levels, and enacts water restrictions to match each stage in order to reduce demand.

The municipality is also involved in regional mutual assistance agreements due to the limited resources available to a small community. These agreements have been relied upon in the past when water was trucked in from the neighbouring community of Ucluelet, where the primary potable water source is a groundwater aquifer. This approach can be counted as one of the few truly adaptive strategies displayed by Tofino to account for drought hazard.

Tofino relies on source stream-level monitoring, strong public and private sector adherence to water restrictions, and strategies outlined in the "District of Tofino Water Shortage Response Plan," to manage drought impacts. Past emergency responses to severe drought impacts have focused primarily on reducing demand by shutting down tourism operations, placing heavy water restrictions on public consumption, and trucking in water from neighbouring communities through private suppliers. A major drought event would necessitate bringing in water from external sources, most likely private sector water suppliers. The data clearly states that the municipality would also quickly declare a local State of Emergency and ask the Provincial government to step in and manage the event. These strategies remain the core of current plans and are certainly reactive and, at best, mitigative solutions to drought hazard.

4.2.2 Merritt

The city of Merritt focuses almost exclusively on minimizing demand and conservation of supply to account for drought hazard. This community is able to rely on these strategies due to the large storage capacity in the aquifers supplying the city. Groundwater sources are less susceptible to seasonal drought than surface water sources; still, aquifers and groundwater are not immune to drought (Alley, Reilly & Franke, 1999; Peters, Van Lanen, Torfs, & Bier 2005). In addition, the research showed that the city closely monitors water volume in its wells and alarms are triggered if levels fall below certain thresholds.

The water utility for Merritt strives to maintain storage capacity at or above 60%, primarily as an asset in case of interface wildfires, which are a hazard in the area.

Groundwater aquifer sources have specific attributes that can reduce a community's concern for drought hazard and negate strategies to deal with drought impacts (Alley, Reilly & Franke, 1999). One benefit from utilizing ground water sources is they often hold very large quantities of water. Second, they are less susceptible to evapotranspiration and other hydrological drought impacts or fluctuations that can affect surface water sources (Allen, et al., 2014; Peters, et al., 2005). Some aquifers like Merritt's are recharged through the filtration of riparian water through sand and soil deposits, producing large underground reservoirs benefitting from that natural filtration (Allen, et al., 2014). However, filtration aquifers often have very slow recharge rates, and if drawn down to low levels a lengthy period of time may be needed for the aquifer to recharge, even with new precipitation (Peters, et al., 2005; Alley, Reilly & Franke, 1999). Allen, et al., have reported that the shallow aquifer in Merritt is closely dependent on surface water, which itself is heavily dependent on precipitation in the fall and snow melt in the spring (2014). This aquifer is the primary source for the city and its level trends only lag behind the local surface water level trends by approximately one month (Allen, et al., 2014). Therefore, despite the robustness of ground water sources, the shallow location and sensitivity to surface fluctuations of this particular aquifer indicate that this source may be more susceptible to drought than is currently considered.

The data tells us that there are very high water usage statistics for residents in Merritt, compared to the national average. This could be an indication that the water source is not well understood by residents, and some may not view it as a finite or delicate resource. One possible factor is that groundwater sources are not visible to users and this can, at times, lead to limited understanding of the impact of high water use on the water source. Alley, Reilly & Franke (1999) noted several cases in the United States where lack of understanding and over-use of groundwater sources lead to increased depletion in drought conditions. Merritt could face a similar situation, whereby if a drought event occurs, or as it is occurring, the continued high water use by local residents could exacerbate, speed up, or prolong the drought impacts.

The provincial government maintains a monitoring well on the city's main aquifer, and data from it has shown a slow but steady decline in water quantity in recent years (Allen, et al., 2014). The interview data indicates that this is not an immediate concern, although it may present an obstacle to future development. Given that its aquifers are slow to recharge and that this source is fed by the rivers in the Nicola watershed with flows that may become less consistent, Merritt faces a real possibility of significant drought hazard in its future. If high use combines with a slow recharge rate over an extended dry period, a seemingly inexhaustible water source could be at serious risk.

Despite awareness of water source decline at both the municipal and provincial level, no consideration of drought as a serious hazard to Merritt exists in current disaster and emergency management documents. Without dedicated disaster or emergency response plans to address the impacts of drought, Merritt may be forced to rely upon the provincial government to advise and assist in the case of any drought event. However, this is not the way disaster management roles are structured in BC, as outlined in the Emergency Preparedness Act. Additionally, there is evidence in the data of a weak relationship between the city and its residents with regards to residents' poor adherence to water restrictions. This is an indicator that the attitudes and actions of residents may hinder the municipality's ability to manage the adverse impacts of a major drought event.

4.2.3 Dawson Creek

Despite considerable concern about watershed management in Dawson Creek on the part of some residents and the local government, there is a complete lack of planning for drought as a hazard in the city's emergency management plans. Data acquired from participants responsible for creating, updating, and implementing local emergency plans, indicates that drought is not identified as a hazard in disaster management planning for the city and is not a hazard worthwhile of such consideration. "When we did our hazard risk and vulnerability assessment, drought wasn't one of the things that even came up in conversation. Because it's never been an issue. I mean there has [sic] been times where it's been a really dry year where we have had to have water restrictions on. But it's never been a 'uh oh now what do we

do'." Thus Dawson Creek has no official plans for severe drought or for a significant decline in water supply. Interestingly, this perception of drought hazard exists in stark contrast to information from other data sources from this case site, which state that minor drought events occurred as recently as 2015 and 2012.

Dawson Creek does closely monitor the Kiskatinaw watershed through a variety of institutional and structural assets, including paid staff dedicated to watershed management who engage with relevant stakeholders. The city government is aware of its available stored water, and maintains considerable storage capacity in various reservoirs and in the watershed system itself. However, despite high local confidence in the storage capacity of the city's reservoirs, Dawson Creek remains dependent upon a solitary natural water source, one that has proven prone to drought events.

There is little evidence of comprehensive planning for drought contingencies in related official community planning documents to compensate for a deficiency in planning for this hazard in the emergency management plans. The "Potable Water System Emergency Response Plan" includes one brief page on loss of water supply. In this plan, "Actions Required" are: 1) investigate the cause, 2) inform the Water Resource Manager to receive instructions, and 3) advise important contacts of the situation. "Discretionary Actions" include releasing water from the headwater reservoir, implementing water restrictions, communicating with upstream stakeholders, using secondary storage, and investigating secondary sources as needed. This document was written primarily as a quick reference guide for municipal utilities employees, with the section on water supply loss merely the first of twenty listed water system concerns. It provides no great details on how to conduct these actions and certainly does not include provisions for enacting city-wide disaster or emergency responses to a loss of supply due to drought in Dawson Creek.

The "Kiskatinaw River Watershed Source Protection Plan" focuses on contaminants as the primary threat to the water supply for Dawson Creek. There is a brief mention of water quantity as an issue, but it is clearly not considered a significant hazard as it is not elaborated upon in detail. An explanation for this, is that the likelihood of a loss of supply due to drought is considered very low in the

document – although consequences from such an event are listed at the most severe risk level, "catastrophic." In 2007, predictions involving climate change offered mixed messages regarding drought risks and impacts. One important example was considering the impact of Mountain Pine Beetle (MPB) epidemic, then understood to present a threat of a massive die-off of trees in the Kiskatinaw watershed. MPB was predicted in this plan to lead to potential *increases* in available surface water due to reduced water retention of dead forests – a near-complete misunderstanding of the role that living forests play in providing water over time to watersheds. Drought events in 2012 and 2015 demonstrated, unsurprisingly, that MPB impacts upon the watershed have not reduced the drought hazard to Dawson Creek.

4.3 Adaptive Planning and Strategies

The second key focus of this study is on *municipal adaptation planning to address future drought hazards.* Etkin states that "droughts are infrequent enough in most parts of Canada that they're usually not included in long-term disaster management plans" (2010, p.44). However, all three case study sites are subject to specific climate data that indicates potential for increases in occurrence and severity of drought events. How these communities plan to address this hazard through adaptive strategies is important to explore.

4.3.1 Tofino

The town of Tofino has seen significant growth in recent years, a 28% increase in its permanent resident population between 2001 and 2011 (Statistics Canada, 2011). This has led to greater local consideration of a need for more secure water supplies in the future. The "District of Tofino Water Conservation Strategy" provides a plan to enhance the effectiveness of the current water system until 2020. The initially five-, now four-year strategy focuses on reducing residential water consumption, particularly through improving education and outreach to increase local adherence to consumption reduction targets. The plan also addresses reducing outdoor water consumption and improving sustainable water usage by the private sector through usage limitations and bylaws in dry periods.

The Strategy itself appears sufficient to meet its objectives within its limited timeframe, but beyond its restricted scope there is no official plan or consultation process underway to expand or to improve upon the resilience of Tofino's water supply. Research data indicates that infrastructure-improvement strategies could be undertaken, such as expanding existing reservoirs and reducing known leakage in water system piping. There are also informal considerations in the data regarding alternative sources, such as tapping groundwater supplies or exploring ocean water desalination. However, none of these ideas have had any formal process or funding to proceed beyond a concept stage. Progress appears unlikely, perhaps until pressure revives through another significant drought event, and clearly this approach demonstrates mitigation over adaptation.

The interview data indicates Tofino has strong public and private sector adherence to water restrictions, as evidenced by the successful past use of such restrictions and the notable subsequent reductions in water consumption recorded by the municipal water utility. This indicates that water management is part of the local culture and is a result of significant experience with water shortages and annual low-level restrictions enacted each summer. The latter is a mitigation tactic, but its relative success indicates that when future major drought events impact Tofino, its residents should be better prepared to deal with the consequences than citizens of municipalities less aware of the issues and necessary responses. The use of water restrictions as a strategy to reduce demand by the municipal government cannot be considered an adaptive strategy but the strong adherence by residents to such restrictions shows a social adaptive capacity to the hazard.

Private sector adherence to water restrictions in Tofino is a practical necessity, as it has been a practice in the past to shut down commercial water use when major drought events occur. The potential long term damage to the local economy, specifically the tourism sector, could exceed the direct impact of drought events, as Tofino's reputation is crucial in this industry (McDougall, 2016). Damage to the tourism sector would certainly damage the local economy, thus the impacts of drought could affect the community long after any future drought has receded (McDougall, 2016). Tofino's strong adherence to water restrictions in the private sector is further evidence of adaptive capacity to drought impacts.

Another example from the interview data of adaptive strategy to deal with future drought events is Tofino's involvement in regional emergency management initiatives that build and strengthen mutual aid agreements with stakeholders in the region. The potential benefits of this approach cannot be understated. However, adapting and responding to future drought scenarios through infrastructure and disaster management planning remains unresolved within the District. This is evident in lack of consideration by the municipality for climate data on increasing drought severity in the immediate region.

Tofino has reason to be concerned with tsunami hazard given its unsheltered location adjacent to the Pacific Ocean, the continental fault lines and its sea-level elevation. However, such an event cannot be predicted and can only partially be prepared for and responded to should one come. In contrast, drought risk for Tofino exists now, is growing, and could be substantially managed for the present and future with sufficient formal adaptation planning.

4.3.2 Merritt

The main adaptive drought strategy relied upon by the municipal government of Merritt is its focus and effort put into seasonal water restrictions. Merritt was the first community in BC, in partnership with the provincial government, to install a publicly visible drought level sign, with a rating scale similar to wildfire danger-rating signs common in BC communities (Figure 2). Merritt's drought warning sign is located on a major thoroughfare and indicates what stage of water restriction is currently in place, allowing the municipality to directly communicate water restriction levels with residents in an overtly visible way. However, the determination of water restrictions in Merritt is entirely based on generalized drought mitigation recommendations from the provincial government, which regularly communicates suggested water restriction levels to municipalities across the province in summer. The municipal government is not taking an ongoing lead role in adapting to drought hazard, but following installation of its sign relies instead on the provincial government.

Figure 2. *Merritt's Drought Level Sign*

Aside from the drought warning sign there seems to be little further evidence that drought is a hazard that the city of Merritt considers to be worth significant attention. One explanation for this from the interview data is the perception that drought is "a regional issue. Drought is bigger than us". This sentiment, along with confidence in the vast storage capacity of local aquifers, has led to a situation where there are no provisions for drought events or water shortage in long term growth planning for the City of Merritt. Climate-driven hazard adaptation planning is also absent from the long term Official Community Plan (OCP) – despite the purpose of that document to layout the plan for a sustainable future for the community.

The OCP relies on a plethora of data from resident surveys conducted to inform the "Merritt Integrated Growth Strategy". The Merritt Integrated Growth Strategy survey asked respondents to imagine how a child born in Merritt at that time would describe their community in 2030. One of the top selections was "Our community respects its natural resources including water, grasslands and wildlife". Clearly there is existing concern about water as a critical resource for the present and future health and viability of the community. Another main point in the Growth Strategy report is that Merritt residents strongly desire environmentally sustainable growth for their community. The two related points demonstrate thoughtfulness of many community members about the future of Merritt in

environmental/ecological terms, and in particular, protection of its water supply if future generations are to enjoy a good quality of life.

Despite the community's firmly stated desire for sustainable growth and maintenance of water resources, the data indicates residential water usage in Merritt is extremely high, far exceeding national and provincial household averages. In addition, research interview participants report that there is generally poor adherence to water restrictions amongst the majority of local residents. "I've had neighbours where they'll throw their hose on and my backyard becomes a swamp. Just leave it on for days and days and days. They don't care". Research shows that communities with strong social cohesion are more likely to practice water conservation techniques than those with weaker social bonds (Miller & Buys, 2008). This information suggests poor adaptive capacity at the present time to drought at the household level as a result of poor social cohesion. Instead of respecting information provided by the municipal government, interview data explains that local residents take visual cues from the local rivers and lakes to decide if water restrictions are important. "The public sees water going down the Nicola river, they see Nicola lake full, they see some water in the Coldwater river and they say 'What drought?'". When people see water flowing at any significant level in local rivers they feel justified in using copious amounts of water to wash their cars or water their lawns and driveways. However, as described, Merritt relies for its water supply on two aquifers, and although ground water and surface water are linked, the reported perception-based behaviour is problematic due to the nuances and vulnerabilities of the groundwater system. This behaviour is an indication that social aspects of adaptive capacity to drought hazard are lacking.

Consumption problems are especially acute in summer months when outdoor water use is at its peak in Merritt. Two approaches planned by the local government to moderate ground water use for long-term sustainability and to reduce immediate strain on the water system are: 1) enforcing water restrictions, and stated but not yet legislated intent to impose water usage meters on households, and 2) the recycling of water and use of grey water for agriculture and outdoor maintenance. The water utility run by the municipal government currently recycles water to the aquifer using sewage treatment combined with the

natural filtration of the aquifer system. Installation of water meters on all buildings in the city would directly tie billing to usage. It is believed by interview participants that this strategy would encourage adherence to water restrictions, both by charging money for use as well as increasing awareness at the household level of rates of consumption. Despite strong desire to enforce water metering from research participants, these initiatives are not in place and there is no current municipal legislation to do so. The intent to create such legislation is promising, but without action this cannot be counted as an indicator of sound adaptive strategy.

One example of structural adaptation to drought hazard by the municipal government is the drilling of a well in a secondary, significantly deeper local aquifer. This well opens an alternative water source for Merritt reducing its previous reliance on a single aquifer, although the new well does not diversify the type of water source the community depends upon. Merritt also demonstrates significant water conservation strategies on city government property and considerable effort is made to monitor water system infrastructure to reduce leakage and any unnecessary waste of water. Therefore, the municipal government demonstrates adaptive strategies, primarily with structural infrastructure maintenance and improvements. Publicizing such measures is a consideration for the municipal government if its intent is to establish new community norms for water usage in Merritt.

4.3.3 Dawson Creek

In Dawson Creek, local residents' concerns about the hazard of drought are mixed, and as is common in the other communities in these case studies, local government is more concerned about the issue than the average citizen. The mix of concerns is demonstrated by the low adherence to drought-season water use restrictions, which exists in the data in contrast to one major local initiative, which was driven by community residents who pushed upward for civic action to adapt to drought hazard, a push unique among the case study sites in this project. In October 2012, immediately following a major drought event that summer, a group of Dawson Creek citizens approached the municipal government to inquire about the potential to construct a new water pipeline from a new source, the Murray River, to a

community reservoir. This group of concerned citizens believed that tapping an alternate source would help to alleviate drought hazard to the community.

In response the City of Dawson Creek launched the "Sure Water" community engagement process, seeking the creation of a plan with full community consultation to address present and future water quality and quantity concerns. At the conclusion of Phase 1 the community had responded overwhelmingly to support the construction of a new pipeline which would provide water from a new source, the Murray River. This option was by far the most expensive of the four proposals offered in Phase 1 due to estimated construction costs. In response Phase 2 examined the details of possible new pipeline construction, but on a 'twin-track' continued to explore alternatives. An example of the latter was a suggestion to provide alternatives for regionally numerous fracking operations from using fresh water. Another was denying commercial water suppliers' use of municipal water sources without a formal license from the city. Concluding Phase 2, after greater scrutiny of the existing reservoir supply, the construction of a new pipeline was deemed cost-prohibitive, and a second survey showed support for that option had declined. The city decided that it would be more practical to move forward with expansion of raw water processing and storage, and with improvements to the current water system's infrastructure. Ultimately, the decision was taken to make the best of current water sources and to postpone aggressive adaptation strategies. That was despite the fact that the entire process was initiated by citizens wishing to explore creation of a secondary water source, arising from their empirically-based concern regarding existing drought hazard.

Quantity of available potable water has become a crucial consideration in Dawson Creek, quite aside from concerns regarding drought hazard that arise from (ongoing or predicted) natural processes or events. Natural gas fracking operations in the region obtain water from the same source used by the community, and they utilize enormous amounts. This has led Dawson Creek to build considerable infrastructure in water recycling, grey water processing, and raw water storage. Grey water is recycled water treated to a non-potable standard. Water recycling and grey water provide water for industrial use while protecting freshwater supplies, reducing or eliminating competition between public consumption

and private sector needs. This has been crucial to Dawson Creek and is an emphatic example of infrastructural adaptive strategy that has been pushed forward in partnership between local residents and the municipal government. The oil and gas sector provides crucial economic support to the community, and providing that sector with alternatives such as grey water allows the local economy and local water sources to remain viable; that is, with the exception of the onset of drought events, such as that experienced in 2012.

Another major concern voiced by interview participants in Dawson Creek is with water quality due to turbidity in the Kiskatinaw system. Natural contaminants are present at various times, and consequently the city employs a robust water treatment program. Source water treatment and elaborate infrastructure lend the city the potential to extract from its raw water supply with the onset of drought conditions. Raw water supplies can either be used for industrial purposes, or diverted to the potable refinement process for use by residents in times of emergency.

In addition, Dawson Creek has created and maintains dedicated resources for watershed management to coordinate with various stakeholders in the watershed and with the provincial government. This includes membership in a regional working group led by the provincial government known as the Northeast Water Strategy. This group bases its information off of provincial GIS analysis of watersheds in the region and strives to manage issues of water quality and quantity through monitoring and information sharing.

In sum, Dawson Creek displays significant adaptive capacity through its structural investments and collaboration on watershed management with stakeholders, concerned residents, and the provincial government. Weaknesses in the area of adaptive capacity are displayed through low public adherence to water use restrictions and the inaction of the municipal government to include drought in disaster management planning.

Discussion

5.1

"The very reactive nature of climate change planning, and adaptation may fit into a pattern where it is considered, or taken seriously, where an event heightens awareness or indicates vulnerability" (Hanna, et al., 2013, p.7). This pattern is certainly evident in the findings of this research project which show that adaptive capacity and adaptation planning are lacking in each case study site. Adaptation and adaptive capacity may be hindered by various constraints including small local economies, small municipal staffing levels and inadequate information collection (Measham, et al., 2011). This is evident in the strong bias towards mitigation strategies, even when adaptive strategies are pushed forward by concerned residents, as found in the examples provided by the Sure Water campaign in Dawson Creek and the survey results in the Merritt Integrated Growth Strategy.

5.1.1 Tofino

The municipality of Tofino is entirely focused on early warning, mitigation and prevention to address its drought hazard. The demonstrated adaptive capacities in the community include comprehensive stream monitoring as well as strong adherence to water restrictions from the public and private sectors. There is evidence that these approaches have been successful in the past with the implementation of water restrictions being quite closely adhered to by the local population. The adherence to water restrictions is the result of both the effectiveness of outreach and education by the municipal government, as well as recent and extensive experience with significant drought events that remain in the consciousness of the public.

Evidence of a deficiency in long-term thinking regarding drought hazard in the Tofino area, is the apparent lack of consideration for completed scientific research regarding possible future climate scenarios. A significant amount of such data exists that is relevant to the region surrounding Tofino, and it is consistently unambiguous with regard to drought hazard (Lerner, 2011; Shanley, et al., 2016). For example, Lerner, discussing future hydrologic trends and low-flow days in Clayoquot Sound, states that

"small drainages currently with limited or no snowpack potential are the most vulnerable" (2011, p.115) and Tofino relies on such a source for water. Greater consideration of the scientific research would offer the town extremely useful information that could supplement its small data collection on stream flow levels that began just four years ago. The stream flow data will become more robust over time, but it is currently insignificant considering the time scale of hydrological trends. The fact that those trends are by all indications being altered by climate change further reduces their usefulness once identified, if indeed such identification will prove possible. In short, Tofino appears to be moving with limited alacrity, clarity, and effort on a clear and present hazard to it in the form of drought.

There are a few drought-related contingency plans in the planning documents available for Tofino, including dedicated documents on the topic such as the District of Tofino 2009 Water Shortage Response Plan. Despite its qualities, the key concerning aspect of the Water Shortage Response Plan is that the data indicates that it has not been exercised or updated since its creation. The plan includes contact information for various water suppliers, but these contact numbers may not be current and the status of these suppliers is unknown.

The possession of a sound plan does not preclude the need for updates and maintenance, which are basic principles of disaster and emergency management. No disaster or hazard impact event follows pre-determined expectations, and so regular exercise and information is required to keep personnel aware and prepared to act. Having sound plans that are not practiced or regularly updated can create the potential for a false sense of preparedness, which can be compounded by personnel turnover and inexperience. A reasonable explanation for this deficiency is insufficient staffing and funding, which itself can be explained by common constraints of small communities discussed previously in Chapter 2. These constraints are an aspect of the inherent problems with bottom-up disaster management and the disparity of capacity to address hazards between communities of variable economic strength.

Contracting private water suppliers is a strategy that has been used in the past and it is heavily relied upon as a contingency for the future. This is not an adaptive response strategy as this approach would quickly deplete financial resources of the town. This reactive stance is indicative of many

approaches to disaster management and hazard mitigation in general, but especially with regards to an insidious hazard such as drought, which often takes a back-seat to other more visible hazards. Tofino provides a clear example of this.

From the data it is clear that disaster and emergency response plans to address drought in Tofino are not a priority. One explanation for this is that this is a community that faces arguably even greater disaster hazard in the form of earthquake and tsunami. Tofino is situated adjacent to a fault line where the Pacific and North American tectonic plates meet and the hazard of a local tsunami or earthquake is significant. The data shows that this hazard preoccupies the municipal government's disaster management planning to distraction, despite recent and significant drought events that have actually occurred. As discussed previously, drought is a very complex hazard to address and circumstances where other, more visceral, hazards are present can push back considerations for drought issues. This results in even progressive and hazard-conscious communities falling back on the inadequate reactive strategies of the past and this appears to be the case in Tofino.

5.1.2 Merritt

Aside from intended initiatives that focus on increasing adherence to water restrictions, the data for Merritt shows that there is little consideration for drought in either the near-term disaster management planning or the long-term adaptation planning. Data collected in this case study suggests little evident recognition in community plans of climate-related vulnerabilities inherent in shallow aquifers, or the close relationship aquifer recharge may have with surface groundwater levels. Merritt's focus on water conservation could prove to be insufficient to meet its long term growth targets, while disaster management strategies for moderate and severe drought events also require attention given their current absence.

The city of Merritt does not lead its own drought hazard strategy, as evidenced by direct statements in the interview data of the complete reliance on the provincial government to advise on all drought hazard levels. This is problematic because, as mentioned previously, each municipal government

is responsible for creating disaster management plans, and yet with drought hazard this municipality takes all of its direction from the provincial government. Within the current situation the municipality has become reliant on the provincial government for all drought-related warnings, status information, and forecasts, which perhaps has led to a lack of incentive for taking leadership of this issue at the municipal level. The significant problems with this are that it can then lead to a situation where there are unrealistic expectations or false perceptions, that the provincial government has the lead in all aspects of preparation and response related to drought.

A deeper explanation is found in the evidence that points to drought as a hazard that is not considered or addressed in the same terms as other hazards. This is demonstrated directly in the data where drought, or any type of water supply loss scenario is absent from the community emergency management planning. This municipality does not include drought in its adaptation planning and does not even pretend to take the lead on managing this hazard, in the event of a disaster.

The current social adaptive capacity situation, where residents demonstrate poor understanding to the complexity of their water source and show poor adherence to the municipal government's water restrictions, is also problematic. These issues can have potentially serious consequences if drought risk levels increase, because if residents do not respect disaster management directives when a drought event occurs they could greatly exacerbate the hazard impacts.

Data collected in this case study suggests little evident recognition in community plans of climate-related vulnerabilities inherent in shallow aquifers, or the close relationship aquifer recharge may have with surface groundwater levels. Although the groundwater source for Merritt is very large, it is not infinite, and its low visibility could lead to overuse, which would be catastrophic in a drought event. Alley, Reilly and Franke defined "groundwater mining," a "prolonged and progressive decrease in the amount of water stored in a ground-water system, as may occur, for example, in heavily pumped aquifers in arid and semiarid regions" (1999, pp.4). The term refers to groundwater systems with low or negligible recharge, thus the water is "mined" out, becoming non-viable. Merritt is not reliant on a heavily pumped static aquifer of the type to which the authors refer, but their report offers important considerations

nonetheless. Merritt lies within a semiarid region that has seen progressive, sustained declines in available potable water levels over successive decades (Allen, et al., 2014). Though these declines have not yet threatened water supplies entirely, the city should consider measures in the present to evade a future situation wherein its ground water is in effect "mined out."

This situation also demonstrates a disconnect between the desired community that the engaged residents envision for the future and the reality of contemporary practices by many residents. A significant local education campaign regarding the local ground water system and drought hazard might be a necessary precursor to any adaptation initiatives, such as enforcing water metering, to create a political climate that is amenable. This could also serve to improve social adaptive capacity to drought impacts, which could then have benefits in the context of other hazard management or adaptation initiatives.

5.1.3 Dawson Creek

Dawson Creek epitomises the drought preparedness and adaptive capacity contradictions in BC and provides a clear example of the disconnect between resource management planning and disaster management planning. The data indicates that at least one municipal government department and some resident groups are aware that drought is a hazard that they face. Despite the robust work being done by the municipality on watershed management, the fact that drought, or any water issues, are completely absent from disaster management plans is an indication that there is no coordination between the departments. One department of the municipal government is highly concerned with drought issues (and is probably a provincial leader on the topic), while another department in the same small government, that is responsible for public safety, shows a complete disregard for the hazard. There have been considerable steps taken to address this hazard, but these can mostly be counted as short term hazard mitigation strategies, while considerations for drought hazard in both emergency plans for the near-term, or action on long-term adaptive strategies have not been considered or postponed. This community knows that drought is a local hazard, and yet chooses to rely on a source that has been reliant in the past, but has the

possibility to fail in the future, especially if conditions in the climate change towards greater drought likelihood.

This community is aware of drought hazard and has residents who have expressed desire to secure a secondary water source, but cannot find the dollars or political will to do so. The contentment with putting off full-scale infrastructure adaptation for several years or decades is indicative of the inherent problems with a bottom-up approach to disaster management and the constraints to adaptation in small municipalities.

There is evidence of adaptive capacity in the form of a healthy relationship with the private sector who are major water users. This relationship is predominantly a by-product of the need to share water resources with the private sector, whose existence drives the local economy. An explanation for this relationship is that the oil and gas industry is rather young in the region, compared to the forestry sector, and there is not as much social license for oil and gas companies to disregard public concerns about an essential resource that they share.

5.2 Summary

In summarising the various definitions of adaptation, Hanna, et al. found that common themes that emerge include "anticipation, identifying vulnerabilities, integrated approaches, strategic thinking, and resiliency are some of the common threads" (2013, p.4). In addition, adaptation can include a wide range of actions and responses including social responses, economic responses and anticipatory infrastructure construction (Hanna, et al., 2013, p.4). Examples of these adaptation responses are found throughout this project and include strong or weak adherence to water restrictions as a social response, water metering plans as an economic response, and drilling or constructing pipelines to access new water sources as anticipatory infrastructure responses.

The capacity for small communities to view adaptation as the ideal strategy for disaster and hazard planning is affected if the municipal government does not perceive this as a priority, or a realistic objective (Measham, et al., 2011). Adaptation planning at the local level is generally handled by separate

departments who are responsible for strategic planning and land use planning and both types of planning are crucial because they both contribute to the creation and implementation of plans that account for successful climate adaptation strategies (Measham, et al., 2011). Without coordination between these departments creating and implementing successful adaptation plans is challenging and often unsuccessful (Measham, et al., 2011). Adding the necessity for sound disaster management planning to the climate hazard context adds a layer of necessary coordination, which is another layer of constraint for adaptation planning that is demonstrated in the case study sites. The data indicates that adaptation strategies have been avoided due to high cost, however building adaptive capacity may not always require the creation of new resources, but rather "the effective repositioning and alignment of existing capabilities and institutional and organizational systems" (Hanna, et al., 2013, p.5). Expanded thinking and greater appreciation for adaptation benefits are required for the necessary will to overcome the standard constraints for creating adaptive capacity and adaptation planning

Conclusion

Each of the communities in this study have taken some modicum of consideration for the future of their water resources and all have opted for strategies that extend the use of their existing resources for as long as possible. It seems evident that even with recent drought events that have challenged plans and resources, these municipal governments are shy about major adaptation projects that may be cost-intensive for developing alternative or more secure water sources. This is directly in line with prevailing and flawed thinking in disaster and emergency management, whereby no substantial action is taken to address hazards until after those hazards have been experienced in a true disaster event. Municipalities are content to gamble with known hazards instead of investing in preventative measures, even if those investments are adaptive in nature and will secure the future viability of those communities.

In disaster management academia the concept of *social vulnerability* holds that communities are more vulnerable to hazards if they are marginalized economically, socially or politically (Adager, 2006).

Given the concept of social vulnerability to hazards, British Columbia should be one of the most prepared and least vulnerable places on the planet. And yet, even with all the wealth and knowledge that is held here, there is strong evidence of failings in action to address hazards. Part of this must be due to a willful or blind ignorance that matches a common failing throughout the world, where communities do not take hazards seriously until they experience the worst consequences.

Sadly, drought is not a type of hazard that has short term impacts and recovery is often very difficult.. This hazard has demonstrated, on every habited continent, that its affects can be long term and devastating with significant implications for the sustainability and viability of communities. The often slow-onset of drought may beguile communities and higher governments into not taking it seriously. More visible hazards and present dangers may help them to ignore one with graver implications for health and existence on longer temporal scales. Another factor is that thinking and planning does not effectively address the future in decade scales, and there is insufficient proactive disaster planning and investment. This is certainly a factor that is evident in the field of disaster and emergency management. The cyclical, seasonal nature of drought hazard also affects proactive consideration. In places like Tofino, heavy annual winter rains make it 'obvious for any sensible person' to disregard drought as a serious hazard, yet drought conditions occur there most summers with fluctuations in some years already leading to major drought conditions.

Seasonal drought is a hazard that is present and impactful in BC. It is also a hazard that has the potential for increasing in duration and intensity based on the scientific data at hand. The scientific data does not suggest that BC will experience less precipitation on an annual scale; this data does very clearly indicate that the drought seasons could be lengthening and intensifying with even less precipitation occurring in the drought season than current figures indicate.

Dawson Creek has taken significant action to address drought and other threats to their watershed. And yet, they have failed to follow through with a strong desire in the community to secure secondary water sources and have absolutely no consideration for drought in the disaster management context. Likewise, Tofino has preferred to improve the viability of its current water sources through

excellent community-based action and conservation, but still fails to consider the hazard on long term scales, with possible growing risk. Merritt feels content relying on its vast groundwater sources despite that fact that the town is located in one of the very driest places in the province, with a reservoir that is slowly depleting and a population that understands or cares very little about water conservation.

Indeed, none of these communities specifically includes drought in emergency management plans. Each relies upon an expectation that the provincial government will provide them with whatever they require in the event of a drought disaster. Have they thought-through what such an event would cost in dollars or quality of life if it were to persist for a significant amount of time? Certainly water can likely be trucked in, communities have done this in the recent past and may be able to do so again in the future. Costs are likely to rise however. Are they prepared to operate under such conditions for many weeks on end? More crucially, are they prepared to face this situation more and more frequently each summer? What if the situation, as appears likely, becomes not only more common but far more widespread? It is easy to say that extensive action to adapt to these possible conditions is too costly, and that actions to address drought will be reassessed in the future as needed, but is this cost effective not only financially but in terms of human lives? Almost all discussions on cost-benefit analysis agree that investing in prevention and adaptation save costs in the long run (Wilhite, 2005).

Drought is a complex and insidious hazard that is difficult to address, and communities have great variation in their knowledge of their hazards and in their will and capital to address them. Complacency due to the slow-onset nature of droughts is a main reason this hazard is not included in current disaster and emergency management plans. Drought is not easily perceived as having the same catastrophic consequences of fast-onset disasters because the impact on human life can occur slowly. And yet access to water is a basic necessity for human life on a daily basis, and evidence from around the world shows the consequences of the impacts of this hazard. These include water and food insecurity that have devastating impacts on quality of life and health of affected populations. Significant drought events can lead to famine, civil war and massive population displacement, resulting in migration, refugee crises' and internally displaced people.

Do British Columbians think themselves immune to drought impacts? Evidence from recent drought events suggests that we are not. In fact, we see droughts most summers, and the visual evidence of them is frequently stark in the form of wildfires that grab public attention. Compounding this is evidence of increasing changes to our climate, the full implications not yet fully known. It is possible, if unlikely, that a warmer climate will not lead to worse drought events in BC. But recent experience shows that summers are lengthening, peak stream flows are occurring earlier and glaciers are receding. Our communities seem to be doing a good job of planning for some hazards such as earthquakes, but they do not individually or collectively demonstrate a serious concern for drought hazard, without integrated, comprehensive long-term planning. This is obvious in the lack of inclusion of drought in emergency plans. Beyond reducing consumption when necessary, there is an overtly stated reliance on the provincial government to take care of crisis situations. However, droughts affect regions; can any community rely comfortably on an assumption that a higher order of government will not itself be overwhelmed by drought impacts if multiple communities all reach out for aid at the same time? Most BC communities, meanwhile, express a desire and intent to be sustainable, to secure their long-term viability. To plan for a sustainable water supply cannot be less critical, on timescales well within those discussed in long-term sustainability plans.

Ultimately, limited adaptive action is perhaps derived from the fact that drought threatens the very viability of our communities, and thinking about it is demoralizing. I believe this to be a part of the explanation for the current state of drought planning in this province, partly from the mood encountered in some interviews, where drought is framed as an issue too large and complex for a municipality to address. Like so many issues around climate change, we console ourselves by taking minimal steps so that we feel better about a problem that is in fact so massive it overwhelms our ability to face it or to take serious action as a society. A personal analogy would be like writing a master's thesis – it is so massive and personally meaningful that it is difficult to know where to begin. However, once it is started, manageable answers slowly begin to appear. And so we must begin, take small steps, and continue until we have something – a thesis or a drought strategy – that is robust.

Drought is a massive, evolving hazard in my home province that small municipalities are in a difficult position to address. However, despite the challenges and limitations it is their clear responsibility to do so. This requires a process that is best started locally using local knowledge, traditional ecological knowledge, disaster management best practices, and developing science and technology. Once this process has been started we can begin to ensure that BC communities will be happy and healthy ones for many future generations.

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