

**Examining the Effect of Visualization Tool Exposure on Local-level Stakeholder
Perceptions on Climate Change Adaptation**

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Vulnerabilities of human communities, driven by environmental, social, economic, and political dynamics, vary across geographical and social regions. Coastal communities are considered to be among those greatest at risk from climate impacts. To cope with these impacts, communities must assess existing vulnerabilities and adaptive capacities, and begin to adapt. Currently, community-based research often focuses on identifying vulnerabilities and possible adaptations, but rarely examines how local-level stakeholders perceive adaptation-based needs and potential action. This research study focuses on Lennox Island, in Prince Edward Island and the Town of Lockeport, in Nova Scotia to examine how two innovative visualization tools, CLIVE and AdaptNS, influence stakeholder perceptions on climate change adaptation. This study explores whether tool exposure changes perceptions of awareness and priorities for potential action among local-level decision-makers and stakeholders. It further explores which aspects of the visualization tools resonate among local-level decision-makers. This research builds on existing vulnerability assessment information established through the Partnership for Canada-Caribbean Community Climate Change Adaptation (ParCA) research project and uses a methodological approach involving semi-structured interviews and community-based workshops with local-level decision-makers and community stakeholders, respectively. After exposure to visualization tools, this tool finds that stakeholders have a greater awareness of and an enhanced need to prioritize critical infrastructure and regions that are vulnerable to the physical impacts of climate change (specifically storm surge and coastal erosion), to consider the impact of climate change on future generations, and to attain further information regarding climate change impacts. It is further revealed that the visual aspects (including physical impacts, timeframes, and localized focus) and decision-support tool aspects of visualization tools are favourable to stakeholders.

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LIST OF ABBREVIATIONS

2D	Two-dimensional
3D	Three-dimensional
CLIVE	Coastal Impacts Visualization Environment
GIS	Geographic Information Systems
MCPEI	Mi'kmaq Confederacy of Prince Edward Island
NS	Nova Scotia
LiDAR	Light Detection and Ranging
ParCA	Partnership for Canada-Caribbean Community Climate Change Adaptation
PEI	Prince Edward Island

Chapter 1: Introduction

This chapter will introduce the problem and research question being explored in this study. It will do so by first providing a brief introduction to climate change, adaptation, and the program that funded this research. It will then outline the main research question and objectives and the general methods through which these will be addressed.

1.1 Climate Change and Adaptation

The impacts of climate change are inevitably affecting human communities around the world. Coastal communities in particular are facing increasing impacts of sea-level rise, coastal erosion, and extreme storm events. Combined, these changes are and will continue to translate to physical (environmental and structural), social, and financial harm to communities that are not prepared for such impacts. To date, there is a vast amount of climate change vulnerability information available within and for coastal communities, however, there is little attention given to addressing or adapting to climate change at the local scale. Climate change adaptation is a form of adapting the current state of a system to be better prepared for the anticipated impacts, be it to lessen harm or exploit beneficial opportunities (Parry, 2007). The concept of adapting is not a new one for human communities; historically, societies have experienced changing conditions and environments, and have adapted accordingly (Adger et al., 2005; Dovers, 2013). Though adaptation is not limited to the local level, it is frequently observable at this scale. The scope of climate change adaptation is not yet defined within the literature (Moser and Boykoff, 2013). Adaptation may be recognized as all adaptation initiatives within a given unit (e.g., collective community adaptation efforts), or it may be recognized as each individual adaptation initiative (e.g., using gabions for shoreline protection), which each entail a complexity of efforts (i.e., planning, financing, staffing, public engagement, construction, monitoring, etc.), further

exemplifying the complexity of adaptation (Moser, 2009; Moser and Boykoff, 2013). The objective of adaptation initiatives can also vary depending on the region and scale at which adaptation is being explored. Broader goals of adaptation can be to protect, thereby work towards reducing the vulnerability of existing infrastructure/systems; to retreat, thereby work towards adjusting existing aspects of a system; and to accommodate, thereby prepare to absorb some of the anticipated impacts by planning ahead (Klein et al., 2001). It is important to note that adaptation processes may not fully engage local-level stakeholders; this can vary contextually. As coastal communities are expected to face some of the greatest challenges from the impacts of climate change, it is critical that local-level planning and decision-making actively explore adaptation.

1.2 Research Objectives

Partnership for Canada-Caribbean Community Climate Change Adaptation (ParCA) is a multi-study-site project that explores the vulnerabilities and adaptive capacities of four communities in North America: Nova Scotia (NS), Prince Edward Island (PEI), Jamaica, and Trinidad and Tobago. This study focuses on two small, highly exposed coastal communities within the Atlantic Canada ParCA study sites: Lennox Island in PEI and the Town of Lockeport in NS to explore the following research question:

How does exposure to visualization tools affect how local-level stakeholders perceive adaptation needs and potential action in small, highly exposed coastal communities?

This research question is achieved through an examination of the following three objectives:

- 1) Does exposure to the tool change awareness (perceived needs and potential action) among local-level decision-makers?
- 2) Does exposure to the tool change priorities for potential action among local-level decision-makers and stakeholders?
- 3) What aspects of the tools that were presented resonate among local-level decision-makers?

1.3 Project Overview

Two visualization tools, Coastal Impacts Visualization Environment (CLIVE) and AdaptNS, that depict future scenarios of sea level rise, storm surge and, in the case of CLIVE, coastal erosion, are used in this study; details regarding each tool and its developers are discussed later in this thesis. This study is carried out by conducting 1) a series of semi-structured interviews with local-level decision-makers in the two chosen coastal communities to gain insight into perceptions on climate change adaptation and existing adaptation initiatives before tool introduction; 2) a community-based workshop to introduce the tools and conduct pre- and post-tool exposure questionnaires; and 3) a series of post-tool-exposure interviews with the same decision-makers as in pre-tool interviews (with the exception of one participant who was only interviewed during pre-tool interviews) to gain insight into how perceptions on adaptation may or may not have changed since tool exposure.

Chapter 2: Literature Review

This chapter will review literature on stakeholder engagement, visualization tools, and behaviour change. It will begin by critically examining the role of stakeholder engagement in environmental decision-making by exploring the importance of engagement, who is considered a stakeholder, and methods of engagement. Next, this chapter will focus on visualization tools in environmental decision-making through which the purpose, audience, and methods of using visualization tools will be explored. This chapter will conclude with a section on behaviour change in environmental decision-making whereby the literature will be reviewed to understand how environmental decisions are made.

2.1 Stakeholder Engagement in Environmental Decision-making

2.1.1 Why Stakeholder Engagement is Considered Important

Stakeholder engagement is widely thought to be important in environmental decision-making (Reed, 2008; Stringer et al., 2007). It is considered to contribute to the enhancement of the quality of decisions as it promotes the inclusion of local knowledge and can provide an open environment for discussions (Pellizzoni, 2003; Steele, 2001). Stakeholder engagement also promotes the development of robust and regionally accepted solutions (Brody, 2003; Mearns and Norton, 2010); thus, making the implementation of decisions a smoother process (Macnaghten and Jacobs, 1997; Schenk et al., 2007). Though a general agreement about the importance of stakeholder engagement exists within the literature, actual testing of the benefits and drawbacks is limited. A summary of the advantages and disadvantages, as found within the literature, of having all relevant stakeholders involved is discussed later in this section. First, let us explore who qualifies as a stakeholder.

2.1.2 Who is a Stakeholder and Who Should be Included

Stakeholder literature dates back to the early 1960s and continues to evolve to this day (Mitchell et al., 1997; Reed et al., 2009). In particular, the broad concept of stakeholder identification has been vastly explored by researchers, resulting in the development of various theories and models for identifying stakeholders (Mitchell et al., 1997; Achterkamp and Vos, 2007). Prior to analyzing who should and should not be included, one must first understand the nature of an issue at hand (Reed et al., 2009). Once the issue at hand is understood, boundaries can be established; boundaries are needed to guide the selection of various social, physical, political, and ecological criteria for stakeholder identification (Reed et al., 2009). From here, Freeman's (1984) broad definition of stakeholder can be applied: "any group or individual who can affect or is affected by the achievement of the organization's objectives". Identifying such stakeholders requires an understanding of issue at hand; thus, defining the issue is crucial to understanding who may or may not be impacted by the issue at hand. Mitchell et al. (1997) highlight that stakeholders are generally agreed to be anything or anyone from people, groups, communities, organizations, institutions, societies, and nature itself. It is further agreed upon that these can be state or non-state actors - that is, affiliated with a government or state or not, respectively (Newig and Fritsch, 2009). Further, within the various stakeholder theories that exist, there are different perspectives on specific qualifications. For example, Bowie (1988) recognizes stakeholders to be only those individuals or groups who are critical supporting members of an organization (Reed et al., 2009). Others such as Starik (1995) and Hubacek and Mauerhofer (2008) recognize all, biological, non-biological, and even "mental-emotional constructs" (such as the concern for future generations) to be stakeholders (Reed et al., 2009). Checkland (1981) considers only those who are contributors to a given issue to be the key stakeholders with the right to be involved in resolving the issue.

The approach one takes to defining stakeholders comes down to first defining the issue and project type (e.g., goals, timelines). From here, the literature outlines various methods of identifying stakeholders (as summarized by Reed et al., 2009). However, the discussion around who should and should not be included as a stakeholder remains disputed. Bryson et al. (2002), for example, use social justice as reasoning for ensuring inclusion of all stakeholders to warrant all members of society are given equal opportunities to voice their opinion. Similarly, Renn (2006) argues that an open exchange is necessary among all stakeholders to allow for individual (or group) perceptions and respective arguments to be made and heard. The benefit of such an approach is questionable and dependent upon the given context within which it takes place.

Achterkamp and Vos (2007) take an interesting approach to classifying stakeholders of a given project by assigning roles that certain groups of stakeholders shall play during various stages of a project. Set boundaries are used to determine which stakeholders will and will not be involved in different stages of a project (Achterkamp and Vos, 2007). Reed et al. (2009) summarize such boundaries broadly by separating project types into: one, projects where the input of stakeholders will determine the output (e.g., in planning processes) and thus all those who may gain or lose from the project should be included (Grimble et al., 1995); and two, projects that are focused on effectiveness, whereby only stakeholders who will impact the end goal of the project should be included (Grimble et al., 1995).

In summary, the literature on stakeholder identification is vast, but in general agreement that those (i.e., individuals, groups, organizations, communities, institutions, societies, natural environments) impacted by or impacting the issue at hand should be included as stakeholders in decision-making. By setting boundaries as necessary for the given context and issue at hand (e.g., physical, social, political, ecological boundaries) and for the various roles different

stakeholders will contribute to a project, the identification of stakeholders can take place. The next section will examine the pros and cons of having all stakeholders involved.

2.1.2.1 Advantages and Disadvantages of Having Everyone Involved

As pointed out by Newig and Fritsch (2009), the literature as well as existing political systems accept that stakeholder engagement is beneficial and effective for decision-making (Rodima-Taylor, 2012; Brody, 2003; Mearns and Norton, 2010; Robinson et al., 2011).

However, in addition to the advantages, there are also some disadvantages to having all stakeholders involved in decision-making. A study by Newig and Fritsch (2009) examines various aspects of stakeholder engagement to determine which are beneficial and which are not beneficial to the quality of environmental decision-making.

The study by Newig and Fritsch (2009) finds that the goals of stakeholders (state and non-state) significantly impact decision-making outputs. Thus, depending on whether the goals of a stakeholder are in alignment or not with a given decision can determine whether or not that contribution is beneficial or not to the overall output (Newig and Fritsch, 2009). This can be challenging, especially in cases where there are multiple and clashing interests and goals among stakeholders.

Newig and Fritsch (2009) also find that the involvement of non-state actors (those who are not affiliated with any government or state) does not necessarily improve sustainable outputs. This ties back to the previous finding, whereby local interests of stakeholders may distract from the actual issue at hand. Another challenge to work with as stakeholders are likely to have personal concerns and various strategies of expressing these concerns, particularly when an opportunity to do so arises. Their study does find that stakeholder engagement helps increase acceptance of decisions, but that acceptance itself is the main factor in successful implementation

of a given decision (Newig and Fritsch, 2009). Thus, there is a general agreement that stakeholder engagement can help increase public acceptance of decisions.

The method of communication is found to be a contributing factor to the quality of decision-making. Newig and Fritsch (2009) find that two-way communication is not considered beneficial to environmental decision-making as it allows for topics of discussion to derail, potentially taking away from primary goal of environmental protection. However, their study did find face-to-face interactions to be beneficial for decision outputs (Newig and Fritsch, 2009). This again links back to the general agreement within the literature that stakeholder engagement can be beneficial.

Lastly, Newig and Fritsch (2009) find that the greater the involvement of various levels of governance and number of actors, the better the quality of environmental decision-making and outputs. Thus, multi-level stakeholder engagement is found to be beneficial to environmental decision-making. However it is important to note that even within such approaches of engagement, potential for other issues to arise remains possible.

Overall, stakeholder engagement is still considered an important component to environmental decision-making. Though there are barriers that can arise from engagement, these can vary across different contexts. As further research is needed to better understand the complex interactions and influences of various variables of engagement, working with the knowledge at hand regarding the benefits of engagement, we proceed to explore the literature for various methods of engagement.

2.1.3 Type of Engagement

The foundation of stakeholder engagement can be traced back to Arnstein's (1969) "ladder of participation", which emerged in the late 1960s as a gradient of citizen participation

levels to represent citizen control and manipulation. Though the definition of participation has been reshaped since 1969, the meaning of public participation remains similar today with the degree of public participation corresponding with levels of empowerment (Lawrence, 2006). The concept of bottom-up (grassroots and local knowledge) and top-down (managerial and central knowledge) approaches is also conceptualized from Arnstein's "ladder of participation", whereby the two different approaches can be categorized into the polarities of Arnstein's ladder (Lawrence, 2006).

The literature categorizes mode of stakeholder participation into four main types: consultative, whereby local stakeholders have little power in actual decision-making; functional, whereby local stakeholders provide input but have no real power in decision-making; collaborative, whereby local stakeholders actively interact with decision-makers to develop plans; and transformative, whereby local stakeholders are key decision-makers and are supported by central stakeholders (Lawrence, 2006; Arnstein, 1969; Farrington, 1998; Nelson and Wright, 1995). Typically, the contextual nature of complex environmental issues makes it ideal for decision-making processes to combine multiple participation types (Brody, 2003; Reed, 2008; Lawrence, 2006). This is because engaging multiple stakeholders can increase the likelihood of understanding the connectivity between multiple issues and perspectives, thereby providing a more robust understanding of a given system.

The duration of stakeholder engagement can vary depending on how the issue at hand is defined; for example, it may be deemed appropriate to involve non-state stakeholders only at the problem defining stages or throughout an entire decision-making process (Reed, 2008). Reed (2008) highlights the importance of organized and skilled facilitation of stakeholder engagement as a means of achieving beneficial participation. Reed (2008) also discusses the importance of

adjusting methods of engagement as relevant to a given context. For example, regional differences in social and cultural environments exist, and thus, certain contexts may be more or less comfortable with certain types of engagement. Thus, different contexts may require different types of engagement (Few et al., 2007). Motivation to take responsibility and willingness to participate as a stakeholder also vary contextually; this is not only associated with existing values, but with awareness and perceptions of the issues at hand (e.g., risks of climate change), which may be influenced by lifestyle, fear of change, emotions, priorities, etc. (Javeline, 2014).

2.1.4 Methods of Engagement

There are various methodological approaches that can be taken for stakeholder engagement. These can include communicative approaches, such as providing information through presentations, brochures, mass media, posters, websites, and public meetings; consultative approaches, such as surveys, opinion polls, focus groups; or participative approaches, such as consensus meetings, public meetings where votes are involved, or other hands-on group activities such as workshops (Reed, 2008; Rowe and Frewer, 2000). Rowe and Frewer (2000) categorize the various methods of stakeholder engagement methods by participant type, time commitment, and characteristics of each method. They conclude, in agreement with other literature (Smith et al., 1997), that combined methods of stakeholder engagement are ideal (Rowe and Frewer, 2000). Rowe and Frewer (2000) also point out that determining the effectiveness of engagement methods is highly context dependent as there are multiple factors that can shape how useful a method is for a given context.

For climate change related issues, Few et al. (2007) state that multiple participative tools and working with small groups is ideal. This is because of the complex nature of climate change such as long-range timeframes and uncertainty regarding expected changes (Few et al., 2007).

One particular approach that has been used for stakeholder engagement is the use of visualization tools. This approach has been found to be especially useful for issues relating to climate change (Sheppard, 2012) and will be discussed in the next section.

2.2 Visualization Tools in Environmental Decision-making

2.2.1 Why Do We Use Visualization Tools

Geographical visualization tools have been used in planning and decision-making for decades (Van Lammeren and Hoogerwerf, 2003), with maps being one of the earliest forms of visualization (Maarleveld et al., 2006). More recently two-dimensional (2D) images and three-dimensional (3D) visualization models have been used in many disciplines as a means of communication and are increasingly being used in climate change science (Sheppard, 2012; Nicholson-Cole, 2005; Moser, 2010; Sheppard et al., 2008; Maarleveld et al., 2006).

There are many factors that play a role in defining our perceptions, such as the method and type of information being delivered and the values, existing knowledge, and desired responses of the stakeholders receiving the information (Sheppard, 2012; Maarleveld et al., 2006). For climate change issues in particular, Sheppard (2012) and Sheppard et al. (2011) state that information must be made relevant to the local context to foster care and engagement from local stakeholders and to develop contextually appropriate solutions. The long-term nature of climate change can make it difficult for stakeholders to perceive information in a way that stimulates interest. Thus, Sheppard (2012) argues that making information visual, as a means of shifting or reinforcing perceptions, is appropriate.

The purpose of visualization tools can vary from communicating information (and thereby raising awareness), collecting information (to allow for more robust representation and/or presentation of data), and/or as a support tool for decision-making (Ricker et al., 2013;

Maarleveld et al., 2006; Sheppard, 2012). Municipalities are increasingly exploring visualizations as decision-support tools (Richardson and Otero, 2012); often these technologies are initiated and developed by non-government institutions and can be either or both informational or participatory in nature (Johnson and Sieber, 2012).

Although humans learn in different ways, be it auditory, visual, or kinesthetic (Felder and Silverman, 1988), humans are instinctively stimulated by visual imagery (Sheppard, 2012). Thus, using visualization tools can be effective at engaging local stakeholders' emotions and for conveying relatable and important climate information (Sheppard, 2012). Sheppard (2012) argues that visualizing climate change is the missing link in terms of moving from information, to knowing, recognizing, caring, and, ultimately, action on climate change (see Figure 1). Similarly, Maarleveld et al. (2006) discuss the idea of abstract conceptualization as a means of achieving independent perceptions and definitions of a problem at hand. By further exploring alternative scenarios of problems at hand, Maarleveld et al. (2006) argue that stakeholders become more aware and involved in decision-making processes, eventually contributing information to what solutions may be most suitable.

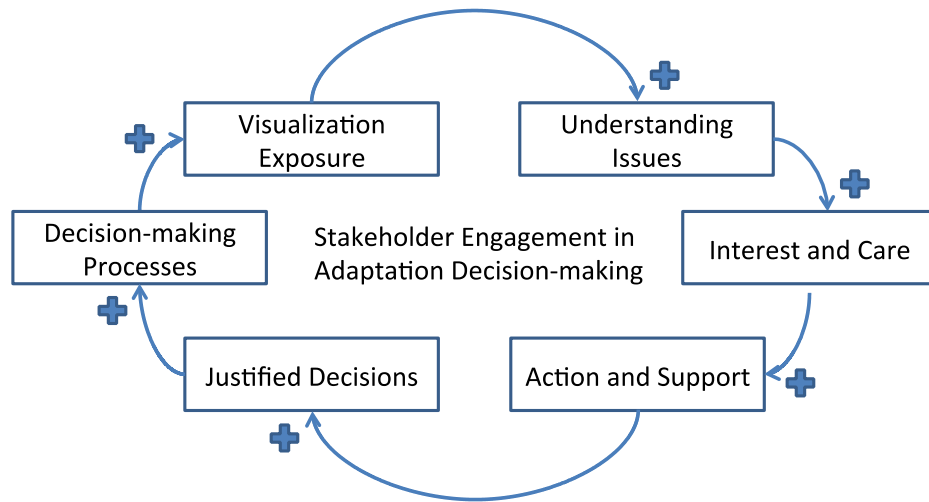


Figure 1: The Role of Visualizations in Motivating Stakeholder Engagement

Positive polarity indicates as the initial variable increases or decreases, the variable being influenced changes in the same direction. Adapted from Sheppard, 2012.

2.2.1.1 Benefits and Constraints of Visualization Tools

The literature highlights many positive aspects of using visualization tools as a method of stakeholder engagement, but also some of the drawbacks of using such methods; these are discussed below.

Sheppard (2012) outlines several factors rationalizing the benefit of utilizing visualizations for climate change adaptation. For example, using such tools to present relevant and local information is arguably an attractive method of informing today’s society; one that is very technology oriented (Sheppard, 2012). Visualizations can also be seen as a universal language that incorporates both qualitative and quantitative information; this can be beneficial for complex issues such as climate change, which encompass multiple forms of vulnerability (e.g., social, physical, financial) (Sheppard, 2012). Such tools are also useful for providing a relatable first person perspective on what the future may look like (Sheppard, 2012). This is especially useful given the abstract nature of how climate change is expected to impact our

future. Visualization tools can also combine and overlay various types of data, which is useful in providing a holistic understanding of the future (and potentially addressing multiple goals for a given context) (Brzeski et al., 2013; Maarleveld et al., 2006). Building on this, Sheppard (2012) states that these tools can be useful for being able to efficiently envision and compare variations of localized futures, which can typically be updated to represent new information as necessary and relevant.

Others such as Ricker et al. (2013) find that the use of web-based visualization tools can result in stakeholders having a better understanding of their localized environmental changes. In their study, Ricker et al. (2013) used a tool, which allowed for user contributions whereby local knowledge was added and represented within the tool itself (Ricker et al., 2013). This can be highly useful for engaging stakeholders, especially when taking into consideration that there may be marginalized stakeholders who previously may not have had avenues for voicing their opinions.

Though the use of visualizations is found to be positive, there are some drawbacks and potential disadvantages. Firstly, though the use of such tools can promote inclusivity, there is a risk of introducing a new barrier for those who are unable to use computer-based tools (Ricker et al., 2013). This issue is rooted in digital literacy and can create a chain of psychological/emotional impacts for those unfamiliar or uncomfortable with using technology. Furthermore, issues building on the digital divide can occur with the use of visualization tools whereby societal divisions can determine who does and does not have access to a given tool (Ricker et al., 2013; Miller, 2007).

Another drawback for using visualization tools is the level of accuracy presented in such tools. Although global climate models are commonly used for identifying potential climate

impacts while taking some social factors into consideration, these models are not necessarily representative of actual change at the local scale, but rather, are best estimates (Heal and Kriström, 2002). Projecting and visualizing exact regional impacts and associated costs of adaptation is information that will never be completely accurate as the complexities in global and regional socio-ecological systems translate to a high degree of uncertainty (Heal and Kriström, 2002; Kriebel et al., 2001). Further, in cases where data is being collected to contribute to visualization tools, there is a risk of information being inaccurate or exaggerated (Ricker et al., 2013). Thus, presenting and collecting information through the use of visualization tools comes with the risk of having varying levels of interpretation. This can be a significant barrier for cases where visualized information is to be used for decision-making purposes, as unclear messages could skew perceptions of climate information in a particular direction. Thus it is crucial to verify data (quantitative and qualitative), as necessary and possible, as a means of maximizing accuracy.

2.2.2 With Whom Do We Use Visualization Tools

Visualization tools are used not only for conveying scientific information to decision-makers (state stakeholders) (Nocke et al., 2008), but also as participatory approaches for communicating with non-state actors (i.e., public stakeholders) (Sheppard, 2012; Ricker et al., 2013; Robinson et al., 2011; Brzeski et al., 2013; Arciniegas et al., 2013). Literature surrounding the rightful use of visualization tools in terms of who should and should not be exposed to such tools remains limited. There are, however, general strategies outlined within the literature that work towards reducing barriers to engagement. For example, Moser's (2006) strategies for engagement include increase the sense of urgency, broaden the issue of climate change beyond just an environmental challenge, be open about what is and is not certain in climate science, be

cautious with alarmist messages, focus on engaged individuals (cannot please everyone), be socially inclusive, develop a positive vision, and be kind. Such strategies can be useful to consider when utilizing visualization tools for communicative/participatory purposes.

Furthermore, Moser (2010) highlights that in addition to little ethical research, there is a lack of empirical research that tests the usefulness and implications of new communication tools. In particular, Moser (2010) states that further research is needed to examine contextualized differences of communication processes, effective and ethical uses of visualizations, implications of visualizations on public perceptions of climate change adaptation, sustaining long-term engagement through communications, and communicating effectively (without overwhelming audiences) to a larger range of people.

2.2.3 How Do We Use Visualization Tools

Methods of using visualization tools build upon existing stakeholder engagement methods (mentioned previously) with the added component of having the tools themselves be present (e.g., at meetings, workshops, through the use of posters, presentations, etc.). In some cases, if visualization tools are web-based, participants may use the tools at their own convenience by accessing the web (given that stakeholders have access to the web and that the tool is available publicly) (Lathrop et al., 2014; Lieske et al., 2014). The following section will explore the characteristics of some existing visualization tools.

2.2.4 Overview of Existing Visualization Tools

There are many existing visualization tools that represent change at the community scale. Some examples from the literature of how coastal visualizations have been used in decision-making practices, with a particular emphasis on stakeholder engagement, are outlined in this section. The tools discussed are not an exhaustive selection, but rather the most relevant

visualization tools to this study that have been tested within the literature and represent coastal change (dominantly sea-level, storm surge, and/or coastal erosion) in a North American context (see Table 1). This section concludes with a description of two visualization tool examples from an international context to highlight the transferability of tools in decision-making practices.

1. Between 2011 and 2013, the Ecology Action Centre in NS carried out a climate change adaptation study in the town of Chéticamp, situated in Cape Breton Island, NS. The project utilized a variety of participatory approaches including the use of photos and 3D visualization models to show sea-level change and flooding at the community level (Brzeski et al., 2013). The visualizations were designed to focus on economically and culturally significant regions within the community and simply show rising water levels (a conservative representation of what would realistically happen during a storm) (Brzeski et al., 2013). Through an open house, the visualizations were displayed to community members (Brzeski et al., 2013). Based on this study it was found that the visualizations presented provided community members with more meaning to the maps, as they could identify with the areas shown and thus, gain a better sense of what the portrayed information meant for them (Brzeski et al., 2013). Brzeski et al. (2013) highlight that the visualizations were dominantly an awareness-raising tool and were not collecting new information. The potential benefit of having an interactive map that could show sea level and erosion changes was discussed, however the complexity of designing such a model was a limitation to developing such a tool. Lastly, Brzeski et al. (2013) state that visualizations must be used carefully to avoid sending alarmist messages to audiences. An important factor to remember when dealing with issues such as climate change.

2. Another study by Maher et al. (2012) examined the usefulness of six different visualizations depicting sea-level rise for decision-makers (planners and politicians in particular) and for effective public communication. The visualizations included mapping, rendering, photo-simulations, digital animation, interactive maps, and floodable models (Maher et al., 2012). Visualizations were presented to members of the Halifax Regional Municipality through an open house event, during which a series of quantitative and qualitative response surveys and questionnaires were completed (Maher et al., 2012). The results of this study revealed that accuracy of information was a primary concern for participants, regardless of which visualization tool was being presented (Maher et al., 2012). This opinion was strongly associated with how information will be presented to the public. Participants also favoured the realism represented through photographic visualizations as opposed to other visualization types, such as maps and physical models. However, the high level of interaction required by physical model visualizations was found to be greatly engaging and thus, provided for superior learning for participants (Maher et al., 2012). The use of six different types of visualizations was found to be quite beneficial as the combined information from all tools provided a better understanding of the complexity of issues involved with sea-level rise (Maher et al., 2012). Lastly, Maher et al. (2012) found that it is crucial that visualizations be suitable for a range of demographics - a realistic consideration that could easily be overlooked. Overall, the study by Maher et al. (2012) demonstrated valuable preliminary insights into what aspects play a major role in good visualization tools.

3. A study by Shaw et al. (2009) conducted in Delta, British Columbia (BC), examined the effect of 3D climate change visualization scenarios on stimulating regional action on climate change. This study involved a series of steps: first, global climate change scenarios were synthesized; second, these global scenarios were downscaled to local contexts; and third, local climate scenarios (depicting four future mitigation and adaptation scenarios (from do nothing to increasing levels of action) over three time periods (2020, 2050, and 2100) were converted into visualizations (Shaw et al., 2009). Next, the visualizations were tested through a series of participatory group sessions involving core researchers, extended researchers, and local governance representatives (Shaw et al., 2009). Each presented scenario considered a complexity of variables, such as population, economy, land use, energy use, and carbon dioxide emission changes (Shaw et al., 2009). The results from this study revealed a number of challenges and benefits. Key challenges included the high time- and cost-commitment required to facilitate the participatory study during a time of fast-paced research on climate change emissions and impacts, and the lack of information on how adaptation strategies may counterbalance mitigation strategies (Shaw et al., 2009). The next part of this study was to test the impact of the developed visualization scenarios on public perceptions on climate change through a series of workshops. The visualizations were presented to approximately 100 public citizens in south Delta (Sheppard et al., 2011). Sheppard et al. (2011) summarize the findings of this research and discuss the effective aspects of the tool. They found the realism portrayed through the visualizations was a key factor in maintaining participant engagement and learning (Sheppard et al., 2011). The authors further found that there was an evident increase in desire to take action towards climate change issues; thus, an increase in community agency (Sheppard et al., 2011).

Overall, the results from the study by Sheppard et al. (2011) support the usefulness of climate change visualization tools to enhance public cognition and awareness on climate impacts (Robinson et al., 2011), and consequently, to foster effective decision-making (Sheppard et al., 2011).

4. Similar to the tool developed in Delta, BC, there are several visualization tools that have been developed using geographic information systems (GIS) and LiDAR (light detection and ranging) data. A study by Lathrop et al. (2014) tested the usability and technical aspects of a sea-level rise visualization tool known as NJFloodMapper. This empirical study also examined the usability of five other sea-level rise visualization tools; these tools include NOAA Coastal Services Center's Sea-level rise and Coastal Flooding Impacts Viewer, The Nature Conservancy's Coastal Resilience tool, State of California's visualization tool, and Pacific Institute's Impacts of Sea-level rise on the California Coast tool (Lathrop et al., 2014). Through this study, participants were shown web-based visualization tools and were surveyed on aspects that translated into technical and need-based functionality (Lathrop et al., 2014). Participants found the tool to be informative, interesting, and useful (Lathrop et al., 2014). Beyond the visualization tools tested by Lathrop et al. (2014), many other tools exist, some of which overlay a variety of data (such as regionally significant areas, areas of high vulnerability based on demographics and other variables, etc.). Thus, tools can provide a valuable and context relevant picture of what the future may look like. A notable example of a visualization tool that provides a robust vulnerability analysis is Climate Central's Surging Seas Risk Finder (Climate Central, 2015a). Surging Seas Risk Finder considers over 100 variables and covers a large geographical area. For further information regarding

technical aspects of different visualization tools, a Tools Comparison Matrix (<http://sealevel.climatecentral.org/matrix/NJ.html>) developed by the Nature Conservancy, NOAA's Office for Coastal Management, and Climate Central, provides a thorough summary of various tool aspects by region (Climate Central, 2015b).

5. A study by Lieske et al. (2014) examined the impact of visualizations on risk perceptions of local stakeholders in the Tantramar Region in New Brunswick. Surveys were completed in three different communicative forms: one, basic communication regarding climate change; two, the basic communication plus animations (including pictures of the downtown core being flooded); and three, an interactive web-based map (Lieske et al., 2014). The purpose of this study was to examine the change in perceptions on climate change that occurs before and after being exposed to each of the three communicative methods (Lieske et al., 2014). Pre-and post-surveys included questions such as “do you feel that global climate change is a problem?” and “how vulnerable are you to the risk of a Tantramar dyke failure?” (Lieske et al., 2014). Lieske et al. (2014) found that 71% of participants whose response agreed that moving was a realistic long-term adaptation strategy were from groups two and three of the communication methods (visual pictures and interactive geo-based tool, respectively). Further, Lieske et al. (2014) found that 83% of respondents (15 of 18) who specified having an interest in raising awareness and becoming politically involved in community-based climate change adaptation strategies were from the third communicative group (those who were exposed to the interactive visualization tool). In all three communicative methods, Lieske et al. (2014) found that perceptions of participants regarding flood risk increased in seriousness. However, communicating using visualizations had an emotional influence,

resulting in participants stating they were “shocked” and inspired to take action; thus, the visualizations effectively delivered messages about climate impacts (Lieske et al., 2014).

Lieske et al. (2014) conclude by emphasizing the need for clear and regular communication on climate change issues and potential adaptation options (Moser and Dilling, 2004; Lorenzoni et al., 2007; Fischhoff, 1995).

6. An empirical study by Nicholson-Cole (2005) examines first how people visualize perceptions of climate change and second how this translates in terms of the influence of visualizations (e.g., from the media) on interpretations and perceptions of climate change. This study did not test a specific visualization tool, but rather aimed to understand the general impact of visualizations on human perceptions on climate change (Nicholson-Cole, 2005). A total of 30 semi-structured interviews were conducted with public citizens in the coastal community of Norwich, United Kingdom. Participants ranged in age from 16 to 40 and for analysis purposes, were categorized into three age-determined groups (Nicholson-Cole, 2005). Nicholson-Cole (2005) found that certain aspects of visualizations make them more likely to motivate behavioural changes; for example, relatable and realistic imagery (spatially and temporally), factual imagery, imagery with transparent messages, attention grabbing characteristics (involving people or animals), and participant targeted (based on the audiences’ interests, values, age, etc.). Nicholson-Cole (2005) summarizes by emphasizing the need for visualizations as a complimentary mechanism for raising awareness, while stating there is a need for increased community involvement, context based information, emphasis of climate change in educational programs, and regular news about actual impacts being faced by communities around the world.

7. Lastly, several empirical examples exist surrounding the use of geo-based tools used for landscape planning purposes (e.g., wind farm placement in Spain (Chias and Abad, 2013), land use allocation in the Netherlands (Arciniegas et al., 2013), and sustainable planning in Thailand (Wanarat and Nuanwan, 2013). In all cases, the general benefit of visualizations was agreed upon, as tested tools were found to improve public awareness and promote inclusivity amongst a wide-range of stakeholders (Wanarat and Nuanwan, 2013). Further, benefits of information being represented in an understandable manner were recognized. However, the fact that visualization tools are typically technologically demanding was pointed out to be a limitation (Chias and Abad, 2013). Overall, the aforementioned empirical studies demonstrate that the use of visualization tools for decision-making is not only beneficial for various regions across the world, but for a range of specific of planning objectives.

Table 1: Examples of Existing Research on Testing Visualization Tools

Study	Location	Purpose of tool	Data presented	Method of presentation	Capabilities	Limitations
Brzeski et al., 2013	Cheticamp, NS	Awareness raising	Sea level change Flooding	Photos and 3D models through open house	Iterative	Private access No feedback incorporation
Maher et al., 2012	Halifax, NS	Decision-making Public communication	Sea level change	Mapping, rendering, photo-simulations, digital animation, interactive maps, and floodable models through an open house	Iterative Partial feedback incorporation for optimization of tool (as opposed to for incorporation)	Resource intensive Private access
Shaw et al., 2009	Delta, BC	Testing public perceptions on climate change	Sea level change Coastal change Population Economy Land use Energy use Carbon dioxide emission changes	3D visualization scenarios through workshops	Thorough representation of actual change (holistic approach)	No feedback incorporation Difficult to iterate Private access Resource intensive
Lathrop et al., 2014	Various North American coastal regions	Testing usability of tools	Sea level change Flooding (Some incorporate other variables such as demographics)	Web-based visualization tools	Iterative Available online	No feedback incorporation
Lieske et al., 2014	Tantramar Region, NB	Understanding perceptions on climate change	Flooding	Web-based visualization map	Iterative Available online	No feedback incorporation

2.3 Behaviour Change in Environmental Decision-making

As discussed earlier in this chapter, in stakeholder engagement processes the goals of stakeholders significantly influence an outcome of a decision. Thus, in the case of climate change adaptation, having stakeholders with pro-environmental goals/behaviour, whereby the goals/behaviour are aimed at reducing adverse impacts on natural and built surroundings (Kollmuss and Agyeman, 2002), is ideal. However, changing behaviour is difficult, as will be discussed in this section (Kollmuss and Agyeman, 2002).

Kollmuss and Agyeman (2002) review several different models that explore the relationship and gap between attitude and behaviour. They highlight that attitudes do not translate to behaviour, but rather that attitudes are one of many components that may influence intentions to act. It is this behaviour intention that leads to behaviour change (Kollmuss and Agyeman, 2002; Ajzen and Fishbein, 1980). A summary of Kollmuss and Agyeman's (2002) findings is outlined below.

2.3.1 Factors that Influence Behaviour

Kollmuss and Agyeman (2002) categorize the influencing determinants of behaviour change into three factors: demographic, external, and internal. The authors point out that the categorization of these factors is rather broad and simplified and that in reality, there are interrelationships and complexities that shape behaviour change that are difficult to define. The three aforementioned factors are discussed in this section.

2.3.1.1 Demographic

Gender and number of years of education are found to be contributing demographic factors for pro-environmental behaviour. As found by Fliegenschnee and

Schelakovsky (1998) and Lehmann (1999), women have a greater likelihood of showing greater concern for the environment. Additionally, the greater the number of years of education, the more knowledge one is likely to have regarding environmental problems. Greater environmental knowledge can influence one's attitude towards being more pro-environmental, but not necessarily influence actual behaviour (Kollmuss and Agyeman, 2002).

2.3.1.2 External

External factors are further divided into three factors. Firstly, institutional factors can act as enablers or barriers for one to exert pro-environmental behaviour (Kollmuss and Agyeman, 2002). In smaller communities, having a lack of services such as public transit can act as a barrier to pro-environmental behaviour. Though such barriers can be overcome by active public action (Kollmuss and Agyeman, 2002), it can be challenging to do so in situations where institutional power and resources are limited (e.g., small communities).

Secondly, economic factors can influence pro-environmental behaviour (Kollmuss and Agyeman, 2002). However, it is important to acknowledge the complexity involved as economic factors are further influenced by societal, infrastructural, and psychological factors (Kollmuss and Agyeman, 2002).

Thirdly, social and cultural factors can influence pro-environmental behaviour. These vary across different regions around the world. Kollmuss and Agyeman (2002) state that smaller densely populated regions (as opposed to large and dispersed ones) are more likely to be pro-resource conservation. Though this can vary contextually, for example smaller communities or communities with large influxes of outsiders may have

attitudes and behaviours strongly determined by internal factors or by social and cultural factors with which they feel most affiliated.

2.3.1.3 Internal

Kollmuss and Agyeman (2002) categorize internal factors into eight separate factors. First is *motivation*, the driving force for behaviour, which can be obvious or not (Kollmuss and Agyeman, 2002). Stern et al. (1993) model motivation for pro-environmental behaviour as having three main drivers (or orientations) for motivation. These are egoistic orientation, whereby personal concern and harm alleviation is primary; social orientation, whereby concern for alleviating pain for others is primary; and biospheric orientation, whereby concern and harm alleviation for the natural environment is primary (Stern et al., 1993; Kollmuss and Agyeman, 2002). It is important to note that motives may exist and not necessarily translate into behaviour; for example, if there are habits that contradict one's intent to act pro-environmentally, that intent will likely not be actualized, unless the habits, which are acting as barriers, are changed (Preuss, 1991; Kollmuss and Agyeman, 2002).

Next, *environmental knowledge* is generally considered not to be a strong influencing factor contributing to pro-environmental behaviour (Kollmuss and Agyeman, 2002; Kempton et al., 1995). Though there is some level of influence, studies have found the level of pro-environmental behaviour to be the same for environmentalists and non-environmentalists (Kollmuss and Agyeman, 2002). Once again, habits and economical factors can act as barriers for actualizing intentions to behave pro-environmentally.

Another factor that influences pro-environmental behaviour is *values*. Values are shaped by an individual's personal social network and upbringing (Kollmuss and

Agyeman, 2002; Chawla, 1998). A study by Chawla (1998) finds that it is the emotional attachment with nature that allows one to value nature and thereby promote environmental awareness and concern.

The next factor is *attitudes*, which is found to be indirectly related to pro-environmental behaviour (Kollmuss and Agyeman, 2002). The literature indicates that those with pro-environmental attitudes do not necessarily behave pro-environmentally (Kollmuss and Agyeman, 2002; Diekmann and Preisendoerfer, 1992). That said, those with pro-environmental attitudes have been found to be more likely to take part in lower cost (financially and mentally) behaviour (such as recycling) and are more supportive of policies that promote pro-environmental behaviour (Kollmuss and Agyeman, 2002; Diekmann and Preisendoerfer, 1992; Lehmann (1999). Closely tied to attitudes is the knowledge and beliefs one has regarding a given issue.

The factor of *environmental awareness* is based on having knowledge of the impact of human behaviour on the environment (Kollmuss and Agyeman, 2002). Kollmuss and Agyeman (2002) describe three main characteristics of environmental issues that act as barriers for people to cognitively become aware of environmental problems, such as climate change. First is the non-tangible aspect of environmental issues, which makes it difficult for emotional attachment to develop (e.g., not being able to see the impacts directly, but rather through information and language) (Kollmuss and Agyeman, 2002; Preuss, 1991). Second is the time lag of actual environmental change; the gradual nature of environmental issues (such as climate change), which can act as a barrier for humans to cognitively understand what is occurring (Kollmuss and Agyeman, 2002). Lastly is the complex nature of environmental issues, which can make it very

difficult for people to easily draw linkages between various contributing components and impacts (Kollmuss and Agyeman, 2002). All aforementioned characteristics of environmental issues make it difficult for an emotional attachment to develop, and subsequently any intention to act to take place.

Next is the factor of *emotional involvement*, which Kollmuss and Agyeman (2002) define as “the extent to which we have an affective relationship to the natural world”. Emotional involvement can be existing or developed during an onset of environmental harm (Kollmuss and Agyeman, 2002). It can act as a barrier in cases where there is resistance to information (whereby people do not wish to change their ways) or there is simply a lack of knowledge and awareness (which may or may not lead to one having emotional concern) (Kollmuss and Agyeman, 2002). There are also a series of emotional reactions that one can have to environmental harm, which can influence the level of pro-environmental behaviour one may or may not show (Kollmuss and Agyeman, 2002). Kollmuss and Agyeman (2002) point out that emotional feelings of sadness, fear, pain, and anger are expected to be more likely to lead to pro-environmental behaviour. Thus, in regions where people and communities have been impacted by environmental harm, there is likely to be a greater emotional attachment and thus potential for pro-environmental behaviour.

The *locus of control* factor is the degree to which one believes he or she has the ability to create change through his or her actions (Kollmuss and Agyeman, 2002). This can vary depending on the issue at hand and the amount of power one feels they have towards controlling the output.

The final factor ties in closely to the previous three. This is the factor of *responsibility and priorities*, which is determined by one's values, attitudes, and locus of control (Kollmuss and Agyeman, 2002). For example, in a highly vulnerable region, community members may have a more protective attitude and prioritize safety of their community, homes, and families, as these are likely to be valued greatly.

In conclusion, the literature indicates that simply having information and knowledge (no matter how technical) is not enough to create behaviour change (Diekmann & Preisendoerfer, 1992; Fliegenschnee & Schelakovsky, 1998). There are several complex barriers to achieving pro-environmental behaviour. However, further research is needed to determine how certain methods of engagement/raising awareness (such as through the use of visualization tools) at the local-level can go beyond just providing information and influence other factors, such as those outlined by Kollmuss and Agyeman (2002) (i.e., responsibility and priorities, emotional involvement, values, and attitudes).

Chapter 3: Study Site and Methods

This chapter will begin by describing the study sites selected for this research. An outline of why these sites were selected and the various physical, human, governance, and existing adaptation aspects of each community will be described. This chapter will then provide an explanation of the two visualization tools used in this study, CLIVE and AdaptNS, by examining the various components of each tool (including goal, type of data, and user interaction). This chapter will conclude with an outline of the methods used to carryout this project. The methods section will provide details about the processes that took place by focusing on the two data collection groups: key informant interviews and the wider community.

3.1 Study Area

The ParCA project focuses on studying four coastal regions (Jamaica, Trinidad and Tobago, Nova Scotia, and Prince Edward Island). Given the similarities between the two Canadian study areas, PEI and NS, and the availability of visualization tools focusing on Atlantic Canada, two similar, highly vulnerable coastal communities within each Province were considered as study sites for this master's thesis: Lennox Island in PEI and the Town of Lockeport in Nova Scotia. These two communities were selected as study sites based on their comparable aspects as island communities with similar exposure-sensitivities to the impacts of climate change (see Appendix A). The two study sites were considered ideal for this research study as they are of a manageable scale for examining how the two visualization tools used could change awareness and priorities for climate change adaptation. Background information for each study site is discussed in this section.

3.1.1 Lennox Island

3.1.1.1 Physical System

Lennox Island, located on the northern shore of PEI, is home to the Mi'kmaq First Nation community (Dillon Consulting Limited, 2007). Spatially, Lennox Island is approximately 3 kilometers in width, 3.5 kilometers in length, and is surrounded by the waters of Malpeque Bay (Dillon Consulting Limited, 2007). The highest point of elevation is 6 meters with most of the island at sea level. A strip of sand hills protects the northeastern part of the island, acting as a natural breakwater structure. Fresh water resources on Lennox Island are contained within groundwater sources and are extracted through three active groundwater wells (one commissioned in 1995 and two in 2005) (Dillon Consulting Limited, 2007). Like PEI, the geology of Lennox Island is made up of sandstone, which is a highly erodible bedrock (Davies, 2011; MacDonald, 2014). Temperatures in PEI range from -7 degrees Celsius to 19 degrees Celsius with July and August being the warmest months of the year (Government of Prince Edward Island (GPEI), 2014a). An average of 1078 mm of precipitation is received annually in Lennox Island (Dillon Consulting Limited, 2007).

As for existing environmental vulnerability, Lennox Island is particularly vulnerable to high levels of coastal erosion (see Figure 2), sea-level rise, increased frequency and intensity of storm events and flooding, and potential saltwater intrusion (if the water table rises beyond 1 to 2 meters above sea level), all which are expected to increase as a result of climate change (GPEI, 2014b; GPEI, 2014c; Dillon Consulting Limited, 2007). The northeastern end of the island is greatest at risk from erosion given its low elevation. Lennox Island has previously dealt with coastal erosion near the

species (Lennox Island, 2013a). Today, fishing remains an important economic activity for Lennox Island with a Lennox Island First Nation owned and operated fish harvesting corporation, Fisherman's Price Inc., and lobster processing plant (as of 2010), Minigoo Fisheries (Lennox Island, 2013c; Lennox Island, 2013a). Other businesses on the island include tourism-based companies, arts and crafts, and property management, along with others (Lennox Island, 2013c). Major services and infrastructure on Lennox Island include one public elementary school (John J Sark Memorial School), the cultural center, a health care center, a fire department, the band office, a fishing wharf, a wastewater treatment plant, a historical church, a cemetery, and a causeway (built in 1972) (Personal interview, 2014; Dillon Consulting Limited, 2007).

3.1.1.3 Local Governance

In terms of governance, the Mi'kmaq Confederacy of PEI (MCPEI) is an institution that works with the Mi'kmaq people of PEI to ensure inclusivity for PEI First Nations, build capacity within First Nation communities, and act as a linking organization with other institutions across governance scales (Mi'kmaq Confederacy of Prince Edward Island (MCPEI), 2015). The local formal government on the island consists of the Band Council: one chief and three councilors (Lennox Island, 2013d). The Band Council represents the community and all its members. The chief and each council member hold a term for three years. The chief represents all members of the Band Council and has the responsibility to make operational decisions as budgets and policies permit. The Band Council members are involved in major decisions, policy development, administrative responsibilities, and guiding programs and services. Environmental groups within the

community do not currently exist; thus, the Band Council is also responsible for environmental initiatives.

3.1.1.4 Current State of Climate Change Adaptation

As for climate change adaptation, though the Band Council has an interest in understanding more about the environmental vulnerabilities that the community faces, currently no adaptation plan exists.

3.1.2 Town of Lockeport

3.1.2.1 Physical System

The island community of the Town of Lockeport is located in South Shore, Nova Scotia and is approximately 1 kilometer in width and two kilometers in height. The elevation of Lockeport ranges from 0 to 5 meters in height. The bedrock along the South Shore is dominantly greywacke and granite (Neily et al., 2003). The climate along this part of the NS is highly influenced by the Gulf Stream, which results in warmer winters and cooler summers (Neily et al., 2003).

The Town of Lockeport has already been facing challenges with erosion, sea-level rise, and flooding resulting from extreme storm events (Atwood, 2013). It is projected that these climate impacts will continue to accelerate with time (Atwood, 2013). There are several low-lying areas particularly within the island portion of Lockeport that are highly vulnerable to the aforementioned impacts of climate change. The community has dealt with environmental issues in the past by reinforcing the causeway, when it was damaged overtime by storm events; rebuilding infrastructure that was damaged during storms; and armouring coastal areas (e.g., Crescent Beach area) to reduce the rate of erosion.

3.1.2.2 Human System

According to Canadian census data, the population of Lockeport was 646 people in 2006 and 588 people in 2011 (Statistics Canada, 2012b). Today, Lockeport is home to less than 600 people (median age is 56), of which 90% are above the age of 15; overall, indicative of a declining population (Statistics Canada, 2012b). The community of Lockeport relies heavily on the coastal regions and access point to and from the island as the town has been and still is dominantly a fishing town. Originally, the town of Lockeport was a trading hub for salt cod and lumber to the West Indies for commodities including salt and molasses (personal communication, 2014). In the 1800s, the town was a successful fishing community with eight fish plants and a lobster cannery (personal communication, 2014). Although fishing remains the primary economic livelihood for most people within Lockeport, tourism has always been present (since the 1800s) and is still present today (personal communication, 2014). Some local attractions include the Crescent Beach, Black Point Beach, Buchanan's Beach, Canada Hill Lake, Col. Locke's Beach, Western Head Beaches, Freddy's Beach, Louis Head Beach, Rockland's Beaches, the Shelburne County Lobster Festival, Lockeport Sea Derby (3day event), and Canada day celebrations (personal communication, 2014). Some key town infrastructure and businesses include tourism accommodations, waterfront businesses, the town hall, an elementary and high school, two museums, a post office, a pharmacy, a town market, waterfront residential homes and cottages, a tourist center, a power station, and a sewage treatment plant.

3.1.2.3 Local Governance

The local formal government in Lockeport is the Town Council, which consists of a mayor, town clerk, and four council members (Town of Lockeport, 2015). The term for the councilors and mayor is four years. The Town of Lockeport falls within the larger Municipality of the District of Shelburne, along with the Town of Shelburne (Tipton, 2013). The Town of Lockeport itself consists of the island as well as some surrounding mainland area known as Brighton (Atwood, 2013). There is one causeway access to and from the island and one non-operational trestle, which is used only as a pedestrian bridge access (Atwood, 2013). The Town owns the north side of the causeway and the Province owns the south side, where the beach is present (Atwood, 2013). Thus, the Town Council is responsible for decisions and long term planning involving the entire Town of Lockeport boundary including the north side of the causeway. Key functions of the Council include approving budgets, developing local by-laws, approving major purchases, representing community members, and resolving conflicts within the community. The Town Council is responsible for administrative, protective, transportation, environmental health, and recreation services. Matters surrounding energy and infrastructure are the responsibility of the Province. As for environmental organizations, there are none specific to Lockeport. However, there are provincial level organizations such as the Ecology Action Centre, which have worked with the Town Council and been affiliated with projects within the Town of Lockeport in the past.

3.1.2.4 Current State of Climate Change Adaptation

There are climate policies that exist for both PEI and NS. Firstly, the Regional Adaptation Collaborative (RAC) program is a federal scaled initiative that was renewed from 2009 to 2012 and aimed to assist Canadian communities in adapting to climate

change (Natural Resources Canada (NRC), 2015). As part of the RAC program, Natural Resources Canada allocated \$3.5 million towards the Atlantic Region's Adaptation initiatives; the Atlantic Provinces supplemented this with an additional \$4.6 million (Atlantic Adaptation, n.d.). As such, the Atlantic Climate Adaptation Solutions network was established to support and organize Atlantic efforts towards addressing climate change. A number of research projects have been completed across all Atlantic Provinces including vulnerability assessments, coastal change studies, sea-level rise mapping, flooding assessments, saltwater intrusion studies, climate change scenario development, as well as others (Atlantic Adaptation, n.d.).

In 2008, the Provincial-Federal Gas Tax Fund Agreement was renewed between the Federal government and Province of Nova Scotia. The new agreement involved transfer of an additional \$223 million over the period of 2010 to 2014 to be spent towards select municipal projects (Province of Nova Scotia (PNS), 2011). To receive this additional funding, municipalities were required to complete and submit a Municipal Climate Change Action Plan (MCCAP) by the end of 2013 (PNS, 2011). By following a guidebook developed by the Provincial government, these plans were intended to outline the strategies municipalities would take to address climate change adaptation (PNS, 2011). MCCAPs are increasingly common around the world yet there are varying perceptions regarding the usefulness of such documents. Mukheibir and Ziervogel (2007) highlight that Municipal Action Plans should be seen as an evolving process rather than a single document that should be used for municipalities as an ongoing strategic planning tool. The Town of Lockeport is one of many municipalities in NS that has completed an MCCAP.

3.2 Visualization Tools Used in These Study Areas

The two visualization tools used in this study are CLIVE (for Lennox Island), and AdaptNS (for the Town of Lockeport).

3.2.1 CLIVE

CLIVE is a 3D GIS-based tool developed by a research team from UPEI and Simon Fraser University (SFU), including Andrew Doiron, Alex Chen, Adam Fenech, and Nick Hedley. CLIVE merges LiDAR data for the province of PEI with sea-level change and storm surge information and with coastal erosion data based on the average erosion rate (28 cm/year) from 1968-2010 (derived from aerial photographs), to show how communities in PEI could change over time (see Figures 3, 4, & 5). It is important to note that the represented erosion rates are based on existing rates, and thus, do not represent accelerated rates of erosion as is anticipated with climate change. The tool represents the aforementioned physical changes only (no social dimensions represented) and is meant for awareness raising purposes. The CLIVE tool is highly detailed; using a game console, the tool operator can zoom into property level to show viewers how homes, cottages, wind turbines, and roads are likely to be impacted and flooded with sea-level rise and coastal erosion over the next 30, 60, and 90 years. This tool is not a web-based tool and thus, is only accessible privately. Replicating the tool requires extensive data and resources and thus it cannot easily be iterated.

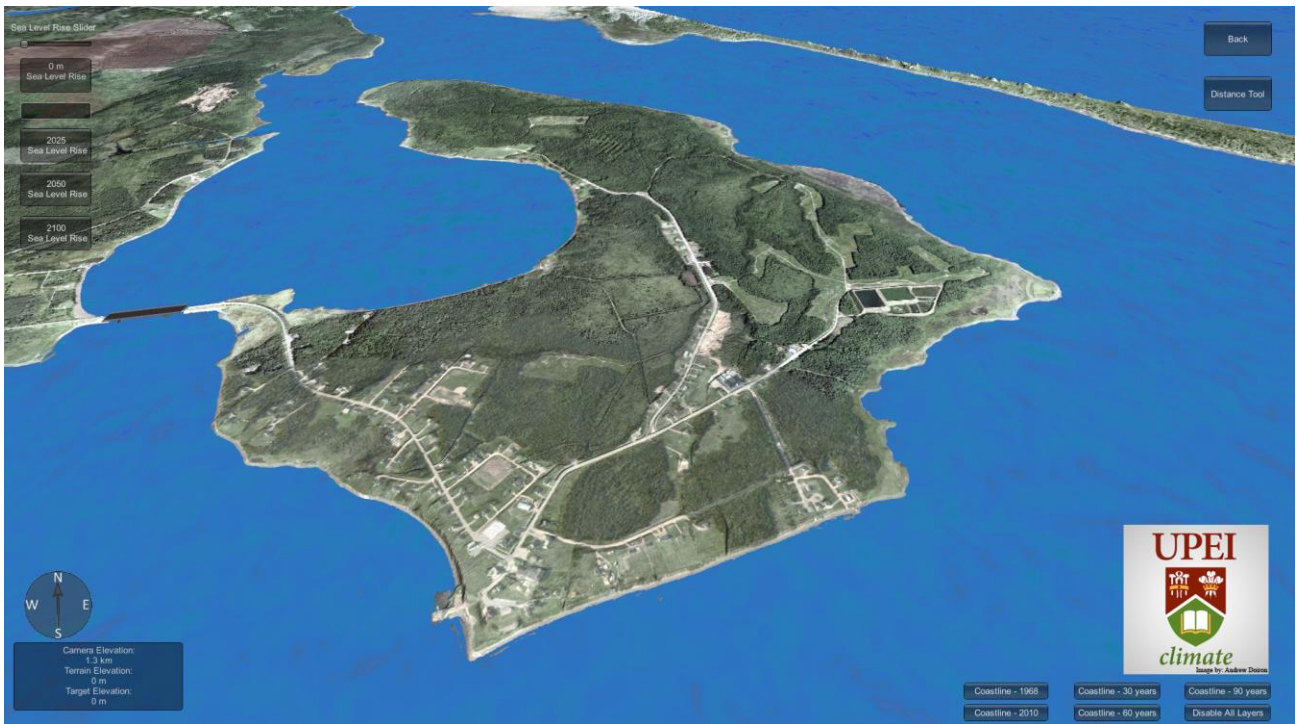


Figure 3: CLIVE Tool Showing Lennox Island in Current State
 Source: Screenshot of CLIVE by Andrew Doiron



Figure 4: CLIVE Tool Showing Lennox Island 2-meter Sea Level Rise
 Source: Screenshot of CLIVE by Andrew Doiron

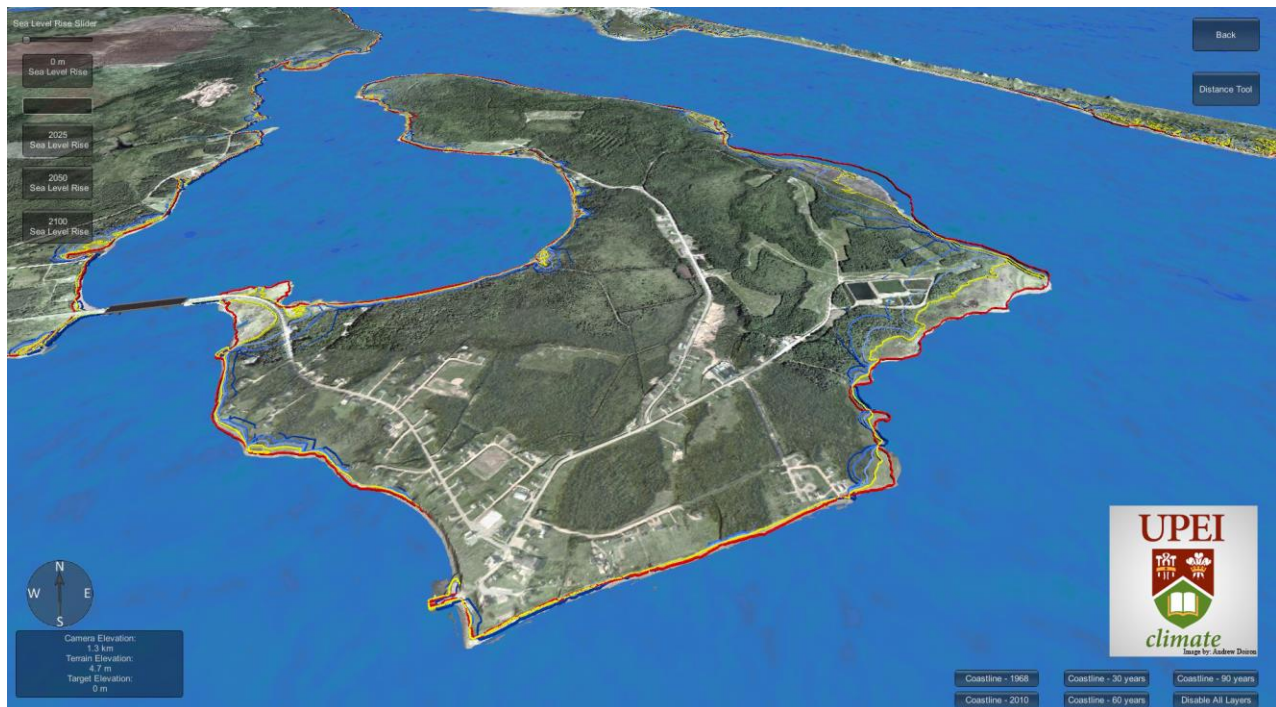


Figure 5: CLIVE Tool Showing Lennox Island Coastal Erosion
 Source: Screenshot of CLIVE by Andrew Doiron

3.2.2 AdaptNS

The second visualization tool used in this study is AdaptNS, which has been developed by researchers Andrea Minano and Peter Johnson at the University of Waterloo (Minano, 2015). This tool uses a 2D web-based platform derived from Google maps to display LiDAR derived sea level change and storm surge for nine communities in NS. Sea-level rise and storm surge projections for AdaptNS are derived from a NS- and PEI-based climate change study by Richards and Daigle (2011). AdaptNS allows users to interact with the tool and explore a range of scenarios differing in time frames (including the years 2000, 2025, 2055, 2085, and 2100), sea-level rise, and storm intensity (10-, 25-, 50-, 100-, and extreme-storm) (see Figure 6). Unlike the CLIVE tool, AdaptNS has an additional component through which users may geographically place and add comments regarding community concerns (e.g., social, cultural, or

environmental) and corresponding comments. Thus, the purpose of this tool is to allow a two-way stream of information regarding climate change impacts and vulnerability (Minano, 2015). It is important to note that although there is potential for the tool to represent a more holistic view on community vulnerability, the information represented by the tool is limited to physical vulnerability of sea-level change and storm surge. The data resources that were required to develop the tool make the tool difficult to iterate.

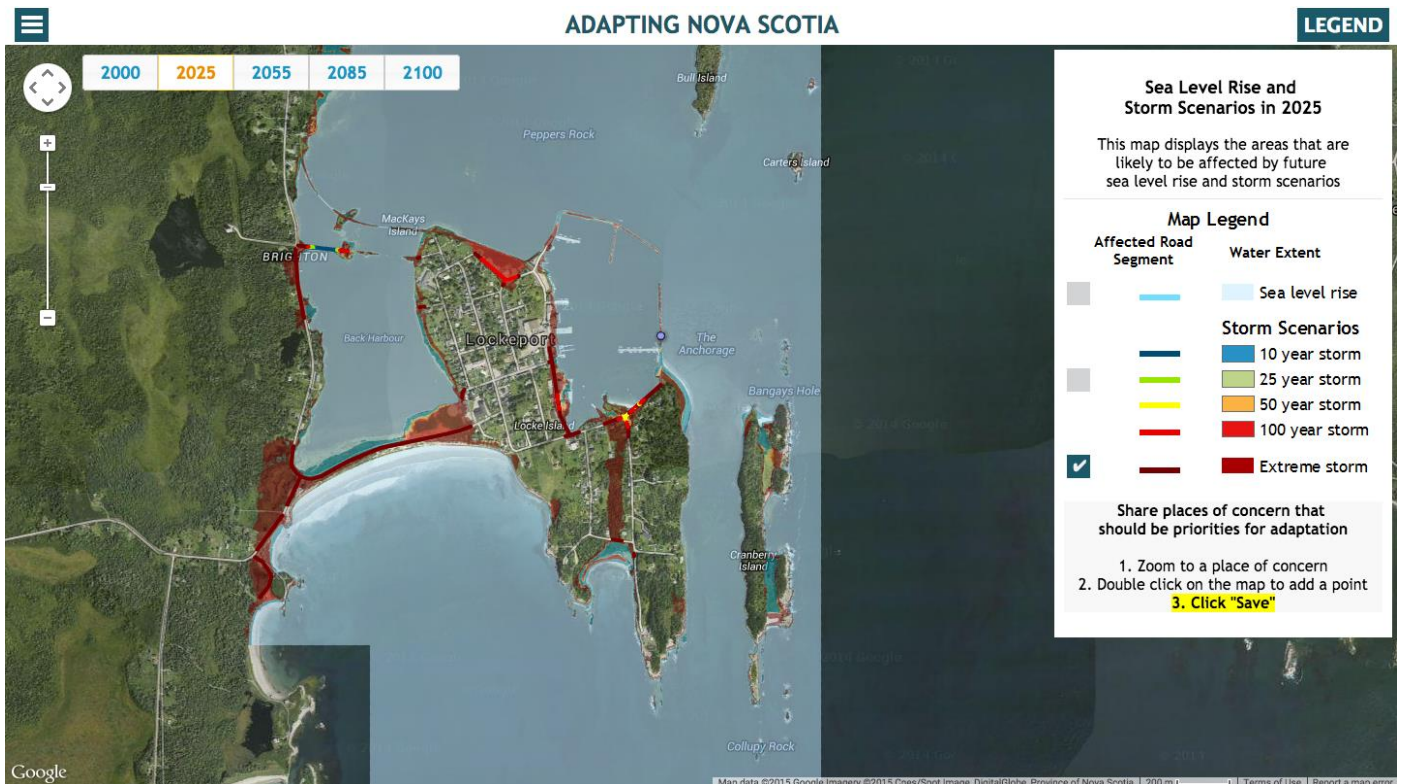


Figure 6: AdaptNS Showing Town of Lockeport in 2025
 Source: Screenshot of AdaptNS by Maliha Majeed

Table 2: CLIVE and AdaptNS Characteristics

Tool	Location	Purpose of tool	Data presented	Method of presentation	Capabilities	Limitations
CLIVE	Prince Edward Island	Awareness raising	Sea level change Storm surge Coastal erosion	3D GIS-based map	3D visual navigation	Private access Difficult to iterate No feedback incorporation
AdaptNS	Nine communities in Nova Scotia	Awareness raising Public communication Decision-making	Sea level change Storm surge	2D Web GIS-based Map	Feedback incorporation Potential for more holistic vulnerability representation Available online	Difficult to iterate

3.3 Methods for Data Collection

The methodology for this research study involved a series of steps over a two-year time frame (see Figure 7). The research concept initiated in consultation with Johanna Wandel whereby the study would explore the gap between vulnerability assessment and local-level adaptation. This concept further evolved when members of the ParCA project developed and introduced two different visualization tools: CLIVE and AdaptNS. The idea of using these tools was discussed to explore climate change adaptation in coastal communities. Preliminary visits to both Nova Scotia and PEI involved introductions by ParCA members (particularly Shandel Brown, Saveena Patara, and Randy Angus) to the study sites (Lockeport, NS and Lennox Island, PEI) and key stakeholders within each community.

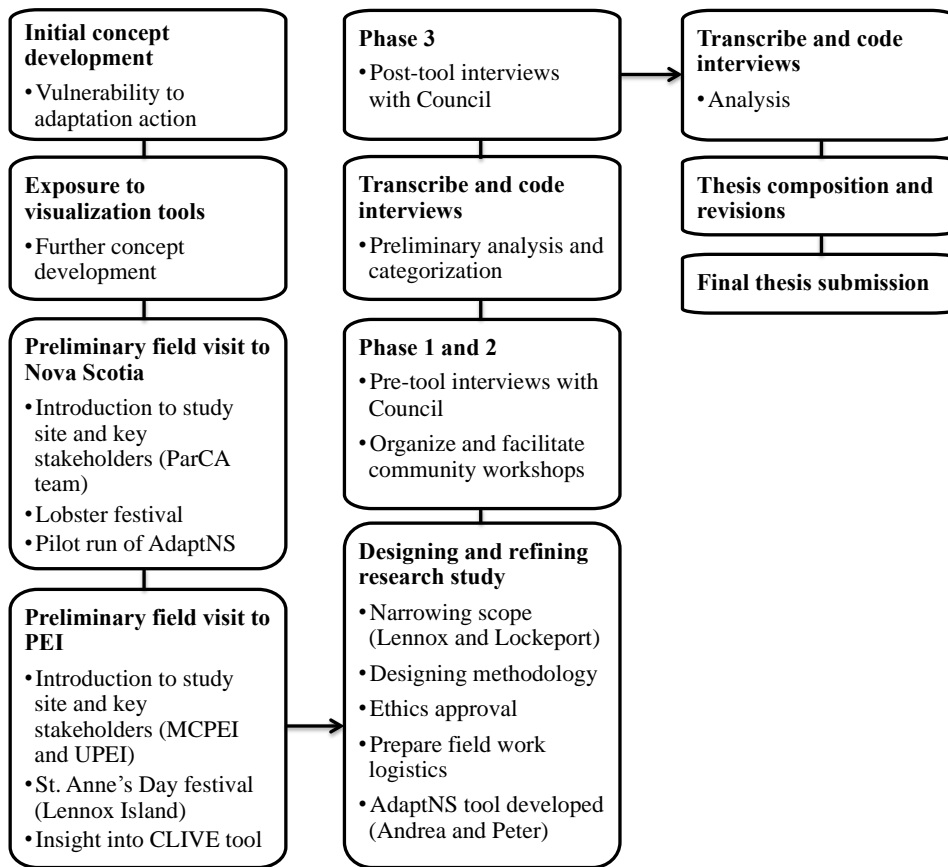


Figure 7: Research Methodology Flow Chart

The preliminary visits were significant components to the development of this research study as they involved pilot testing of the AdaptNS tool by Andrea Minano, and insight into the CLIVE tool by Andrew Doiron, Laura Sailsbury, Derek Ellis, Adam Fenech, and Don Jardine. These visits also allowed for me to elaborate on existing networks and introduce myself to both study site communities. Shandel Brown and Saveena Patara, and Randy Angus were key players in facilitating the introductory process in Lockeport and Lennox Island, respectively. In the Town of Lockeport, I was able to meet community members and councilors during the Lobster Festival over June 5-8, 2014. Similarly, I had the opportunity to meet community and Band Council members

of Lennox Island through the St. Anne's Day festival on July 27, 2014. Information from this visit provided context for workshop planning, questionnaire criteria development and provided useful information for substantive variables focusing on context-based adaptation.

After the preliminary field visits to both study sites, the designing and refining of the research study and detailed methodology took place. It was during this stage that ethics approval was attained for conducting three phases of fieldwork as part of this master's research. Concurrently at this time, Andrea Minano and Peter Johnson completed the development of the AdaptNS tool. From here, three phases of fieldwork were conducted for this study: one, pre-tool interviews; two, community-based workshops; and three, post-tool interviews. The details of the methods are described in this section using the two participant groups involved: key informant stakeholders and community stakeholders.

3.3.1 Key Informant Interviews

Key informant interviews involved one-on-one semi-structured interviews with local-level decision-makers of each community (Band Council and Town Council). Interviews were conducted before and after tool exposure. The goal of these interviews was to understand how priorities and perceptions on climate change adaptation may or may not shift after being exposed to a visualization tool. The interviews also discussed information needs before and after tool exposure and aspects of the tools presented. Pre-tool semi-structured interviews were conducted on October 20 and November 3, 2014 in Lennox and Lockeport, respectively. Post-tool semi-structured interviews were conducted on January 26 and January 29, 2015 in Lockeport and Lennox Island, respectively.

3.3.1.1 Participants

All council members (Lockeport) and Band members (Lennox) were invited to participate as key informant stakeholders. All participants were invited via e-mail communication. Phase one (pre-tool interviews) in Lennox Island involved 3 in-person semi-structured interviews and 1 telephone interview and phase two in Lennox involved only 3 in-person interviews (with the same 3 in-person participants as phase one), due to availability. In the Town of Lockeport, phases one and three involved 7 in-person semi-structured interviews (mayor, councilors, town clerk, previous town employee). All participants involved in phase three had exposure to a visualization tool.

3.3.1.2 Process

All interviews took place within each community, as this was most convenient for participants. The venues for interviews included the Town Hall in Lockeport and Lennox Island Band Office in Lennox Island. Information consent forms were distributed and completed at each phase of the study. The interviews ranged in length from approximately 15 to 70 minutes and were recorded using an audio recorder. Interviews were then transcribed using Transcribe ([transcribe.wreally.com](https://www.transcribe.wreally.com)) and coded using NVivo, which provided a platform to help organize and analyze data using common themes and topics of discussion. Once coded, a contextual analysis of the data was conducted.

The process of one-on-one interviews was ideal as it avoided a two-way stream of information, which as the literature finds can be derailing for a given discussion (Newig and Fritsch, 2009). Having a two-month gap before conducting the post-tool interviews was also ideal (even given the short time-frame of this project) because had post-tool interviews been conducted immediately after tool-exposure, it is possible that participant

responses to the tools would have been mixed with emotional reactions (Kollmuss and Agyeman, 2002), thereby potentially skewing the results. It may have been useful to conduct semi-structured interviews with non-state participants to obtain a broader understanding of the impact that visualization tools can have. Nevertheless, the conducted interview process was sufficient for the scope and scale of this study.

3.3.2 Community Workshops

Community-based workshops were held in Lockeport (November 13, 2014 – 2-hour workshop) and Lennox (November 20, 2014 – 3-hour workshop). The purpose of these workshops was to introduce and expose wider community participants to a visualization tool (AdaptNS in Lockeport and CLIVE in Lennox Island) and conduct a questionnaire to understand how participant priorities and concerns regarding their community may or may not change after being exposed to a visualization tool.

3.3.2.1 Participants

Community workshop participants were directly invited, using e-mail to all those with e-mail addresses held by the Town Office and poster invitations throughout the town in the Town of Lockeport and mass-mail out to all Lennox Island community members and poster invitations in Lennox Island. All participants were over the age of 18. A total of 14 participants were present at the Lockeport workshop and 23 participants at the Lennox Island workshop. In Lennox Island, all but one band member attended the workshop. Participants included band staff, general community members with an interest in fisheries and tourism, lobster fishermen, crab fishermen, carpenter, basket weavers (tourism), retired community members, fish plant employees, and tourism business employees, In the Town of Lockeport, all but 2, council members made an appearance –

those who were unable to attend in Lockeport were given the same visualization tool exposure presentation prior to the workshop. Generally, participants in Lockeport included councilors, town employees, business owners and managers, retired community members, and teachers.

3.3.2.2 Process: Structured Questionnaire

For each community, a questionnaire was developed posing questions to help understand how exposure to the visualization tool may or may not change perceptions on climate change and climate change adaptation needs and priorities (see Appendix A & B). Questionnaires were completed as one component of the community workshops (other components included providing participants with an overview of climate change vulnerability and adaptation, tool introduction and interaction, and group discussions).

The questionnaire included a map of the community being surveyed on which participants were asked to label three sites or geographical areas of importance to them that must be protected (see Appendix B and C). Next, the following two questions were asked:

1. List the top three actions needed to protect your community
2. Who is responsible for climate change adaptation in your community?

Lastly, a series of criteria were listed on a Likert scale of importance (Garland, 1991) for which participants were asked to rank in importance from not at all important, not important, neither important or not important, important, to very important. Criteria were adapted from adaptation response findings within the literature (Vasey-Ellis, 2009; Zeppel, 2012) and included procedural variables focusing on theoretically broad areas of climate change adaptation (e.g., relocate roads, relocate buildings) and substantive

variables focusing on context-based adaptation foci (e.g., band council's role in adaptation strategy development). These criteria in combination with previously mentioned questions were used as the basis of a before- and after-tool exposure questionnaire for participants to qualitatively understand change in perceptions. All questionnaire data was organized and analyzed using Microsoft Excel.

The questionnaire developed for this study seemed to resonate better with participants at the Lockeport workshop (higher completion rate). Perhaps a closer examination at contextual preferences (Few et al., 2007) or combining multiple methods of engagement (Brody, 2003; Reed, 2008; Lawrence, 2006) could have allowed for a stronger response rate in Lennox Island.

3.3.2.3 Process: Workshop

To maximize accessibility, workshops took place within each community, as suitable for the participants. Each community donated the use of a workshop venue and presentation screen. Workshops took place in the Lockeport Recreation Center (Lockeport), and the Lennox Island school gym (Lennox Island). Supper service was ordered from the Town Market in Lockeport and the Aboriginal Women's Association in Lennox Island. After consulting with community leaders, it was decided that in addition to supper being provided, a prize draw would be included as part of the recruitment process for the Lennox workshop; this is conventional for researchers in aboriginal communities. To maximize community engagement and participation, the timing for data collection was selected based on off-peak tourism and fishing seasons.

During the workshops, participants were first introduced to the study and climate change vulnerability and adaptation concepts. Participants were then asked to fill out

questionnaire “1” of two identical questionnaires, located within an envelope that was placed at each seat. Participants were then introduced to the tool, which, depending on the tool, involved varying levels of interactivity. AdaptNS, presented by tool developer Andrea Minano, involved the shared use of four tablets and one laptop. Andrea provided an overview of her tool by visually presenting the various future sea level rise scenarios in years 2025, 2055, 2085, 2100 and corresponding variations in storm intensity. Participants were able to physically interact with AdaptNS using provided tablets; through this participants were able to explore and zoom in and out of the map. I provided assistance to answering participant questions and helping with technological errors (such as the tablet turning off or zooming to an unknown region) during this time. In Lennox Island, CLIVE was presented by Derek Ellis and tool developer Andrew Doiron and involved one main screen showing the tool. Derek and Andrew provided an overview of existing climate change related challenges in PEI (such as historic flooding events) and subsequently presented the CLIVE tool, visually outlining scenarios of one, two, and three meter sea level rise (accounting for impacts of storm surge) and corresponding rates of coastal erosion. During tool exposure in Lennox, discussions took place whereby participants requested to see certain regions of the island under certain scenarios using CLIVE. During tool presentations in both study sites, I provided technical support to the tool presenters, as needed, and observed participants. After approximately 60 minutes of tool exposure, participants completed the second questionnaire (identical to the first and labeled B).

The process of having a large group discussion made for a challenging environment for data collection. As found in the literature, one-way communication is

ideal for stakeholder engagement processes (Newig and Fritsch, 2009). Holding a workshop was, however, an effective way to reach a variety of stakeholders in a time-efficient manner. Having focus groups with multiple facilitators could have been a more suitable approach.

Chapter 4: Results

This chapter will provide insight into the results of this study. First, the findings from the pre- and post-tool key informant interviews will be discussed for each study site by revisiting each research objective. Possible reasons for any stated changes in awareness or priorities will be discussed. A section discussing certain aspects of each tool that stood out will follow this. Next, the findings from the community workshops will be discussed. This section will examine how priorities changed after community participants were exposed to a visualization tool and reflect on possible reasons for these changes.

4.1 Results from Key Informant Interviews

The results from pre- and post-tool key informant interviews are outlined in this section and organized by research objective (awareness, priorities for potential action, and aspects of the tools) and study site (Lennox Island and the Town of Lockeport).

4.1.1 Awareness

Lennox Island

Key informant interviews in Lennox Island revealed existing awareness regarding a number of factors. Some of these factors were unique to pre-tool interviews and some were discussed both before and after tool exposure. Topics unique to pre-tool interviews included the concern for **groundwater supply**; one participant noted: “our water supply and our water lagoon...is really part of our lifeline here on Lennox Island. It is ultimately our lifeline on Lennox Island...and if that's damaged or breached [with saltwater], I'm very concerned for all community members” (Participant 8, personal interview, 2014). In reference to if the groundwater supply were to be breached with saltwater, the effects of such an impact were questioned: “what will be the effects of that? Will we be done? I

think so” (Participant 8, personal interview, 2014). The topic of groundwater supply was not raised in post-tool interviews; this is likely because the CLIVE tool did not address groundwater changes.

Another factor unique to pre-tool interviews was the awareness of **rising temperatures** and the associated adverse impacts as well as potential benefits. One participant stated, “when it's too hot, they [community members] don't wanna leave the house really. Get out in the sun, it's real bad, especially the elders, they have a hard time getting around and stuff” (Participant 9, personal interview, 2014). Another stated Lennox Island is “the best place to be. You couldn't ask for a better place. So in the summer if the heat's going to rise, that would probably be a benefit” (Participant 8, personal interview, 2014). This was not elaborated on greatly. The CLIVE tool presented to Lennox Island participants did not address temperature changes; this may have been a reason why this factor was not raised during post-tool interviews.

Another topic discussed only during pre-tool interviews was the role that the **sand hills** bordering Lennox Island play in protecting the island. One stated, “if the sand hills wasn't there we'd, I don't imagine we'd be here... sand hills ever let go there and we'll be gone...It's pretty big break but, that's gettin pretty narrow too. Before we even fix here, we should try and do something over there, cause that's the main part of, us. It's the sand hills because if the sand dunes go, like I say, we don't have much of a chance here. Not only here, across all the communities nearby” (Participant 9, personal interview, 2014). The topic of sand hills was not raised during post-tool interviews. The CLIVE tool did take the sand hills into consideration with sea-level rise and erosion. Thus, it is possible that the attention of participants was simply diverted to direct impacts to their Island, as

opposed to the impact on the sand hills, possibly explaining why the area did not receive any attention during post-tool interviews.

A factor that was acknowledged and discussed dominantly in pre-tool interviews is the topic of **sea-level rise**. One participant acknowledged, “sea rise on Prince Edward Island as a whole was alarming” (Participant 8, personal interview, 2014). The participant elaborated on the impact of the rise on the sand hills: “the levels of rise on our protectors here which would be sand hills, that's gonna be, that's kinda like buffering us from the Atlantic” (Participant 8, personal interview, 2014). Considering sea-level change was one of the main physical components represented on CLIVE, it is surprising how little the topic is discussed in post-tool interviews. There are two possible reasons for this: one, sea-level rise was considered the primary threat to cause saltwater intrusion of groundwater sources. As groundwater was not represented in CLIVE, it is possible that attention was diverted elsewhere; two, post-tool interviews included a great deal of discussion surrounding storm surge. It is possible that the terminology for sea-level and storm surge was merged into one by participants (who may have perceived the two impacts as one) after viewing the CLIVE tool. This is possible as the tool displayed the fluctuation of storm surge on top of sea-level rise data, making it appear as one type of physical change (as opposed to two distinct impacts).

Next, there were several factors of awareness that participants discussed during both pre- and post-tool interviews. Firstly, the awareness of **storm surge** as a threat to the island was raised to be an issue. During pre-tool interviews, this was expressed through comments such as “our water surge came up quite a ways. Seems to be coming up farther and farther every year” (Participant 9, personal interview, 2014). Others discussed the

extent to which the water levels were reaching nowadays: “the tide comes really high, sometimes it's right up to the rocks” (Participant 10, personal interview, 2014). Another said “we had water damage, like people with um floods from the storm surge, like they were affected” (Participant 8, personal interview, 2014). During post-tool interviews participants revisited their concerns with storm surge being an issue. One stated, “I know from personal experience here in the community where we've had storm surges with high tide, and it is eye opening” (Participant 8, personal interview, 2015). Another stressed, “the lower places, like there's a lot of places and they've got houses on low areas...the last time we had a storm surge. And the way that tool looks, if it's gonna keep going the way it's going, then those places won't even be there in 25 years probably” (Participant 9, personal interview, 2015). The CLIVE tool did demonstrate how storm surge would impact the community; this was likely an influential factor for ongoing awareness and discussion regarding the impact and risk of storm surge.

Another factor common to both pre- and post-tool interviews is the vulnerability of the island’s **sewage treatment plant** (or **lagoon**). During pre-tool interviews, one participant was expressed their concern by stating, “if that's [the lagoon] damaged or breached, I'm very concerned for all community members” (Participant 8, personal interview, 2014). Through discussions it was revealed that an engineer assessment stated the lagoon would be “OK” in terms of its vulnerability (Participant 8, personal interview, 2014). However, in post-tool interviews, concern was expressed by the same participant, “I'm kind of concerned about our lagoon, cause it is really low-lying...but supposedly, according to our engineers, we're going to be alright. I'm still kind of dubious because it is quite low-lying” (Participant 8, personal interview, 2015). Another participant said, “I

don't know how we're going deal with the lagoon anyways because it's in a low, low area” (Participant 9, personal interview, 2015). The same participant elaborated, “you can...put all the filling you want, the water's going to take it away...that's a low period. They already built that up quite a bit up there. They built some up, and then it just dropped off” (Participant 9, personal interview, 2015). This shows that the CLIVE tool may have influenced an increase in concern regarding an area that was previously considered a managed risk. This is likely because the positioning of the lagoon is in a geographically low-lying area, making it highly vulnerable to the physical impacts that are represented through CLIVE.

The last factor common to both pre- and post-tool interviews is **coastal erosion**. During pre-tool interviews participants stated, “you can still see erosion up the banks” (Participant 9, personal interview, 2014) and “it [erosion]...washed out a lot of places all around the island” (Participant 10, personal interview, 2014). Though participants were aware of erosion being an issue on the island, there was an extensive amount of discussion surrounding erosion during post-tool interviews. The same participants stated, “I don't know if there's going to be much of an island here in a hundred years” (Participant 9, personal interview, 2015) and “there's a spot down the road there, there's a house probably about 50 feet from the edges of the shore and I imagine another ten years and they're gonna...they loose about a foot a year!” (Participant 9, personal interview, 2015). Another stated to be “surprised to see how much erosion it will be!” (Participant 10, personal interview, 2015). Further concerns were expressed as one stated, “over [on] this side, we're high up, but we're still vulnerable to erosion...We have a graveyard that's right there and then houses along here and houses along there” (Participant 8, personal

interview, 2015). It is apparent that the visual exposure to erosion through CLIVE raised awareness and concern towards the issue.

Lockeport

Key informant interviews in the Town of Lockeport revealed an existing awareness regarding a number of factors. Almost all factors were discussed during both pre- and post-tool exposure interviews with occasional emphasis on one or the other.

Firstly, the **vulnerability of elderly community members** was discussed as a concern. One participant stated, “we are down here in the middle of nowhere...and when you're in the middle of a hurricane, you're not going to put an elderly person in a helicopter...or a fishing boat” (Participant 1, personal interview, 2014). Another expressed, “so let alone if there was an injury due to a weather event, that would be one thing, but daily the ambulance from Shelburne comes in from Shelburne to pick up someone at the nursing home and take them to the hospital for whatever reason because they're elderly and they're in a nursing home” (Participant 2, personal interview, 2014). During post-tool interviews, the same participant restated their awareness of the vulnerability of elder residents, “the nursing home - one of the biggest employers in town. A vulnerable location, and we're dealing with a lot of people that can't jump in a car and take off in the event of a storm” (Participant 2, personal interview, 2015). Another stated, “when you stop to think that you have a large portion of your population that you can't serve, you can't even reach, they're isolated, cut off - you know elderly, a lot of people here are elderly. So to provide them with ambulance service or fire protection or just the basic services that they expect, how can you do it” (Participant 7,

personal interview, 2015). The awareness and concern for the vulnerability of the elderly population in Lockeport remained quite similar during pre- and post-tool interviews.

Next, the general awareness of **social vulnerability** was discussed during both interviews, but mostly during pre-tool interviews. One participant stated, “how do we get people to look at things differently? By allowing a town to be affected by climate change and the forces of climate change, not only do you see a breakdown in physical infrastructure, but you also see a breakdown in social, community, and family structure. We're much better at measuring and putting a dollar amount on the physical infrastructure; but the dollar amount that is tied up in people's social affiliation with a community is priceless. So, it is a cost, without a dollar figure attached. But that dollar figure...in breakdown of families, in people's need in support from department of community services, in education not being finished, in health and wellness, in dependence - substance dependence, all these things are huge!” (Participant 3, personal interview, 2014). During post-tool interviews, the same participant briefly acknowledged awareness of social vulnerability again, “do we even have to think about is relocating something that in the long run would be more beneficial? If you do that, you have all the social aspects” (Participant 3, personal interview, 2015). It is possible that other participants did not discuss social vulnerability because it is difficult and often not possible to visually see social vulnerability, especially through the tool used, which only showed physical vulnerability.

Another factor discussed during both interviews was the **vulnerability of the power station** within Lockeport. Participants expressed their concern “I would like to see the power station relocated” (Participant 1, personal interview, 2014). Another said, “our

power source is very very vulnerable...our power distribution station is in the very low end of town. When we had one of the last storms, I mean the water came, you know, right up to the bottom of the superstructure!” (Participant 3, personal interview, 2014). During post-tool interviews, the same participant exclaimed, “the power substation. It's gonna happen! That's gonna flood!” (Participant 3, personal interview, 2015). Others stated, “I would definitely like to see Nova Scotia Power address the issue there with the substation...” (Participant 1, personal interview, 2015) and “I think Nova Scotia power is quite aware of it; but again, that tool [AdaptNS], if that's available to them, they would be aware of it” (Participant 2, personal interview, 2015). It is evident that exposure to AdaptNS and being able to view the impact of sea-level rise and storm surge on the power station provided a greater awareness about the vulnerability of the power station. It is also interesting to note that participants only pointed towards Nova Scotia Power during post-tool interviews; this is possibly because the awareness of the threat to the station triggered an emotional or actual intent to act.

Next, awareness regarding the vulnerability of the Town to impacts of **storm surge and flooding** was acknowledged during both interviews. One participant provided an example, “when hurricane Bill flooded our museum complex and shut the road into Lockeport back in 2009...we had our museum complex was flooded, we were cut off from the mainland for about 45 minutes” (Participant 2, personal interview, 2014). Another said, “I have seen the effects of erosion and climate change and the tidal surges growing over the years” (Participant 7, personal interview, 2014). Participants elaborated during post-tool interviews, “you do get flooding along rivers and roads washing out and things like that but...all our services whether it's the water or the power or first

responders or transportation for economic purposes are affected by one or two pieces of geographic placement” (Participant 2, personal interview, 2015). Another stated, “we've had a lot of rain and everything and the storm surges seem to be more frequent. But, I think we discussed that the last time, that the storm surges were becoming more frequent and they're continuing that path” (Participant 1, personal interview, 2015). This quote validates the constant concern for the impact of storm surge and flooding. Others stated particular areas that had flooded in the past, “substation down there is prone to flooding” (Participant 2, personal interview, 2015) and “it [the power station] was flooded - it was flooded extremely high! It was flooded right back to the street, the homes across the street” (Participant 1, personal interview, 2015). Another said, “I was not aware until you people did this study [with AdaptNS] and I seen this study here. Which is in regard to the south end of town, there's a low area, which I was not aware of. That tidal surge would virtually separate one part of the town from the other...I don't know that we were aware of that until we saw the tool and the projections of tidal increasing” (Participant 7, personal interview, 2015). It is evident that there was a great deal of existing awareness on how storm surge and flooding has impacted the town, however tool exposure showing physical impacts of storm surge on Lockeport was definitely an influential factor for further increasing awareness on storm surge and flooding.

A topic that was discussed during both pre- and post-tool interviews, but emphasized during post-tool interviews is the **vulnerability of the causeway (bridge)**. Participants expressed, “we are pretty much cut off from the rest of the world in an event that takes out our causeway” (Participant 1, personal interview, 2014). The same participant elaborated, “that is our only access...over the next five years I'd like to see a

second access” (Participant 1, personal interview, 2014). Another stated, “my one dream would be that we had a second access, on and off the island” (Participant 4, personal interview, 2014). During post-tool interviews, the same participant acknowledged, “one of my main concerns with the Town of Lockeport is our isolation and that we only have one access road off the island” (Participant 4, personal interview, 2015). Other participants also acknowledged the causeway’s vulnerability, “we know that that access road is going to go” (Participant 7, personal interview, 2015). Another stated, “there's one access into and from the town, which is breached almost annually, sometimes a couple times...in my adolescent years, even in my young adults, I had never seen our main access road breached ever. So with the tool and because you're able to project the rapid progression of things, people realized look...this crisis could be upon us anytime. We're facing a major storm Tuesday, tomorrow! So within a matter of days we could be looking at this. It's not a matter of being able to look ahead for years. Days! So this tool makes us aware. This is a crisis - an imminent crisis” (Participant 7, personal interview, 2015). Participants’ awareness of how Lockeport’s causeway is vulnerable was greatly emphasized after tool-exposure. This is likely because the tool represented the great extent to which the causeway is expected to be impacted by sea level rise and storm surge – and that is without consideration of erosion, which is already an ongoing issue.

Another factor mostly raised in post-tool interviews, though it was mentioned once during pre-tool interviews, is the vulnerability of **Chetwynd’s Lane**. In pre-tool interviews, it was revealed that the area of Chetwynd’s Lane was known to have low elevation: “we've got a whole section of road, very short road...Chetwynd's Lane, [that] is getting worse and worse all the time - so yes, we know that we have to elevate that

road at some point” (Participant 1, personal interview, 2014). No further elaboration on the vulnerability of this area existed until post-tool interviews. One participant stated, “Chetwynd's Lane. And also, just down from Rood's head. It's where the land goes across and separates and would almost separate the island in two...of course we're going to have erosion of the road. We've reinforced some of it, but the rest of it is vulnerable” (Participant 3, personal interview, 2015). Another expressed, “I don't think that anybody, even the people...that live there. We were not aware of the urgency of that crisis until we saw this [the tool]. The town would literally be cut in two. And these people would be separated and isolated. And when you stop and think of things like ambulance and policing and if the power is out servicing out people that live there...it's the tool that made us aware of this” (Participant 7, personal interview, 2015). These quotes identify how participants became aware of the extent to which Chetwynd’s Lane is expected to be impacted by climate change, particularly sea-level rise and storm surge; it was the AdaptNS tool that made people more aware of this vulnerability.

Lastly, a surprisingly little amount of discussion was based on **sea-level rise**. Only one participant elaborated on this factor during post-tool interviews by stating, “sea level rise...was probably the one that hit home the most because it gave people the understanding of again their access to services, their access to whether it's getting to the store, whether it was the sewer system, whether it was the fire trucks getting to them in emergencies, medical whatever...I think it brought to the forefront” (Participant 6, personal interview, 2015). It is interesting to note that sea-level rise was one of the main components represented through AdaptNS but was not discussed as a great concern. Similar to Lennox Island, it is possible that the physical impacts of sea-level change and

storm surge were merged and perceived as one physical impact (even though the two impacts are separated on the tool) or that storm surge resonated better with participants than sea-level rise; a possibility since flooding and storm surge were discussed extensively during both pre- and post-tool interviews.

4.1.2 Priorities for Potential Action

Lennox Island

Several factors that were considered priorities and areas/topics in need of action were discussed through the interview processes. In this case, all factors were either discussed in both pre- and post-tool interviews, or only in post-tool interviews.

Firstly, the need for **financial resources** was expressed during both interviews. During pre-tool interviews, one participant expressed, there is “not enough time to go and bank everything down here. Like, we don't have the money for that. There is no money for that!” (Participant 8, personal interview, 2014). Another stated, in reference to banking up shores, “I don't know if we have enough money to do it ourselves...we only get so much money, eh, from the province or government” (Participant 9, personal interview, 2014). Another said, “if we could only have all that around the bankings it would be good, but, it's expensive as usual” (Participant 10, personal interview, 2014). During post-tool interviews, participants continued to express the need for finances by stating, “there's the shoreline protection - at a massive scale, which is going to cost a lot of money” (Participant 8, personal interview, 2015) and “being an island and the cost of everything, you know, it's ah, money really is our need right now...“it's gonna cost a lot of money to protect this whole place” (Participant 8, personal interview, 2015). Another said in reference to adaptation initiatives, “all of that costs money” (Participant 10,

personal interview, 2015). It is evident that the need for financial resources was and remained a significant priority for participants before and after tool exposure.

Next, the need for **more information and/or education** was expressed as a priority during both pre- and post-tool interviews. As for needing accessible and accurate climate information, one participant stated, “I need more data here because I need to see what the erosion rates are...I do need more information” (Participant 8, personal interview, 2014). Participants elaborated on the use of information and the need to take this further to educate community members. One stated, “we have to educate the community to what climate change is” (Participant 8, personal interview, 2014). Another expressed, “if we had more information sessions...to show them what's going on, how much corrosion is coming off our banks here every year. I think they [community members] need a hands on look at things, instead of just telling them what's going on. They've got to see it” (Participant 9, personal interview, 2014). During post-tool interviews, the perceived need for information and education remained strong. The same participants expressed, “[we need] education at a community level because, like I said about infrastructure...in getting that knowledge, like in being equipped - we need to be equipped with that research that's available to us so that we can...give that knowledge to our community” (Participant 8, personal interview, 2015). The participant elaborated, “education, for sure [is needed], because then people wouldn't want to build in those low-lying areas. And it's our due diligence to ensure that people don't, with the information that we have...The more knowledge I know in terms of our vulnerabilities, the better for us...That's half the battle. Instead of waiting for everything to collapse around us, at least we can be proactive in our planning process” (Participant 8, personal interview, 2015). It

is likely that CLIVE, which provided some information, triggered a need to further explore the impacts Lennox Island is expected to face as well as to share this information with all community members.

Another factor of concern raised during both interviews was the need to protect the **causeway (bridge)**. Pre-tool interviewees expressed, “we had a storm surge, not this one passed but the one before I think it was in 2010. We had the bridge on this side eroded and then um, you know the rails when you're coming on the bridge, the rails actually fell down because all that eroded” (Participant 8, personal interview, 2014). The participant further expressed the potential need to replace the bridge: “our bridge was built in 1972, 42 years ago and it's 45-50 year lifespan...we started last year on phase 1 of phase 2 of bridge repairs, but...eventually we're gonna have to have a new bridge. But I don't know how long that's going to hold us over, like how many years...again it goes back to data” (Participant 8, personal interview, 2014). This quote highlights the acknowledgement of the bridge needing attention, but the uncertainty regarding timelines. During post-tool interviews, the same participant stated, “well it [the bridge] was only designed to last 45 years. 45 - 50, I'm gonna say, stretch it and say 50. But we're at the end of that cycle now” (Participant 8, personal interview, 2015). This response was an acknowledgement that the bridge is definitely ready for replacement. Another stated, “we gotta keep an eye on our bridge. We don't wanna lose that! Cause we lost part of that road before...You gotta do a lot of planning cause you gotta plan to do something about the bridge, you gotta plan to do something with the low areas, you gotta plan about this here” (Participant 9, personal interview, 2015). It is evident that there is a concern regarding the bridge and need for attention towards protecting and potentially replacing

the bridge, particularly during post-tool interviews. The CLIVE tool does show the impact of sea level rise and storm surge on the island's bridge, which is likely the reason why participants expressed more attention towards protecting the bridge during post-tool interviews.

Next, the need for **expert assistance** was discussed in both interviews, but emphasized greatly in post-tool interviews. One participant said, "I need some engineers to come in and help...figure out what do we do for the immediate" (Participant 8, personal interview, 2014). During post-tool interviews, the same participant expressed again, "I think we need...engineers equipped with that research. You know, could make some really good recommendations in terms of building" (Participant 8, personal interview, 2015). Another stated, "we would probably have to bring in some...[engineers]...in here somehow or something to survey around and, that costs...Has to figure out what parts we have to work on" (Participant 9, personal interview, 2015). It is likely that the awareness of potential impacts gained through viewing CLIVE raised concern and interest to learn more about the expected impacts. This ties in closely with the next factor, which is the need to do a cost-benefit analysis to determine the pros and cons of addressing adaptation issues.

The need for **cost-benefit assessment** of different options was discussed only during post-tool interviews. One participant stated, "I don't know if they'd have to build that up or...see that's another thing, if we build it all up and it washes away...you're just wasting your time" (Participant 9, personal interview, 2015). The participant elaborated by saying "all the money you'd be spending on trying to fix something and may be gone the next week with all the storm surge that we're having now...sometimes I wonder, you

know you'd be putting millions of dollars into something and thinking it'd wash away” (Participant 9, personal interview, 2015). The participant expressed the need to bring in experts to conduct “surveying the areas, use the tool...then we'll know where to start to try and do something” (Participant 9, personal interview, 2015). Others also stated similarly that there is a need for recommendations prior to making decisions (Participant 8, personal interview, 2015). One participant emphasized, “I'd like to see it [an assessment] getting started. It's something hard to start building around it, seeing somebody to see [assess] what to do” (Participant 10, personal interview, 2015). It is evident that the CLIVE tool is linked to this perceived need to weigh options and proceed accordingly, as the tool showed various hypothetical scenarios of physical impacts the island may face.

The need to address **coastal erosion** was discussed in both pre- and post-tool interviews. During pre-tool interviews, one participant expressed what they have done on their personal property to address erosion: “I have rock all around where I live...we put it in there because of all the erosion” (Participant 10, personal interview, 2014). Though others expressed the impact of erosion on various parts of the island, the need to further protect was not emphasized until post-tool interviews. Participants stated, “there should be lots done like building up rocks like they did on along the wharf. But all of that costs money” (Participant 10, personal interview, 2015) and “we're gonna have to start trying doing something. We're really gonna have to start doing something I guess, especially if your place has been washin up fast” (Participant 9, personal interview, 2015). Another stated similarly, “our needs here are huge...there's the shoreline protection - at a massive scale, which is going to cost a lot of money” (Participant 8, personal interview, 2015). It

is evident that the perceived need to act to protect the island from coastal erosion increased after tool exposure. This is likely because of the demonstration of how erosion is expected to impact the island over the next 30, 60, and 90 years.

Another perceived need brought up during pre-tool interviews but emphasized mostly during post-tool interviews was the need to consider **future generations and consider longer timeframes**. During pre-tool interviews, one participant stated, “maybe 50 years time, maybe gonna be a lot of sand gone from the island. Can't get it back - it's not coming back. Once it's gone it's gone” (Participant 9, personal interview, 2014). Though the thought of thinking long-term was present, it was not until post-tool interviews that the need to protect future generations was emphasized. The same participant stated, “I don't think I'll have to worry about it but my kids might! My grandchildren. And the way that tool looks if it's gonna keep going the way it's going, then those places won't even be there in 25 years probably...we're gonna have to start doing something soon” (Participant 9, personal interview, 2015). Another stated, “the second thing [needed] is our community planning in terms of long term. And now we've been here for ages and this is our home. And for new buildings and more development, more thought has to be considered about not only us and our children, but our grand children, great-grandchildren, down to seven generations...will this place be around in seven generations...” (Participant 8, personal interview, 2015). The participant also stated, “...we could all hope that things will change, but in a short period of time, 50 years is not a long time, 100 years is not a long time, in the big scheme of things with climate change” (Participant 8, personal interview, 2015). It is evident that seeing various physical changes expected to impact the island over time triggered a perceived need to

prioritize the lives of future generations and think with a longer-term mindset.

The last factor that was only discussed during post-tool interviews is the perceived need to consider **moving off the island** as an adaptation option in dealing with climate change. A participant expressed, “if it's not feasible for a long term fix for mitigation like in terms of shoreline protection, then we need to start developing off the reserve. We have land off-reserve that we could build upon” (Participant 8, personal interview, 2015). This statement demonstrates that the physical impacts presented through the CLIVE tool may have caused participants to seriously think of more drastic adaptation strategies as a method of dealing with climate change.

Lockeport

There were many factors that were considered priorities and areas/topics in need of action discussed through the interview processes in the Town of Lockeport. All factors were discussed in both pre- and post-tool interviews, but some of these factors were emphasized more so during post-tool interviews.

Firstly, the **need for financial resources** was expressed as a great concern for participants during both pre- and post-tool interviews. Participants stated, “as small town, municipal unit, we don't have a lot of money” (Participant 4, personal interview, 2014) and “Money. That is our biggest challenge” (Participant 1, personal interview, 2014). Others expressed, “[we] don't have the resources nor the money to even consider or moving the town or even putting things in place to shore up the rock, roads, or shore up the shorelines and put all these by-laws in place that may or may not do anything for us” (Participant 6, 2014) and “what good is it doing any of these other things if there's no flippin money to do anything else?” (Participant 3, personal interview, 2014). During

post-tool interviews, participants continued to express the need for money as a concern: “on a municipal level, even if we amalgamated with the Town of Shelburne and the Municipality of Shelburne, I'm not sure on a Municipal level that any one of us or even as a group could reach those financial costs [needed]...we're really going to have to look at it...and it's scary!” (Participant 4, personal interview, 2015). Others stated, “we know that some of those actions are gonna cost a lot of money and we're just not prepared” (Participant 2, personal interview, 2015). One participant said, “we, the town of Lockeport doesn't have funds available, I would very much like to see somebody who does have funds available and I know the Provincial and the Federal governments are strapped as well, but they are in a better financial situation than we are” (Participant 3, personal interview, 2015). The participant elaborated on the extent to which finances are needed, “anything you wanna do always involves money. Right. Even if it's something as simple as changing a by-law...it has to be put through the public, it's got to the lawyer, it's got to be read out twice in council, it's got to be published in the newspaper. These things all take money. So when you have an incredibly limited budget, how do you do these things?” (Participant 3, personal interview, 2015). One participant pointed out the complexity of financial limitations, “the taxes are high, the people are elderly, most are on fixed incomes. It's just hard to generate the revenue - well it's impossible to generate the revenue that we would need to tackle these problems. We just cannot do it. Just cannot...we do not have the financial resources” (Participant 7, personal interview, 2015). The participant concluded with, “we do not have the ability to provide, to raise, the capital that it would take to begin to resolve these problems. Now we done patchwork things, 2 or 3 hundred thousand dollars, which most of that has come from Federal or

Provincial money and we put in a little bit...because of our financial limitations that we'd have to do things in small steps” (Participant 7, personal interview, 2015). The concern for financial need was ongoing during both pre- and post-tool interviews.

Another factor of concern revealed was the **need to consider weighing adaptation options (cost-benefit)**. During pre-tool interviews, participants expressed, “you've got to weigh your priorities...do you put that \$50,000 into that road, that could be flooded in the next storm, or do we put \$50,000 into building up that causeway because if we lose it in the next storm, the whole island is cut off... you can't just throw money at a little project cause you've gotta weigh your priorities” (Participant 1, personal interview, 2014). Another exemplified cost-benefit analysis, “making another bridge in another area for a secondary access, which seems good, might last for 20-30 years, might last for 100. I just don't like to waste my time” (Participant 6, personal interview, 2014). Another stated, “we would have to really sit down and look at all the options...and see what's...within reach to do” (Participant 4, personal interview, 2014). One participant expressed, “to make things work you have to have the research, you've gotta have the numbers, you've gotta have the figures, you've gotta have the, you know the extent of what's gonna happen out there - how do you get that? So I think that's what we need” (Participant 3, personal interview, 2014). The participant continued by stating, “money is always the factor, and yet, that seems crazy because by not spending the money to make the changes that we need to make, it's going to cost us 10 times - 100 times more in the long run...I think if we took on some of our challenges head on, and try and combine them, I think we would be able to save money in the long run. Be much more efficient and effective at making these changes” (Participant 3, personal interview, 2014). During

post-tool interviews, participants continued to express similar thoughts. One said, “many people that are involved with the town right now, don't either have the time or the knowledge to access that data [on adaptation options]...and some of us may not have either of those. So...how do you get the wisdom that's out there to help you make a really good decision? Because if the best decision is relocating people from the town of Lockeport, then why would we invest in any of these other things?” (Participant 3, personal interview, 2015). The participant also said, “the cost of repairing the damage after the impact is so much more substantial than just dealing with it before hand” (Participant 3, personal interview, 2015). Lastly, one participant stated, “we haven't delved into or spoken to other levels of government to see what options could be there for us” (Participant 4, personal interview, 2015). It is evident that the need to understand options and weigh the associated pros and cons of these options is an ongoing perceived need and concern.

Another priority expressed by participants was the **need for education**. One participant stated, “We've got to get access to informed, educated people that know what they're talking about and can lead us in the right direction” (Participant 1, personal interview, 2014). Another said, “[I] think the education component is probably the largest one because you can't expect political change without the will of the people to push it” (Participant 6, personal interview, 2014). The participant elaborated by saying, “I would say that education has to be front and foremost but it also has to recognize what the target audience is and if they're not coming and you have to get it to them, it [the information presented] has to be very simple” (Participant 6, personal interview, 2014). During post-tool interviews, the same participant continued to emphasize the importance of education:

“we need to educate the council, the people that are making decisions - the decision makers, and we need to educate the public” (Participant 6, personal interview, 2015). Another questioned, “how do we make this [climate change information] exciting enough and accessible enough that we can make people more aware of it? ...is there some way that this [climate change information] could get introduced into the school? Ok, so students become aware and are a way of getting through to adults and parents” (Participant 3, personal interview, 2015). Finally, one participant stated, in reference to general awareness about climate change, that “people are far more aware, far more concerned, than they were in the past” (Participant 7, personal interview, 2015). The need for education was expressed during both pre- and post-tool interviews. It is possible that the AdaptNS tool was inspiring as a means of reaching a wider audience (e.g., through incorporating the tool into school programs).

Another priority expressed by participants was the **need for collaborative governance efforts**. During pre-tool interviews, one participant stated, “as we get people out of their houses, we get different age groups working together...I want to see a way, partnership, funding, I don't know what it is...to widen the awareness at different levels; at the citizen level, at our council level, at a provincial level, and at a national level. So I think that is one of the really, really, really, important things” (Participant 3, personal interview, 2014). Another expressed, “we've got to do it all together cooperatively” (Participant 1, personal interview, 2014). During post-tool interviews, the same participants stated, “why aren't we working together?...the cost of repairing the damage after the impact is so much more substantial than just dealing with it before hand that why on earth do organizations, the levels of government that have the funding, why are

they not seeing that? and helping us with that” (Participant 3, personal interview, 2015). Another stated, “I really don't think that the federal government has bought into climate change. They want you to do your action plan, to tick that off of their to do list and put their gas tax money into it; but to me it sounds like they don't have the will to follow through with it...from a grassroots [approach], a municipal council has to keep hammering at the Provincial and Federal levels proactively” (Participant 2, personal interview, 2015). Lastly, one participant stated, “I don't believe all the general public need or have a necessity to get into all the nuts and bolts. But they have to have some faith and confidence in the people that are leading them. And so, the people leading them need the information, right, they need to understand the nuts and bolts. So it can start at our levels in the grassroots. I think there is and I would suggest that there is pretty strong awareness through the different levels of government, but at some point in time we have to stop making plans and put the plans to action. And that's what I think you'll see most of the time is that, there's all kinds of plans and there's been a study done on this, and all that's ok we know it's out there because we've studied it. But at some point you have to implement those plans” (Participant 6, personal interview, 2015). The need for collaborative governance efforts was found to be constant throughout the data collection process.

The **need for further assessment** is a priority that was discussed during both pre- and post-tool interviews. During pre-tool interviews, one participant stated the need for “access to project facilitators...people that would be on the ground physically drawing a plan up. Somebody that's gonna sit there as work is being done” (Participant 6, personal interview, 2014). This participant questioned, “how do we get the expertise to make sure

that we're making the appropriate by-laws” (participant 6, personal interview, 2014).

Another expressed, “councilors are not engineers, so and staff are not engineers, so we can't just jump at what we think is a good idea. We've got to get access to informed, educated people that know what they're talking about and can lead us in the right direction” (Participant 1, personal interview, 2014). One participant gave an example highlighting the need for external expertise, “we've got a project now, we don't have an engineer. We don't have the access to one. And we will borrow an engineer and say 'this is how it's gonna be done and he'll talk to the contractor. And we've been able to get it done, but other municipal units have engineers, they have planning departments, they have all kinds of access and I'm probably exaggerating - not all kinds of access - every municipal unit is stressed in one way or another. But in order to maintain this town with all the services and infrastructure that we have, we really don't get a lot of outside help” (Participant 2, personal interview, 2014). During post-tool interviews, the same participant reemphasized, “we need some sort of a project manager or an engineer for the town” (Participant 2, personal interview, 2015). One participant stated, “our best interests are probably served in bringing somebody in to assist us to put pen to paper, and again it'll come back to access to funding” (Participant 6, personal interview, 2015). Another said, “if we had access to people with the knowledge, like engineers or any type of engineer or expert that would say, 'ok, if this is what it's going to do in 15 years time or 20 years time, these are some things that you need to do now', because we're lay people; that's not our expertise. We can think well if we shore that up and build that up, that'll be it, but it's a lot more than that...So we need that expertise and at the Municipal level, we don't have it. So that would be important as well, very important!” (Participant 4,

personal interview, 2015). It is evident that the necessity for external expertise is an ongoing issue and was apparent during pre- and post-tool exposure.

Next, there was an ongoing concern for the **need to protect the power station** on the island. One participant stated, “we have a power station down at this end of town, in the north end of town, that got flooded in the last big storm we had...I'm not sure but I'm thinking...that where it's owned and operated by a different entity than us you would have to work very closely with them” (Participant 4, personal interview, 2014). Others stated, “it makes sense that we provide a better access for electricity for the town” (Participant 3, personal interview, 2014) and “I would like to see the power station relocated” (Participant 1, personal interview, 2014). During post-tool interviews, participants continued to highlight the power station as a priority: “ongoing thing [concern] since the substation flooded...Nova Scotia power has begun to do some work down here at the substation” (Participant 2, personal interview, 2015). Another stated, “the power substation - it's gonna happen! That's gonna flood! ...if we don't start looking at really big ideas, little changes aren't going to be enough. Wherever you can, start the little changes...don't wait! Don't say "oh i'm gonna wait cause I'm gonna wait for this giant pot of money to fall out of the sky" - we've got to get started!” (Participant 3, personal interview, 2015). Lastly, one participant elaborated in detail of what the plans to protect the power station since tool exposure have been: “the adaptation process, that we're going to have. That's going to be a big project. It's something that we know what areas we've got to deal with, but we've got to do it step by step and one of them is the revisions to the land use by-law. Definitely there, we've been in discussion with Nova Scotia Power. Actually it's been through our EMO coordinator regarding the substation

up here at the north end of town... I don't know what their plans are, but it's on their radar... It's not our responsibility to do anything with it or advise them as to what needs to be done. Just to keep them in the loop as to what we're seeing during different storm events and make them aware... But they're, the Nova Scotia Power have a plan of action - a game plan - and we can't tell them what they can or cannot do or should or shouldn't be doing” (Participant 1, personal interview, 2015). It is possible that the initiated process of contacting Nova Scotia power had to do with increased pressure from Council, who was made more aware (visually, through AdaptNS) of the potential for flooding.

The need for **stabilizing the sand dunes** was discussed extensively during pre- and post-tool interviews. During pre-tool interviews, one participant stated, “number one priority is town accessibility and under that is repair the beach dunes, simply because that is our only driving access on the island part of the town” (Participant 4, personal interview, 2014). This participant further elaborated on an existing small-scale sand dune stabilization initiative: “with the sand dunes on the ocean side, there's an initiative out there and it's just volunteers and they've done it and they've tried a little spot to see how it would work. They took old lobster traps that fishermen take to the dump, and brought them back and...put them in rows of three, right up to the dunes and as the winds blow, it fills them in, and it helps to secure and it has worked very very well...all it is, is a little bit of volunteer work and sweat and equity in it and it's totally manageable for us because it doesn't cost any money. And there are lobster traps readily available because fishermen are always, you know, discarding them at the waste reduction site” (Participant 4, personal interview, 2014). During post-tool interviews, participants further elaborated on previous and planned methods of addressing the sand dune erosion problem. One stated

in reference to past initiatives, “we took those 20 traps and did it in April and by June, sand and tidal action had put quite a volume of sand in behind the traps. We didn't back fill it. We just stuck them there in the sand, they're quite close to the dunes, and all of a sudden, they created a fore dune, a plateau. So it's about a half a meter or maybe three quarters of a meter high. And in June and July and August, vegetation [Marram grass] started growing on top of it, and they were pretty much hidden” (Participant 2, personal interview, 2015). Another reflected on past errors: “I can remember 25, 35 years ago that for the problem of erosion of the sand dunes, council simply would take a bulldozer down to the beach and bulldoze the sand up, make the dunes higher, thinking that that was the problem. Totally unaware, or I shouldn't say unaware, not educated enough to realize, look, the beach is coming in, the tides are increasing, the wave action in and out is washing the beach away and the dunes away, eroding away. So piling it up, it just, it may take it another couple of weeks or a month to ...but that's not solving the problem at all, but that was their view then” (Participant 7, personal interview, 2015). Lastly, one participant elaborated on future plans with sand dune stabilization: “we did just complete, just before you got here, the project on the dunes, and trying to re-secure put a better substructure to the dunes to protect the roadway. With that piece out of the way, we are looking at, we had some money left over in that actual fund and as a project, some people in the community, one of the guys worked on Sable Island, and they were trying to secure dunes there - this is back in the 70's I believe. He worked with another guy and they got old lobster traps and trying to use recycled materials and made like a, I don't know - call it a weave - but put the lobster traps on the water side of the dunes to try to give the sand something and the grass something to adhere to. We're looking to utilize - I think it was

2700 or 2900 dollars that was left in that, which we have to match so we're looking at at least \$5000 to hire...somebody to go out with the actual hands, bring a bunch of the lobster traps down and just have it overseen by one of the gentlemen that helped before. And do a large section of the beachfront by the waterside. It can't hurt. I think it's a good step and it's one of those things that can set an example for other areas or similar, there's not a lot that are similar with the dune structure and beach leading in as the only access in the town...it is going to be a quick and simple project, but again, I don't think council's urgency and ability to even make the decision to say yea, lets come up with the extra \$3000 that we didn't budget for, would be there if they didn't have that tool in the back of their mind and the visualization of what could happen if we don't start looking after this! ...So within the next month we'll be looking to getting that little project underway”

(Participant 6, personal interview, 2015). Though the concern regarding the sand dunes was always present, the rapid pace to take action is likely associated with exposure to AdaptNS. This is because of the vulnerability of this area that was shown via the tool and because of the existing and increased concern regarding the town's only access way, which is currently protected by the sand dunes.

The **need to be proactive**, as opposed to being reactive, was a factor raised by almost all participants. During pre-tool interviews, one participant stated, “being where we are [in Lockeport] we see it [the impact of climate change] daily, our social and economic environment relies on weather conditions, and if we start getting more and more intense weather events happen, we just become more and more aware of it. And...after a while, you start being proactive with that” (Participant 2, personal interview, 2014). In reference to why it is difficult to be proactive the participant stated,

“when they [Council] get elected for a four year term, their goals are within that four years and climate change naturally is long-term and infrastructure upgrades are naturally long-term, and budgeting will only allow sometimes for you to do what is immediate and we try to look at things as proactive but we usually a lot of times end up being reactive... And that’s the way it is with council. It's not that they don't care and they're not interested but their interest is four years” (Participant 2, personal interview, 2014). Others mentioned, “people are seeing us preparing for the effects of climate change or I guess in that case it is a reactive approach, because we've already been damaged right” (Participant 1, personal interview, 2014) and “we want the people that have the responsibility for more than themselves and those that are only responsible for themselves to take a proactive approach” (Participant 1, personal interview, 2014). Another stated, “I see catastrophic things that are very potential. That are strong potential and it doesn't make me comfortable not to be prepared. I don't see us having very much preparedness at all... people expect government to be reactive, I would rather be proactive. And to be proactive isn't popular” (Participant 6, personal interview, 2014). During post-tool interviews, the same participant said, “the community can't just sit back and wait for something bad to happen, or wait for somebody else to give us money. So we're going to have to start putting our money into our interest and our priorities” (Participant 6, personal interview, 2015). Another said, “I think one of the biggest hurdles is trying to be proactive” (Participant 2, personal interview, 2015). One participant specifically addressed the need to proactively implement by-laws: “we need land use by-laws that establish set-backs in areas where people can't build because they're going to - at some point - they're going to flood. So why would we allow people to build where

there is, it's inevitable that one day there will be sea water intrusion, right?" (Participant 3, personal interview, 2015). They elaborated by stating, "it's in their [municipalities'] best interest to be proactive rather than reactive...I'd like to see a program that builds on the information that we've got from the research that you did that would take proactive steps in making sure that we can shore up some of the places that are most at risk...Getting access to what other communities have done and how they've developed a preparedness plan and how they've adapted their by-laws would be an assistance" (Participant 3, personal interview, 2015). Finally, the participant concluded by acknowledging the need for time in being proactive: "even though we've had a visual way of recognizing how great the impacts going to be, it's easy to not find the time that you need to do these thing" (Participant 3, personal interview, 2015). It is evident that the perceived need to be proactive increased after tool exposure. This is likely because of the urgency created from seeing the physical impacts of climate change on the Town's natural and built environment.

Another factor discussed as an area in need of great attention is the town's **causeway (bridge)**. During pre-tool interviews, one participant stated, "we always tend to zoom in on the causeway issue because it is our number one priority and concern" (Participant 1, personal interview, 2014). The participant elaborated by stating, "we have to prepare ourselves for not just the causeway washing out for three quarters of an hour like it did last time. We have to prepare for the causeway washing out and not being reconnected for a couple weeks" (Participant 1, personal interview, 2014). The participant focused on the idea of needing a second access: "bucket-list [includes]: the engineer study on the second access that is again so that if something happens to that

causeway, we can get people off and on the island... We've discussed all types of different things. Build a new bridge. Updating, upgrading the train trestle that I said would be a walking trail. Updating that to accommodate vehicles... all kinds of different things. That'll be a while before we'll get that one checked off" (Participant 1, personal interview, 2014). Another participant stated, "priority right now is to protect the one access route that we have because that's critical... my one dream would be that we had a second access, on and off the island" (Participant 4, personal interview, 2014). During post-tool interviews, participants further emphasized the need for attention to the existing causeway and need for a second access. Participants stated, "we still need a second access"(Participant 1, personal interview, 2015) and "we need to start really concentrating more on what can we do in the next from now until in 10 years, to get a second access... What do we do if we don't get or don't have that access? What will happen to this Town? Cause it's a very real possibility now that those things [loss of access via causeway due to climate change] can happen" (Participant 4, personal interview, 2015). Another said, "one thing we have been working on is building up the sea wall on the, across the causeway, and that's you know, that's pretty well a done deal now, so that's great. But that's not enough" (Participant 3, personal interview, 2015). Another emphasized the difficulty in achieving this need, "there's one access into and from the town, which is breached almost annually, sometimes a couple times. We need a second access road - how much would that cost? Millions... could we resolve that problem? Absolutely not" (Participant 7, personal interview, 2015). The participant elaborated, "first thing that has to be done is there has to be dramatic steps taken to shore up the only access road that we have. And even at that, that's going to be a temporary

measure because Mother Nature can't be stopped” (Participant 7, personal interview, 2015). The AdaptNS tool can be linked to the expressed need to protect and develop access to and from the island; this is because the tool showed the adverse impacts that the causeway is expected to face with the impacts of climate change.

The next prioritized factor is the **need for long-term planning** and **consideration for future generations**. Though this was mentioned in both pre- and post-tool interviews, it was heavily emphasized in post-tool interviews. During pre-tool interviews, one participant mentioned, “we're not looking and talking at the long term picture. And in our meetings people are so pressed for time and to deal with all the things that [need to be dealt with]...and these things take up so much time that at the end of the meeting, right, you know even if it was on the agenda [it doesn't get addressed]” (Participant 3, personal interview, 2014). During post-tool interviews, this participant elaborated on long-term visioning: “I had a fairly good idea of where our issues were, but by using the tool, it gave you a visual, and visuals are very powerful and with the different times, ok, and what could happen it gave you, you know, it gave, I hope will give everybody including myself more of a wake up call” (Participant 3, personal interview, 2015). The participant further stated, “With a hundred year storms happening much more frequently now, it makes sense that all the areas as in the when we were shown the different times and what's going to happen time, storm impact is going to accelerate that and where it may be a one time event, we need to be ready for that so how do we plan for these areas that are most vulnerable” (Participant 3, personal interview, 2015). Others stated, “it [the tool] gets their minds thinking about the future and trying to consider what we could do to mitigate the impact or you know completely change circumstances” (Participant 6,

personal interview, 2015) and “using the tool, it is even...so much more important that not in 50 years time, or even for me in 10 years time, but in my time, here, we need to start really concentrating more on what can we do in the next from now until in 10 years” (Participant 4, personal interview, 2015). Another said, “In the past, we've talked about it as somewhere in the distant future. We're gonna be looking at the possibility of this. Well now, we know not in the distant future - any day we *will*, we will be looking at this. So. Yea. The tool's been very useful in that” (Participant 7, personal interview, 2015). It is evident that the tool’s ability to visualize different timeframes of future impacts influenced participants’ perceptions on thinking long-term and for future generations.

Lastly, the idea of **off-island movement** of the community and its services is a priority that was not considered seriously until post-tool interviews. During pre-tool interviews, the idea was mentioned briefly by one: “if we just let climate change happen and just keep wiping things out as it wants to as it wants to and whatever's in it's path, then we might as well just cut off that...Move everybody and every service off the island section and be done with it...But we can't do that - that's not being responsible” (Participant 1, personal interview, 2014). Another stated, “should I be investing in subdivisions and places where people have other options to move that they aren't so vulnerable. I don't know, that's pretty far fetched - far reaching” (Participant 6, personal interview, 2014). This participant questioned off-island movement while referencing whether or not it makes sense to develop by-laws given ongoing erosion: “in reality, do we just move off the island, start moving people away? Because if we're looking at sea level rise and the highest point in the lot versus the next 20 or 40 years, whatever. When do we stop that? ...you don't want to make a law that you know you're going to change

every five years” (Participant 6, personal interview, 2014). Another implied movement by stating, “I think there's going to come a point where we're going to be forced to say, either we're going to fight or choose flight” (Participant 3, personal interview, 2014). During post-tool interviews, participants continued by stating: “is relocating something that in the long run would be more beneficial?” (Participant 3, personal interview, 2015) and “do we move everybody off tomorrow? or do we make a plan in the next ten years?...I think, best case scenario we take our time but we just keep moving towards letting go, which would obviously be to move people out of harms way and look after the services to make sure they're safe” (Participant 6, personal interview, 2015). This participant elaborated extensively on the idea: “it's you either go full bore and you pack up the island and you start moving now, or you do it in steps and you just do it in ways that make sense. Regardless of how much we educate the public, they're still not going to move today, or tomorrow. But as generations change, as things change, and if we start to centralize we'll save their services and the things that they require and not so much in the vulnerable area, then I think it's a natural migration for them to start doing that. It might be a 50 year process, I may or may not be here to see any of it implemented, but I'd like to know that we did the right thing as far as making sure that there was somewhat of a plan or at least a vision...if it comes to a point of lets say moving infrastructure or creating a new town hall or something. I think you'll see it moved to a point, a place that's less vulnerable” (Participant 6, personal interview, 2015). Another stated it “might be simpler for them to say, look, we'll move you to safer land, settle down...I hope that it would never come to that” (Participant 7, personal interview, 2015). Lastly, a participant pointed out that the development of such an idea is a relatively new one: “is it in our best

interest to build it on our island? Should we be considering that? Should we even be considering things on the island? At least it's in the conversation. Where I would say even six months ago, even suggesting something like that wasn't even an option" (Participant 6, personal interview, 2015). Though the idea of moving off the island existed before tool exposure, it is evident that there was a shift from it being a "far-fetched" idea during pre-tool interviews to a more seriously considered one during post-tool interviews. Whether this is because of tool-exposure cannot be confirmed, though it is likely that seeing the physical impacts of climate change through AdaptNS did influence the consideration of this option.

4.1.3 Aspects of the Tools

Lennox

Participants in Lennox Island highlighted a number of aspects of the visualization tool, CLIVE, which stood out to them. Firstly, the credibility of the informative tool and its **visual movement and change** of physical vulnerability was noted, "I thought well maybe, these two houses area...but actually you have to expand that to include more of an area" (Participant 8, personal interview, 2015). Others expressed the tool "showed us where it's going to take off the most [land]" (Participant 9, personal interview, 2015). Some powerful statements were made, for example one said, "I already know where our vulnerabilities are but to actually see that in motion and over time, and...I'm like oh my god, it's even worse than I thought" and "to actually see it in movement, kind of even made it more real...when I saw the CLIVE tool, I was aware. I was made aware of the possibilities that could happen under certain circumstances, which I think are our reality really. It was more awareness...It was like kind of shocking, really" (Participant 8,

personal interview, 2015). It is evident that the tool's visual motion aspect made for a more realistic image of what the future is expected to bring.

One highlighted that seeing different **time-scales** on CLIVE was beneficial “to see the different changes” (Participant 10, personal interview, 2015). Another discussed the impact of the tool: “it was sobering and my mind did switch. My mind did change in concern cause we are an island. And um, I don't know...my mind is thinking in a different way because of the tool” (Participant 8, personal interview, 2015).

Another aspect was the **credibility** associated with the tool and the potential for it to be a **decision-support tool**. One participant said, “it [the CLIVE tool] also helps us to...gives our answers credibility to say why we're saying what we're saying - we're not saying this because we want to say that or deny you a spot in a certain area, it's because we're working with knowledge. So again credibility it brings, and then uh the bigger scale of things: development, policy development too, and proposal planning with the government, and access in funding, but mitigation too” (Participant 8, personal interview, 2015). This indicates the participant found the information being displayed through CLIVE to be useful as a supportive decision-making tool. The participant further said, “now we have a tool that we could base some sound decisions on going forward” (Participant 8, personal interview, 2015).

Thus, the findings from Lennox Island show that the visual movement, various time-scales, and credibility of information represented within CLIVE, as well as the corresponding use of the tool for supporting decisions were main aspects of the tool that stood out to and influenced participants.

Lockeport

Participants in the Town of Lockeport discussed a few aspects of AdaptNS that stood out to them. Firstly, as was the case in Lennox, the **visual imagery** aspect of the tool was found to be an influencing aspect. In reference to the tool, participants stated, “the best part is obviously the visual part. And I mean the...for people to physically be able to look at the community and see what the changes and the impacts may be. It gets their minds thinking about the future and trying to consider what we could do to mitigate the impact or you know completely change circumstances... So the tool alone, does a lot, it goes a long in making that visualization just sink home so people realize that there is something that they have to do” (Participant 6, personal interview, 2015). Another explained: “for me it's just the visual and to show...like that each person could sit and you could work with them, well say like for me, I wanted to manipulate and look and to use the tool to see how it's going to progress over the years and the damage that's to be done. And I think that'll be essential to the residents as well because when you're looking at a whole picture sometimes the impact isn't as great...as if you could sit down and concentrate on and you could just take that on a computer or a tablet and say, “ok, let's look at this, this is where you live and this is how you'll be impacted” (Participant 4, personal interview, 2015). Another pointed out that the visual aspect was very impactful: “I just wish that everybody could see it” (Participant 7, personal interview, 2015). One participant pointed out the ability of the tool to speak to people of a certain type of group: “when you look at Municipal people, they're typically not younger people. Um, so if they're not younger people then they're less likely to take risk, they're less likely to look forward to the future, they're kind of - they're already done their stakes and they're kind of done setting vision. So I think it was a little bit of an eye opener for them, to be presented

in that fashion where they can sit and watch. So again, the tools right - the visualization brings it home” (Participant 6, personal interview, 2015). It is evident that the tool had an impact on how the participants perceived the physical impacts of climate change represented through AdaptNS. As mentioned throughout the results, the ability to visualize various **timescales** and **geographical locations**, relevant to observers, were more detailed visual components that stood out to participants.

Next, the ability for the tool to help **validate vulnerability information** was expressed as a helpful aspect. Participants stated, “the climate action change plan discusses that to some extent, but again, that tool of being able to look at and go “ohh, so we're going to be cut off from that” “oh this isn't going to be an option”, makes people think and reconsider again...“it gave people the understanding of again their access to services, their access to whether it's getting to the store, whether it was the sewer system, whether it was the fire trucks getting to them in emergencies, medical whatever...I think it brought to the forefront... There's a lot of times that you may know something's coming but you're able to put it on the back burner because it doesn't seem as urgent. This does put some urgency to it. It puts it on the forefront so when council's dealing with issues...that's there... And it [the tool] has been mentioned several times during meetings over the course of the last couple months” (Participant 6, personal interview, 2015). Others expressed, “we were not aware that all that, the severity” (Participant 7, personal interview, 2015) and “the scary thought, that since we've looked at the tool and had that meeting, is just the financial impact that this isn't just fixing that piece of coastal shoreline. Shoring it up like we did the beach dunes. There's so many factors now” (Participant 4, personal interview, 2015). In reference to the vulnerability data

represented by the tool, another participant said, “it's been, sort of seconded” (Participant 2, personal interview, 2015). It is evident that the information represented by tool resonated with participants.

Lastly, the ability for the tool to last as a **decision-support tool** was seen to be beneficial to Lockeport participants. An envisioned future use and already established influence of the tool for adaptation planning was evident. One participant highlighted, “I don't think council's urgency and ability to even make the decision to say yea, lets come up with the extra \$3000 that we didn't budget for, would be there if they didn't have that tool in the back of their mind and the visualization of what could happen if we don't start looking after this!” (Participant 6, personal interview, 2015). This participant elaborated on the **simplicity** of the tool, “before two months ago we would have to bring up the action plan and just remind them of, if we were making plans, were trying to do something, how it would pertain to the action plan or what the implications may be. This again, with that simple tool made things so much more obvious to council” (Participant 6, personal interview, 2015). Another stated, “it would be an excellent tool, for one, we'll take the substation down here, if we were to approach Nova Scotia Power, this would be a super tool, visual, because it is very in your face and very shocking, and it's like, it'll open their eyes I think. So if there's anything, whatever they need to do to upgrade that substation or to figure out what's going to happen in the next few years, excellent tool for them” (Participant 4, personal interview, 2015). Another suggested the tool would be beneficial specifically for **attaining funding**: “Excellent tool for presenting a case for funding to other levels of government, for help in these sites for these situations” (Participant 4, personal interview, 2015). Further within decision-making, participants

found the tool could be used for **public support and engagement**: “with this, people are very supportive. We do have a lot of public support. We do. Thanks to the tool and the presentation that's been made and the efforts of council also” (Participant 7, personal interview, 2015) and “I can see it [being used] for public engagement” (Participant 3, personal interview, 2015). One participant pointed out that community members were already discussing the tool since the community workshop: “...they [workshop participants] do speak within the community and I have run into other people that have mentioned that they spoke to them and that this tool does exist” (Participant 6, personal interview, 2015). As for the using the tool for planning and decision-making, participants stated it could be used “for current, as well as future” (Participant 1, personal interview, 2015) and for “long term, or even short term” (Participant 5, personal interview, 2015). The overall view on this was that the tool would be readily available for all to access, as opposed to books: “it's long term [the tool itself]. Other studies that I looked at, not so much to do with climate change but maybe economic development...some of those sat on a shelf and now aren't relevant. I think this [AdaptNS] can be relevant for quite a while” (Participant 2, personal interview, 2015).

Thus, it is evident that participants perceived the visual, information, and decision-support aspects of the AdaptNS tool to be quite beneficial.

4.2 Results from Workshops

Lenox Island

The findings from the workshop in Lennox Island revealed an interesting change in priorities. The questionnaire results are outlined in the table below:

Table 3: Results from Lennox Island Questionnaire

Lennox Island	
Pre-tool survey results:	Post-tool survey results:
<i>Top three areas of concern:</i>	<i>Top three areas of concern:</i>
1) Causeway	1) Causeway
2) Graveyard	2) Lagoon
3) Infrastructure AND lagoon	3) Infrastructure
<i>Top three actions:</i>	<i>Top three actions:</i>
1) Shoreline protection	1) Shoreline protection
2) Awareness/education/preparedness	2) Relocate infrastructure
3) Relocate infrastructure	3) Protect/build/repair bridge
<i>Who is responsible?</i>	<i>Who is responsible?</i>
Band Council and Federal government	All are responsible
<i>Changes in perceptions of importance:</i>	
Relocate sewage	
Relocate buildings	
Relocate roads	
Change building codes	
Changes to land agreements	

The results reveal that participants became increasingly concerned with critical infrastructure (including sewage, buildings, roads, and the causeway). This is likely associated with the physical impacts shown through the CLIVE tool on the causeway, sewage treatment plant, coastal buildings, and evidently, any roads within those low-lying areas. Other priorities that were rearranged include the importance to “change building codes” and “changes to land agreements”. It is likely that perceptions of the importance of these variables are associated with the perceived need to protect critical infrastructure or adapt by relocating. Again, linking back to the impacts on the natural and built environment visualized through CLIVE. There was also a minor appearance of negative change for the variable “manage nature”. It is possible that there were some mixed interpretations with the survey variable, “manage nature” due to the wording of the variable. This variable was found to have both negative and positive changes in level of importance between the pre- and post-tool surveys. Thus, some participants may have

interpreted “manage nature” as an adverse action and some as a positive action.

Clarification of this wording to imply control for the benefit of human communities may have been useful. Lastly, the frequency of incomplete surveys (with at least one question unanswered) was very high for the Lennox Island study site. It is possible that the types of questions posed were too demanding for the nature of the workshop. Questions requiring more written answers had a lower completion rate than those requiring checking off answers (Lennox Island only).

Town of Lockeport

The findings from the workshop in the Town of Lockeport also revealed some changes in priorities. The questionnaire results are outlined in the table below:

Table 4: Results from Town of Lockeport Questionnaire

Town of Lockeport	
Pre-tool survey results:	Post-tool survey results:
<i>Top three areas of concern:</i>	<i>Top three areas of concern:</i>
1) Access to Island via Locke Street	1) Access to Island via Locke Street
2) Waterfront businesses/homes	2) Power station
3) Sewer/water infrastructure and roads	3) Chetwynd’s Lane area (low lying)
<i>Top three actions:</i>	<i>Top three actions:</i>
1) Protect existing causeway	1) Explore alternative access way
2) Explore alternative access ways	2) Identify, plan and act on adaptation
3) Identify, plan and act on adaptation AND Develop local zoning by-laws / policies to protect coastal land and infrastructure	3) Prevent flooding in low-lying areas
<i>Who is responsible?</i>	<i>Who is responsible?</i>
Town Council / Everyone	Everyone
<i>Changes in perceptions of importance:</i>	
Relocate buildings	
Relocate sewage	
Bring in engineering consultants	

Similar to Lennox Island, the results reveal that participants became increasingly concerned with critical infrastructure and the need for external expertise (including

buildings, power station, sewage, causeway, and need for engineering consultants). It is very likely that these changes are associated with the physical impacts shown through the AdaptNS tool. Particularly, the tool showed great impacts on the power station, causeway, buildings (homes) on Chetwynd's Lane, other coastal buildings, and roads (flooding). The concern for sewage infrastructure is likely associated with the risk of losing power (as the power station is vulnerable) and flooding (as underground sewage system infrastructure would be impacted). The need for external expertise is likely associated with the interest in attaining more information regarding potential impacts of climate change. There was also a minor appearance of negative change for the variable "make changes to property insurance". It is possible that participants interpreted this as an increase in financial costs, which would explain why participants would not be interested in prioritizing changes to property insurance. Lastly, reflecting on the tool some participants expressed, "I can see it [AdaptNS] being a very very useful tool for future planning, and not just for land-use by-law issues but also for town planning for the future" (Lockeport Workshop Participant, personal communication, 2014). Another stated, "with that tool there, to show us what is coming down the road, it's our responsibility to protect our residents. It's our responsibility to protect the businesses that are located here on the island. A lot of the onus is on them as well, but as far as accessibility and everything that's our responsibility" (Lockeport Workshop Participant, personal communication, 2014).

Overall, both workshops revealed that what is visualized through the tools is likely to influence priorities and areas of concern for community members.

Chapter 5: Conclusion and Discussion

This chapter will provide a recap of this research study. It will do so by first providing an overall summary the findings in relation to the study's research objectives. It will then move on to discussing the results in the context of stakeholder engagement, visualization tools, and behaviour change. This chapter will conclude by discussing the general aspects of this study that were found and note the aspects of the tools that could further enhance awareness and guide priorities at the local level.

5.1 Summary

Returning to the question and objectives outlined in this study, this section summarizes the findings of this study; let us review the question and three objectives once again:

Research question:

How does exposure to visualization tools affect how local-level stakeholders perceive adaptation needs and potential action in small, highly exposed coastal communities?

Objectives:

- 1) Does exposure to the tool change awareness (perceived needs and potential action) among local level decision-makers?
- 2) Does exposure to the tool change priorities for potential action among local level decision-makers and stakeholders?
- 3) What aspects of the tools that were presented resonate among local level decision-makers?

5.1.1 Awareness

In both communities, several topics of awareness were discussed. Some of these were only discussed during pre-tool interviews, but most were raised as factors during both pre- and post-tool interviews.

In Lennox Island, the discussions surrounding the awareness of potential saltwater intrusion to groundwater supply, rising temperatures, the vulnerability of sand hills, and rising sea-levels were unique to pre-tool interviews. It is likely that the lack of groundwater supply and temperature representation contributed to the lack of discussion of these factors during post-tool interviews. The impact of sea level rise and storm surge on the sand hills and the impact of sea-level change were both represented on CLIVE, yet there are possible reasons for why these factors were not discussed during post-tool interviews. Firstly, though the physical impacts of erosion, storm surge, and sea-level rise are accounted for in the CLIVE tool, it is possible that participants were more interested in how these impacts will affect them and their natural and built environment directly, as opposed to what the impacts will be on the sand hills. It is possible that this is the reason for a lack of discussion during post-tool interviews on the topic of the sand hills. Second, the impact of sea-level rise may have been perceived as one impact and been merged with the term storm surge. This is likely since the two impacts appear as one on the CLIVE tool. The awareness surrounding the impact of storm surge was ongoing during pre- and post-tool interviews. The awareness regarding the vulnerability of the sewage treatment plant (lagoon) and the impact of coastal erosion on the island were both factors that received a great deal of attention during post-tool interviews. This is likely due the fact that CLIVE displayed direct physical impact to the lagoon, as well as the impact of

coastal erosion on the entire island; thus, raising the awareness of participants on these issues.

In the Town of Lockeport, factors of awareness sometimes tended to be emphasized in either pre- or post-tool interviews. The awareness surrounding the vulnerability of elderly community members and the social vulnerabilities associated with climate change were topics of discussion that were limited but constant during pre- and post-tool interviews. Awareness surrounding the vulnerability of the power station, the impacts of storm surge and flooding, and the vulnerability of the Town's causeway were topics of discussion that revealed to have been influenced by the AdaptNS tool. This is likely because of the representation of the impacts of storm surge and sea-level rise on the power station and the causeway, as these are in low-lying and exposed areas. The general impact of storm surge and resultant flooding was also visually represented on AdaptNS at a localized scale; thus, the awareness surrounding this factor increased during post-tool interviews. Awareness regarding the vulnerability of Chetwynd's Lane area in Lockeport was raised significantly after tool exposure. Though this area was known to be at a low elevation, the awareness surrounding the extent of impacts this area is expected to face was previously underestimated. Lastly, similar to Lennox Island, discussions surrounding the awareness of the impacts of sea-level rise were limited throughout interviews. Though it is possible that this is because participants may have merged the idea of storm surge and sea-level rise after seeing the tool, it is less likely in the case of AdaptNS as the two physical impacts are displayed separately on the tool. Thus, it is likely that the term or impacts of storm surge resonated better with participants

(possibly because of relatable direct impact from previous storm surge events) in both study sites.

Overall, it is evident through examination of the results from both study sites that tool exposure influenced awareness regarding direct impacts of storm surge (inclusive of sea-level rise) on vulnerable built and natural regions for local decision-makers and stakeholders within both communities. It is also evident that awareness was focused on physical impacts, as the information presented was limited to physical vulnerability.

5.1.2 Priorities for Potential Action

Numerous factors of priority and potential action were discussed in both study sites. In Lennox Island, all factors of priority (with the exception of one, which was raised only during post-tool interviews) were discussed in both pre- and post-tool interviews. The degree to which factors changed varied. The need for financial resources was discussed as an ongoing issue and priority for Lennox Island participants. Factors of needing more information and education, protecting the causeway, and needing external expert assistance were all likely influenced by exposure to CLIVE. This is because the physical vulnerability information provided via CLIVE may have triggered the need to further explore climate change impacts. The physical vulnerability displayed highlighted the adverse impact on the island's causeway. Associated with this is the need for external assistance to attain more information for areas of concern (e.g., the island's only access way). Next, the need to take a cost-benefit approach to assess adaptation options, need to address coastal erosion, and need to consider the livelihoods of future generations/consider long-range timeframes, are all factors that were influenced by the CLIVE tool. This is because the representation of physical impacts of climate change

shown through CLIVE (sea-level rise, storm surge, and coastal erosion) displayed extensive impacts on various parts of the Lennox Island (including damage to critical infrastructure because of erosion), and displayed these impacts over various time periods. Thus, the need to consider planning options moving forward, with particular focus on how erosion will shape Lennox Island and how this will impact future generations were all areas of high priority during post-tool interviews. Lastly, linked with the previous factor is the need to consider possibly moving off the island. This is a factor that was only raised during post-tool interviews and was likely influenced by tool exposure, as this was not a topic of discussion during pre-tool interviews.

In the Town of Lockeport, all factors were raised in both pre- and post-tool interviews, though some were emphasized greatly after tool exposure. Firstly, the expressed need for financial resources, need to weigh options, need for education, need for collaborative governance efforts, and need for further assessment from experts were factors that were consistently discussed during pre- and post-tool interviews. Factors including the need to protect the power station, need to stabilize sand dunes, and need to be proactive were all factors that were likely influenced by tool exposure, as these priorities were discussed heavily during post-tool interviews. AdaptNS displayed direct impacts of storm surge and sea-level rise on the Town's power station and sand dunes. The concern for these areas is great as the power station provides power to the entire community and the sand dunes protect the only access way to and from the island. Thus, seeing these regions in danger influenced a need to be proactive in protecting these areas. Lastly, the priorities of needing to protect the causeway, consider long-term planning/consideration for future generations, and consider moving off the island as an

adaptation strategy were all factors influenced by tool exposure. This is because AdaptNS displayed the physical impacts that the community (especially the causeway) is expected to face over various time periods, suggesting that future generations of Lockeport will face great difficulty. This can further be linked with the consideration to move off the island as a strategy to adapt to climate change.

The results of the workshops in both study sites revealed that after tool exposure, local stakeholders changed their areas of perceived importance (priorities) to ones that included vulnerable infrastructure and regions of vulnerability as outlined by the visualization tools. This change is likely a direct result of stakeholder exposure to the visualization tools.

Overall, the results from this study reveal that tool exposure did have an influence local decision-maker and stakeholder priorities and perceived areas of potential action. In both study sites, the expressed need to protect critical infrastructure (causeway, power station, sewer station), consider the impact of climate change on future generations, attain further information and assessment regarding climate impacts and adaptation options was emphasized after tool exposure.

5.1.3 Aspects of the Tools

In Lennox Island, the CLIVE tool had an impact on stakeholder perceptions of awareness and priorities. There are also particular aspects of the tool, which were highlighted by participants. These are the visual movement aspect of the tool; participants found the visual presentation of physical vulnerability information to be impactful. Specifically, the ability to view various timeframes was seen to be favourable. Lastly, the

credibility of the information presented through CLIVE, as well as the tool itself, was considered to be beneficial as a decision-support tool.

As was the case in Lennox Island, in the Town of Lockeport, the visual aspects of the AdaptNS tool were found to be valuable according to participants. Participants particularly highlighted the ability to explore various timeframes and geographical locations (that were relevant to and relatable for viewers). The information aspect of AdaptNS was also found to be beneficial, as participants found this to be a good way of validating existing vulnerability information. Lastly, participants highlighted the decision-support tool aspect of AdaptNS to be valuable. The simplicity of the tool was specifically noted and the various potential uses of the tool (including attaining funding and public support and engagement).

Overall, participants of this study commonly found the visual aspects (impacts, timeframes, localized focus) and decision-support tool aspects of the tools used in this study to be beneficial.

5.2 Discussion

5.2.1 Stakeholders Perceptions

The involvement of local-level decision makers and community stakeholders revealed to be beneficial in this empirical study. Firstly, the findings from this study support Freeman's (1984) definition of a stakeholder, which is anyone impacted by an issue at hand. In alignment with the perspectives of Newig and Fritsch (2009) and Bowie (1988), it was beneficial to set a boundary and narrow the focus of key informant interview and workshop participants to those who are local-level decision makers and community stakeholders, respectively. It may have been challenging and possibly

counter-productive to include all members of society (including those outside the community), as Bryson et al. (2002) argue should be done, as such a method could have easily led to discussions that were irrelevant to the community of interest and potentially derailed the focus of the interviews and community workshops. The use of engagement in this study supports the views of Nocke et al. (2008), who see benefit in using stakeholder engagement for providing scientific information to decision makers, and others (Sheppard, 2012; Ricker et al., 2013; Robinson et al., 2011; Brzeski et al., 2013; Arciniegas et al., 2013) who see benefit in using participatory approaches with public stakeholders. Contradictory to Newig and Fritsch's (2009) view that two-way communication can derail a discussion, two-way communication during community workshops did not distract from the topic of discussion; it is possible that having the visualization tool viewable during most of the allocated workshop time contributed to maintaining this focus. It is also possible that the goals of stakeholders (Newig and Fritsch, 2009) and the egoistic/social/biospheric drivers for motivation (Kollmuss and Agyeman, 2002; Stern et al., 1993) were aligned with discussions, which were based on physical impacts that threaten the community and its members. Overall the findings of this study agree with the general perspective that stakeholder engagement can be beneficial (Reed, 2008; Stringer et al., 2008; Pellizzoni, 2003; Steel, 2001; Brody, 2003; Mearns and Norton, 2010; Macnaghten and Jacobs, 1997; Schenk et al., 2007; Rodima-Taylor, 2012; Robinson et al., 2011).

As for perceptions of stakeholders, the findings of this study agree with the literature (Sheppard, et al., 2011; Sheppard, 2012; Brzeski et al., 2013) that states people relate to what they see when what they are shown is geographically and temporally

relevant to them. While viewing the visualization tools, stakeholders tended to focus on exploring individual scaled impacts (i.e., home and work) and near-future timeframes (i.e., 2025 and 2030). This is because these were the geographical locations and temporal periods of greatest concern that were most relatable for the stakeholders (Sheppard, et al., 2011; Sheppard, 2012; Brzeski et al., 2013). Furthermore, although it is beneficial to raise awareness regarding the physical vulnerability of one's community, it is possible that such community-focused awareness could skew stakeholder perceptions to be biased towards the community of concern; making it appear more vulnerable than other communities that are not represented. Further, as Ricker et al. (2013) discuss, there is a risk that the type of information portrayed in a visualization could be perceived in an exaggerated or skewed manner; for example, exposure to only physical vulnerability does not provide a holistic vision of the actual complex impacts of climate change. The attention participants gave to the physical vulnerabilities of their natural and built environment is indicative of a potentially skewed perspective on the impacts of climate change.

The findings of this research build on existing research that explores local-level stakeholder engagement and behaviour change by identifying specific factors that changed after tool exposure. The need to consider the lives of future generations, moving off the island, bringing in external expertise, and investing in more information and education are all need-based factors that are directly associated with stakeholder exposure to visualization tools.

As we know from the literature, changes in awareness and priorities do not translate to action. There is not only a complexity of information and resources needed to

holistically understand climate impacts (e.g., social/economic vulnerabilities) (Brzeski et al., 2013; Maarleveld et al., 2006; Sheppard, 2012), but also numerous complex and dynamic factors that play a role in shifting attitudes into behaviour (Kollmuss and Agyeman, 2002). The literature states that simply having information and knowledge is not enough to create behaviour change (Diekmann & Preisendoerfer, 1992; Fliegenschnee & Schelakovsky, 1998; Kollmuss and Agyeman, 2002). Yet interestingly, this study reveals evidence of a direct association with the information provided through the AdpatNS visualization tool and willingness to act in the Town of Lockeport. This is exemplified through the town's approval and implementation of a sand dune stabilization project. It was noted that this project would not have been approved as quickly as it was if it were not for stakeholder exposure to the AdaptNS tool; this is in agreement with the findings of Newig and Fritsch (2009), which state that stakeholder engagement helps with acceptance of decisions. Though it cannot be assumed that AdaptNS was the primary reason behind the decision to go ahead with the project, tool exposure was definitely associated with moving the idea forward in a quick manner. Thus, this further emphasizes the linkage between the use of visualization tools and change in awareness and priorities for action.

5.2.2 Visualization Tool Capabilities and Limitations

The use of visualization tools CLIVE and AdaptNS in this study revealed some capabilities and limitations of each tool. Firstly, the geographical location covered by each tool was useful in the context of this study and as discussed in section 5.2.1, was relatable for stakeholders (Sheppard, et al., 2011; Sheppard, 2012; Brzeski et al., 2013). However, making use of CLIVE outside of PEI or AdaptNS outside of the nine

communities represented within the tool would not be possible in the tools' current working states. The purpose of each tool as an awareness tool and in the case of AdaptNS, also as a potential decision-making support tool is, however, realistic. As Lathrop et al. (2014) and Lieske et al. (2014) point out, accessibility of a tool, or lack of, makes a difference in how a tool can and will be used. The CLIVE tool would be difficult to use as a decision-support tool given its current method of private access and method of presentation via a single computer with operated control (game console). AdaptNS, however, is accessible online and has a simple method of presentation through any computer or tablet with an Internet connection; thus it would be a more suitable tool for decision-making support purposes. The added component of feedback incorporation within AdaptNS did not prove to be an advantageous aspect of the tool for the purposes of this study. However, there is potential for this component to be valuable for community members and decision-makers once the tool is released and populated with information, as it would work towards providing a more holistic representation (Brzeski et al., 2013; Maarleveld et al., 2006; Sheppard, 2012) of expected climate impacts.

The data presented within each tool was appropriate; though the added component of coastal erosion, which CLIVE included, proved to be beneficial for stakeholders (as was revealed through awareness and priority changes). In agreement with Nicholson-Cole (2005), the realistic imagery of the visualization tools was found to be a motivating aspect of each tool. Though there is still uncertainty regarding the ethical impact of using such realistic imagery (Moser, 2010), there were no issues raised by stakeholders regarding ethical use of the tools; rather, as Sheppard (2012) finds with the use of technology, the tools used in this study were found to be popular among local-level

decision makers and community members. The general acceptance of the tools, as revealed in this study, supports the advancement of using such technology for stakeholder engagement. Yet, as Moser (2010) points out, this is still an area of research that needs to be further explored.

5.2.3 Generalization of Findings

It is difficult to apply the findings of this research to the general idea that stakeholders will prioritize areas of greatest expected change. However, research does show that relating information to direct experience with climate impacts is an effective method of making climate change relatable for people (Brzeski et al., 2013; Sheppard et al., 2011; Sheppard, 2012). This is because such information would be relevant to the person perceiving it, and likely to be associated with that person's emotional attachment to their direct experiences (Chawla, 1998). As Kollmuss and Agyeman (2002) highlight, those people in regions that have been impacted by environmental harm before are likely to have greater emotional attachment towards pro-environmental behaviour. The results of this study support this finding (Kollmuss and Agyeman, 2002; Chawla, 1998), as stakeholders in this study visualized physical impacts to vulnerable areas that have experienced harm in the past; triggering the need to prioritize certain areas.

Furthermore, one cannot assume that visualizing change translates to enhanced awareness for all equally, especially for an extended length of time. If a shift in attitudes does occur, the length of time the shift would last remains unanswered; this is highly dependent on a complexity of factors and is difficult to determine (Kollmuss and Agyeman, 2002). Whether changes in awareness are linked with emotional involvement from visually experiencing physical harm (Kollmuss and Agyeman, 2002) or with the

absence of more pressing issues is also something that remains unanswered by this study. This goes back to the complexity of climate change and the various dynamic factors that influence attitudes toward pro-environmental behaviour, as outlined by Kollmuss and Agyeman (2002).

The findings of this study build upon the findings of Kollmuss and Agyeman (2002) and Preuss (1991) who highlight that nontangible and time lag aspects of environmental change (sea level rise, for example) act as barriers for humans to cognitively understand climate change. This study finds this to be true as it finds that participants resonate more with the impacts of storm surge, which is quite tangible, as opposed to sea-level rise, which is gradual and less tangible. Though this is beneficial, as it indicates understanding of some physical impacts, it reinforces the idea that more intangible or gradual climate impacts can be overseen or not fully understood.

Lastly, the findings of this research point to areas in need of further exploration. For instance, once local-level decision makers do experience changes in awareness and perceived action areas, do visualization tools continue to play a role and if so, how? Would ongoing access to visualization tools be beneficial, if so, for whom? Finally, further research is needed to explore the potential benefits and drawbacks of using such tools beyond local-level governance.

5.2.4 Moving Forward

There are some aspects that visualization tools could address to be more useful for raising awareness and guiding priorities. Firstly, it would be useful if visualization tools encompassed information on social and economic vulnerabilities. This would provide a more holistic scope of the various challenges and changes a region is expected to face

(Brzeski et al., 2013; Maarleveld et al., 2006; Sheppard, 2012). Secondly, it would be useful for visualization tools to incorporate other physical impacts, which are currently underrepresented not only in visualization tools, but also in climate models; for example, wind and temperature changes. Lastly, it could be useful if visualization tools had an added component through which existing or suggested adaptation strategies could be added or viewed. In some ways, this could begin to bridge the gap between vulnerability information and adaptation that currently exists.

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APPENDIX A: Storm Events in Eastern Canada 1939 to 2010

Source: Adapted from Atlantic Climate Adaptation Solutions, 2011

M	Y	Type of Storm	Max.Tide Gauge Level at Charlottetown (metre above chart datum)	Storm Surge (Metre)	Wind (km/hr)	Areas Impacted	Erosion	Flooding	Property Damage	Storm Surge	Wind
Sep	1839	Hurricane				Charlottetown			X		
Dec	1849	Severe Winter Storm				Province-Wide			X		X
Oct	1851	Yankee Gale				North Shore					X
Oct	1869	Saxby's Gale		1.2 - 2.1		Central Maritimes				X	X
Aug	1873	Hurricane				Gulf of St. Lawrence		X	X	X	X
Jul	1883	Storm				North Shore			X		X
Nov	1898	Portland Gale				Nova Scotia, Prince Edward Island					X
Sep	1900	Galveston Hurricane				Atlantic Provinces	X		X	X	X
Oct	1900	Tropical Storm (Extra)			74 km/hr	Maritime Provinces			X		X
Nov	1922	Northwest Gale	2.250 M		130 km/hr	Cape Breton			X	X	X
Oct	1923	Hurricane	N/A		68 - 81 km/hr	Atlantic Provinces	X		X	X	X
Aug	1924	Hurricane (Category 2)	N/A		158 km/hr	Atlantic Provinces					X
Sep	1932	Tropical Storm	N/A		105 km/hr	Maritime Provinces			X		X
Sep	1932	Tropical Storm (Post)	N/A			Maritime Provinces			X	X	X
Oct	1933	Tropical Storm	N/A			Maritime Provinces		X	X	X	X
Aug	1935	Tropical Storm (Post)	N/A			Atlantic Provinces					
Aug	1937	Tropical Storm (Post)	N/A			Maritime Provinces	X		X		
Sep	1940	Hurricane / Tropical Storm	2.920 M	0.77	102 km/hr	Atlantic Provinces				X	
Sep	1942	Heavy Rainfall (3 day)	2.660 M			Province-Wide					

Sep	1944	Hurricane / Tropical Storm	2.770 M		65 km/hr	Atlantic Provinces			X		
Oct	1944	Great Atlantic Hurricane	2.950 M			Nova Scotia			X		X
Aug	1950	Hurricane Able	2.520 M			Atlantic Provinces		X	X		
Feb	1952	Hurricane (Not Named)	2.890 M			New Brunswick					
Sep	1953	Hurricane Carol	2.950 M			Maritime Provinces					X
Sep	1954	Hurricane Edna	2.370 M			Maritime Provinces					X
Sep	1955	Hurricane Ione	2.980 M			Newfoundland					
Jan	1956	Great 1956 Ice Storm	2.340 M			Cherry Valley to Western PEI			X		
Sep	1958	Hurricane Helene	3.100 M	0.97		Atlantic Provinces				X	
Jun	1959	Escuminac Hurricane	2.800 M		111 km/hr	Atlantic Provinces	X		X	X	X
Mar	1961	Winter Storm	2.220 M			Province-Wide					
Jan	1961	Kennedy Inaugural Storm	3.840 M			Charlottetown					
Apr	1962	Heavy Rainfall Over Snow	2.690 M			Province-Wide		X	X		
Oct	1963	Hurricane Ginny	3.150 M	0.73	166 km/hr	Maritime Provinces				X	
Dec	1964	Severe Windstorm	3.040 M		160 km/hr	Maritime Provinces			X		
Oct	1967	Heavy Rainfall	2.580 M			Charlottetown					
Oct	1968	Hurricane Gladys	2.930 M	0.74	137 km/hr	Maritime Provinces	X	X	X	X	X
Jul	1975	Hurricane Blanche	N/A		111 km/hr	Maritime Provinces			X		
Mar	1976		2.540 M			Robinson's Island	X		X		
Sep	1979	Hurricane David	2.820 M	0.75	93 km/hr	Maritime Provinces				X	
Jan	1980		3.090 M								
Jan	1982	Storm Surge	3.420 M			South Shore of PEI	X			X	X
Feb	1982	Severe Winter Storm	2.770 M		100 km/hr	Province-Wide					
Dec	1983	Storm Surge	3.590 M								
Nov	1986	Nor'easter	3.030 M			Province-Wide	X		X		
Aug	1990	Hurricane Bertha	2.658 M		100 km/hr	Northumberland Strait			X	X	X
Feb	1992	Severe Snowstorm	3.289 M			Maritime Provinces					X

Sep	1996	Hurricane Hortense	2.901 M	0.76	130 km/hr	Atlantic Provinces			X	X	X
Oct	1996	Hurricane Josephine	2.865 M	0.77		Atlantic Provinces				X	
Nov	1997	Winter Storm	3.179 M			Maritime Provinces					
Jan	1998	Ice Storm	3.102 M			Eastern Canada			X		
Apr	1999	Winter Storm	2.926 M		112 km/hr	Province-Wide					X
Jul	1999	Heavy Rainfall	2.582 M			Atlantic Provinces		X			
Sep	1999	Heavy Rainfall	2.576 M			Province-Wide		X	X		
Sep	1999	Heavy Rainfall	2.567 M			Atlantic Provinces		X			
Jan	2000	Nor'easter	4.226 M	1.37		Charlottetown	X	X	X	X	X
Mar	2000	Storm	3.121 M		93 km/hr (E)	Province-Wide					
Oct	2000	Subtropical Storm	3.326 M	1.29	120 km/hr	Atlantic Provinces	X		X	X	X
Dec	2000	Windstorm	2.705 M			Atlantic Provinces					X
Jan	2001	Winter Storm	3.014 M		72 km/hr (E)	Charlottetown					X
Feb	2001	Winter Storm	3.264 M	1.00		New Brunswick and Prince Edward Island				X	
Sep	2001	Heavy Rainfall	2.999 M			Atlantic Provinces		X			
Nov	2001	Hurricane Noel	3.041 M	1.00	119 km/hr (Nov 8), 145 km/hr (Nov 9)	Atlantic Provinces	X		X	X	X
Feb	2002	Winter Storm	2.819 M			Province-Wide					
Sep	2002	Hurricane Gustav	3.494 M	1.35	109 km/hr	Atlantic Provinces	X			X	X
Feb	2003	Ice Storm	3.209 M			Maritime Provinces			X		
Mar	2003	Storm Surge	2.880 M								
Mar	2003	Heavy Rainfall	2.428 M			Atlantic Provinces		X			
Sep	2003	Hurricane Juan	2.927 M	1.10	140 km/hr	Maritime Provinces			X	X	X
Oct	2003	Storm Surge	3.036 M				X			X	X
Dec	2003	Nor'easter	2.556 M		85 km/hr	Maritime Provinces					X

					(E)						
Jan	2004	Storm Surge	3.325 M	1.53							
Feb	2004	White Juan	3.772 M		104 km/hr (E)	Maritime Provinces	X			X	
Oct	2004	Subtropical Storm Nicole	2.404 M		90 km/hr	Atlantic provinces			X		X
Dec	2004	Nor'easter	3.203 M		118 km/hr	North and East Shore, PEI	X	X	X		X
Aug	2007	Windstorm	2.895 M		140 km/hr	New Brunswick and in Prince Edward Island			X	X	X
Sep	2008	Tropical Storm Hannah	2.463 M			Charlottetown Area		X	X		
Dec	2008	Winter Storm	2.648 M		93 km/hr (E)	Maritime Provinces					X
Jan	2009	Winter Storm	N/A		85 km/hr (E)	Maritime Provinces				X	X
Aug	2009	Heavy Rainfall	2.396 M			Charlottetown		X			
Jan	2010	Nor'easter	3.744 M		85 km/hr (E)	Maritime Provinces	X	X	X	X	X
Jun	2010	Heavy Rainfall	2.573 M			Eastern Kings County	X	X	X		
Aug	2010	Rainfall Event	2.647 M			Charlottetown		X			
Dec	2010	Wind Storm, Storm Surge	3.494 M		120 km/hr	North Shore of PEI			X	X	X

APPENDIX B: Lennox Island Workshop Questionnaire

Participant Survey

I understand that participation in this survey is voluntary and that my name will not appear in any thesis or publication resulting from this study unless I provide consent to be identified and have reviewed the thesis text and approved the use of the quote.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at 519-888-4567 ext. 36005. With full knowledge of all foregoing, by completing this survey, I agree, of my own free will, to participate in this study.

Town of residence: _____

Occupation(s): _____ Tourism Fisheries Both

Do you live on coastal property? YES NO

Please circle and label 3 buildings, sites, or geographical areas in on the maps below that are important to you and must be protected:



Top 3 actions needed to protect your community from impacts of climate change:

1.

2.

3.

Who is responsible for climate change adaptation in Lennox Island?

As part of adaptation to climate change, how important is it for you to:

	Not at all important	Not important	Neither important or not important	Important	Very important
Relocate roads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Relocate buildings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Relocate sewage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stop development in vulnerable areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase coastal setbacks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Change building codes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Make changes to land agreements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Manage nature (i.e. beach nourishment)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Consult public for adaptation decision-making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Council's role in adaptation strategy implementation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bring in engineering consultants	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

APPENDIX C: Town of Lockeport Workshop Questionnaire

Participant Survey

I understand that participation in this survey is voluntary and that my name will not appear in any thesis or publication resulting from this study unless I provide consent to be identified and have reviewed the thesis text and approved the use of the quote.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at 519-888-4567 ext. 36005. With full knowledge of all foregoing, by completing this survey, I agree, of my own free will, to participate in this study.

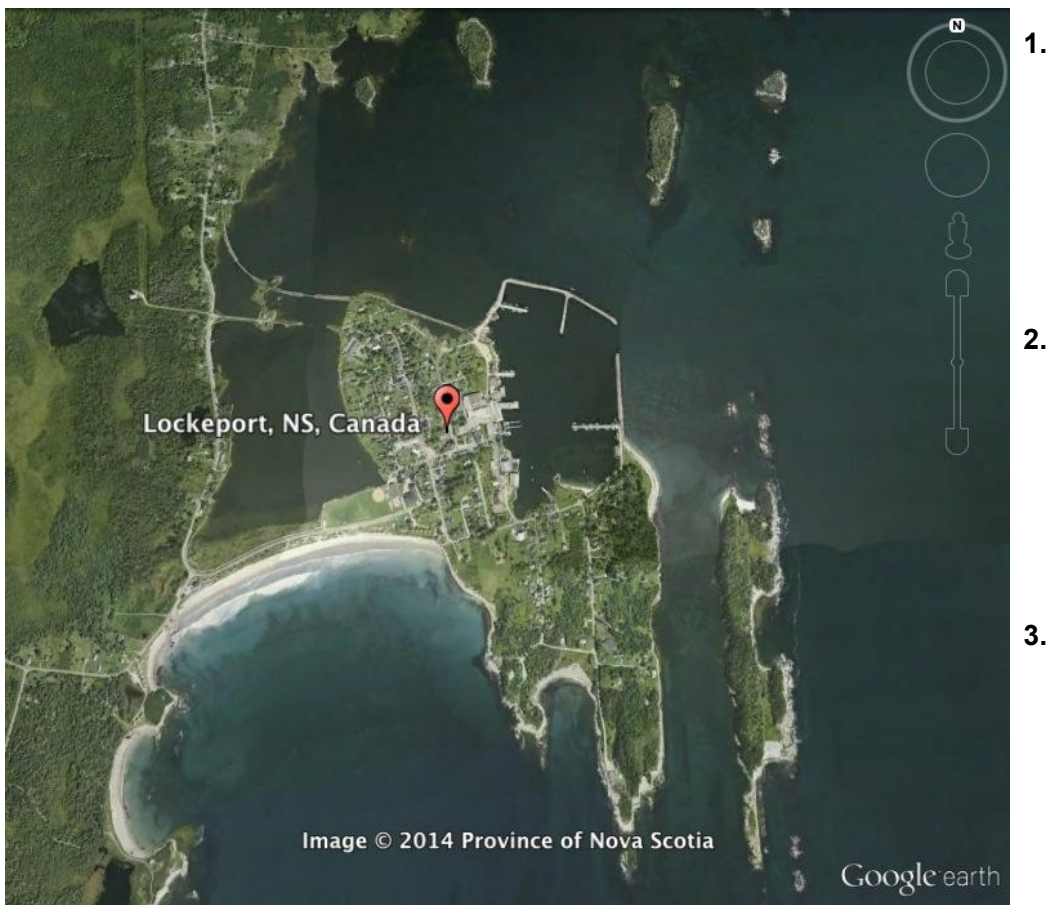
Town of residence: _____

Occupation(s): _____ Tourism Fisheries Both

Do you own coastal property? YES NO

Please circle and label 3 buildings, sites, or geographical areas in on the maps below that are important to you and must be protected:

Label:



Top 3 actions needed to protect your community from impacts of climate change:

1.

2.

3.

Who is responsible for climate change adaptation in Lennox Island?

As part of adaptation to climate change, how important is it for you to:

	Not at all important	Not important	Neither important or not important	Important	Very important
Relocate roads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Relocate buildings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Relocate sewage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stop development in vulnerable areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Increase coastal setbacks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Change building codes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Make changes to land agreements	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Manage nature (i.e. beach nourishment)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Consult public for adaptation decision-making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Council's role in adaptation strategy implementation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bring in engineering consultants	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>