Exploring a Methodology for Creating Flood Risk Vulnerability of Land Use Classification using Professional Opinions from Municipal Planners and Emergency Management Official in Nova Scotia

by

Byung Jun Kang

Submitted in partial fulfilment of the requirement
for the degree of Master of Planning Studies

at

Dalhousie University
Halifax, Nova Scotia
July 2017

Dedication Page

This is in memory of my grandfather, Mr. In Hyun Kang, who passed away on the night before Christmas Eve of 2016. His desire for me to pursue higher education has led me to complete a graduate-level thesis paper.

Table of Contents

List of Tables

List of Figures

Abstract

While climate change increases the need for disaster prevention, insufficient municipal budgets limit efforts to protect coastal residents. Assessing flood risk using land use vulnerability is useful for municipalities as it identifies areas that should be prioritized. Such methods are already used in countries such as the UK; however, their effectiveness is unknown when applied elsewhere.

This research derived a Nova Scotia-wide weighting of land use vulnerability to coastal flooding with the intention of creating a flood risk assessment tool for municipalities. Planners and emergency management officials participated in a survey that assigned vulnerability scores by ranking various types of land uses. Their responses were used to derive an analysis of similarity using Kendall's Coefficient of Concordance. Additionally, a focus group approach was used where planners and emergency management officials were tasked with devising a collective ranking of vulnerability to determine if this process would lead to concordance in weightings of land use.

Results showed that Nova Scotian professionals' opinions differed substantially for land use vulnerabilities when using the survey approach. In a group setting, one individual could dominate the group outcome despite widely differing opinions among participants. This suggests that each municipality has different perspectives on land use vulnerability. A survey or group meeting approach will lead to a compromise on perspectives on what land use is relatively more vulnerable than another.

List of Abbreviations Used

AW: Average Weighting

CBRM: Cape Breton Regional Municipality

DCLG: [British] Department of Communities and Local Government

EMO: Emergency Management Organization

GDP: Gross Domestic Product

GIF: Group Influence Factor

GIS: Geographic Information System

HRM: Halifax Regional Municipality

HRVA: Hazard Risk Vulnerability Assessment

ICSP: Integrated Community Sustainability Plan

IPCC: International Panels for Climate Change

LUB: Land Use By-law

MCCAP: Municipal Climate Change Action Plan

MCE: Multi-Criteria Evaluation

MPS: Municipal Planning Strategy

NOAA: National Oceanic and Atmospheric Administration

NS: Nova Scotia

RVAT: Risk and Vulnerability Assessment Tool

SEPA: Scotland Environmental Protection Agency

SNSMR: Service Nova Scotia & Municipal Relations (now Service Nova Scotia and the Department of Municipal Affairs)

SPI: Statement of Provincial Interests

UNDRO: United Nations Disaster Relief Organization

UNISDR: United Nations International Strategy of Disaster Reduction

W: Kendall's Coefficient of Concordance

Acknowledgements

This study would have not been possible without the contribution of my committee members. I am forever indebted to my supervisor, Dr. Eric Rapaport, as well as the reader and the current Director of the School of Planning, Dr. Patricia Manuel, for their academic and moral support over the last six years. Your wisdom in critical research, concise writing, and general life skill will help me throughout this journey that I am about to begin.

I would like to thank Dr. Rapaport and Dr. Manuel again, as well as the Faculty of Graduate Studies at Dalhousie University for their financial support of the Nova Scotia Research and Innovation Graduate Scholarship during the all-but-dissertation stage.

Special thanks to my colleagues at the School of Planning, Uytae Lee and Brendan Lamb, for their research suggestions, thought-provoking questions, motivational speeches, and great friendship overall. I also thank Wheejae Kim, Ellen Jung, and Minhee Jin for sharing their experience in graduate school and thesis writing.

Thanks to Ga Young Rhee, Do Hyun Kim, Jaeyoung Oh, Younghyun Ko, and Hyelin Seo for their personal support from the other side of the World.

I express my gratitude to my relatives in the Republic of Korea including Yeonju & Hyeyoung Jang, Sohyun & Haesung Kang, Kyung Hun & Hee Yeon Cho, and Taimin Kang, who were there for me during the period of grief.

Finally, I would not have been able to complete this work without the support from my family. Your decision to come to Canada 13 years ago for me and my sister to have a better life has finally come to fruition.

Research Commenced: August 31, 2015
Proposal Approved: February 25, 2016
Final Defense: July 21, 2017
Revision Approved: August 23, 2017
Submitted to the FGS: August 31, 2017

Chapter 1 Introduction

Risk associated with climate change is increasing. The resulting effects of climate change like sea level rise threatens communities situated in close proximity to coastlines. Therefore, coastal communities plan out and allocate land uses to mitigate such disastrous events in the future. Luckily, tools are available in different parts of the world to evaluate the risk of coastal flooding. Flood risk evaluation requires the following two components: the probability of flood hazard and the perceived impacts due to the characteristics of element at risk. While the probability is measurable, the impacts are determined by the perspectives of community stakeholders. That is, a way to assess the vulnerability for one area may differ from another area due to differences in culture, politics, and other various factors. The objective of this research is to explore if people in different regions have similar perspectives in land use vulnerability. If so, then a wide application of risk evaluation tools in other places may be possible.

This section argues that there is a need for determining land use vulnerability to coastal flooding in different regions, which will be of use in the risk assessment of land allocations. As awareness and acceptance of climate change grows, changes in water levels raise new concerns in protecting people's lives and properties along coastal zones. This leads to a discussion on prioritizing resource allocation for climate change mitigation, as most of the local government budgets are scant. Decision makers can foster a rational process of prioritizing areas for coastal protection by conducting a risk analysis.

1.1 Climate Change

The climate stayed relatively stable and remained predictable until the onset of industrialization (Cao & Woodward, 1998). Industrialization led to increased emissions of greenhouse gases such as carbon dioxide that altered the chemistry of the atmosphere (Naudé, 2011). The accumulation of greenhouse gases resulted in changing the average global temperature and rainfall patterns, impacting waterways and ocean conditions (Gleckler, Durack, Stouffer, Johnson, & Forest, 2016). As the average temperature began to rise, meteorological disasters became increasingly unpredictable, frequent, and powerful (IPCC, 2014). This affects the built environment in the form of storm surges, flooding events, and other types of natural disasters. In addition to changes in weather events, climate change impacts such as sea-level rise introduce the possibility of permanent land loss and increased coastal erosion.

Human settlements along coasts and waterways have always been vulnerable to flooding since their foundation (National Oceanic and Atmospheric Administration [NOAA], 2009; Wright, 2006). "Such disaster was viewed as acts of gods" due to the unpredictability of the weather (Wright, 2006, p. 102). Eventually, agrarian societies developed new technology to tame rivers and to restrain the sea through the construction of ditches, dykes, and sea walls (Guisepi, 1998). Those technological advancements have ultimately enabled in 634 million people to live along coastal areas less than 10 metres above sea level (McGranahan, Balk, & Anderson, 2007). This is especially true for a province like Nova Scotia where the majority of its population resides in coastal communities.

The IPCC (2014) forecasts that the global mean sea level will rise between 0.26 and 0.98 metres from 2000 to 2100, depending on the greenhouse emission level. There will be regional differences around the world, with the northeastern coast of North America potentially experiencing a sea level rise rate higher than the global average (Goddard, Yin, Griffies, & Zhang, 2015; Sallenger et al., 2012). One of the reasons for the differences is land subsidence due to glacial-isostatic adjustment, resulting in some of the earth's crust rising and other parts sinking (Forbes, Manson, Charles, Thompson, & Taylor, 2009; Milne, Gehrels, Hughes, & Tamisiea, 2009). As a result, the combination of sea level rise from global warming and land subsidence extends the area of inundation (Pirazzoli, 1997). Since Nova Scotia is on the northeastern coast of North America, scientists expect a large increase in sea-level rise.

The strength of storms is expected to increase as well (Emanuel, 2005; Webster, Holland, Curry, & Chang, 2005). Scientists project the frequency of category 4 and 5 storms to nearly double by 2100, despite a decrease in the overall frequency of storms (Bender et al., 2010). The implications of climate change are not solely reliant on the gradual, predictable sea level rise that was originally imagined. Instead, climate change has increased the potential for accelerated shoreline erosion and a rapid increase in the power of storm surges within a relatively short amount of time. Therefore, the combination of sea level rise, land subsidence, and stronger storms will result in extreme flooding conditions in Nova Scotia.

1.3 Importance of Prioritization

With growing numbers of people and infrastructure investments within urban areas near coastlines, the need for plans for how to adapt to climate change-induced sea level rise and flooding becomes more urgent. Planners, along with emergency management officials and other stakeholders, have the responsibility of preparing community members for such threats.

While some technological fixes are available for municipalities to adapt to a new climate, municipal budgets generally do not permit the retrofit of all vulnerable structures to high levels of resistance (Mirza, 2007). Without an increase in budgets, planners need to focus on the effective distribution of resources. Reprioritizing municipal budgets so that elements at higher risk are given more support in preparing for storms and weather events would make budgets more efficient when addressing climate change. Prioritization is critical for small communities like those in Nova Scotia as most of the Province is coastal, has low population density, and faces the problem of dwindling taxpayers with rural depopulation.

Members of the community may oppose prioritization if based purely on political considerations (District of West Hants, 2013; Town of Truro, 2013). A risk analysis can support the prioritization based on scientific evidence and wider consensus before a hazard occurs (Chang, 2003). That way, communities can minimize the risk and recovery cost after a disastrous event.

Chapter 2 Literature Review

This research is useful for governments that are in charge of allocating resources by planning land uses. Land use planning has an impact on the residents living in a community and the distribution of land use types such as residential, commercial, industrial, institutional, and public, as well as the distribution of infrastructures and essential services. As such, land use planning impacts the exposure of areas to hazards like coastal flooding.

One way to find out if people in different regions have similar perspectives on land use vulnerability is to reproduce the list of common land use types and allow them to assign weights to each land use for vulnerability. This chapter reviews assessment tools that are used in local planning process to evaluate land use vulnerability. Then, statutory plans or policies are identified in relation to land use vulnerability in the case study area, in which one of the tools may be applied. This answers the following question: is the assessment tool applicable in other places?

Before conducting this research, we need to know how people and governments understand risk, the different components of risk, and their relationships. Terminology such as risk, hazard, and vulnerability appears frequently throughout this study. However, among countries and even within a country, the terminology is not precisely defined (Fell et al., 2008). In fact, confusion may occur even in the same geographical area or on the same report. This chapter defines specialized terms used in this study to avoid confusion and to allow consistency.

2.1 Risk

Risk refers to an expected damage over a given period of time (UNISDR, 2012; Pinkerton, 2014). The definition of risk by academia and local government differs from the one defined by international organizations. Peer-reviewed journal articles (Boudou, Danière, & Lang, 2015; Cardona et al., 2012; Douglas, 2007; Fell et al., 2008; Lindell, Prater, & Perry, 2007) and government reports (City of Moncton, 2013; Dickie, 2009; District of Lunenburg, 2013; Halifax Regional Municipality [HRM], 2007; Province of Manitoba, n.d.; Scottish Environment Protection Agency [SEPA], 2012) state that risk is the combination of the likelihood of a harmful physical phenomenon – a hazard, and the characteristics of a person, a community, or other entity that make it susceptible to the damaging effects of such phenomenon. These characteristics may include physical, social, economic, and environmental factors. To simplify, risk is the intersection of hazard and vulnerability. International organizations and their scientists, especially in the United Nations, add exposure to the components of risk. Exposure is the number of assets, such as people, properties, systems, or other elements present in hazard zones that are thereby subject to potential losses (UNISDR, 2011b, as stated in UNISDR, 2012). By the definition of IPCC (2014) and UNISDR (2012), risk is the interaction of hazard, exposure and vulnerability, a relationship justified because should any one of the components be absent, then the risk is nil (Peduzzi, 2001; Peduzzi et al., 2002; United Nations Development Programme, 2004, as stated in UNISDR, 2012).

2.2 Hazard

The colloquial definition of hazard is a potential source of danger (Oxford Dictionary, 2015). This study focuses on natural disasters, such as hurricanes leading to high wind speeds or floods, as the potential sources of danger. Hazard may be calculated from the likelihood of storm events, which is estimated from local storm return rates (Bernier, Thompson, Ou, & Ritchie, 2007).

Government reports use terms such as ‘probability’, ‘likelihood’, ‘potential’, and ‘frequency’ of disaster to define hazard. Throughout this paper, a hazard means the probability of occurrence of an event which may cause damages, loss of life, injury, or other health impacts (Douglas, 2007; Fell et al., 2008; HRM, 2007; IPCC, 2014; UNISDR, 2011a). Note that without hazard, there is no risk.

2.3 Vulnerability

Vulnerability is the term applied to a variety of systems and defined in various ways across disciplines (Beniston et al., 2014; Cutter, 1996a). Cutter (1996a) describes vulnerability as the potential for loss, while Birkman (2007) and Lauire (2003) suggest that vulnerability determines the impact of a hazard on the element at risk. In Nova Scotia, words such as ‘severity’ (HRM, 2007), ‘risk tolerance’ (Town of Truro, 2013), ‘sensitivity’ (District of West Hants, 2013), ‘hazard frequency’ (County of Antigonish, 2013), ‘consequences’ (District of Lunenburg, 2013), and ‘impact’ (Dickie, 2009) replace the term ‘vulnerability’ when describing the potential for loss or the impact of a hazard on the elements. Substantial number of government reports referred to *hazard* as *vulnerability*.

National governments and international organizations describe vulnerability as the degree of susceptibility to potential harm from exposure to hazards, and lack of ability to cope with hazards, arising from various physical, social, economic, and environmental factors (City of Moncton, 2013; Douglas, 2007; IPCC, 2014; Province of Manitoba, n.d.; UNISDR, 2011a). SEPA (2012) also suggests susceptibility and resiliency as a measurement for vulnerability. Susceptibility is the propensity of an element to suffer harm from flooding (McCarthy et al., 2001), while resilience is the ability of a receptor to recover from damage incurred as a result of flooding (Folke, 2006, as cited in Beniston et al., 2014).

In the past, vulnerability has been limited to physical susceptibility; however, understanding of this concept is now becoming more comprehensive to include exposure, coping capacity, adaptive capacity, social inequalities, and physical, institutional, and economic weaknesses (Bender, 2002; Birkman, 2007). Makoka & Kaplan (2005) and UNISDR (2004) propose four major types of vulnerability: physical, social, economic, and environmental.

2.3.1 Physical vulnerability. Physical vulnerability focuses on "events that threaten physical body of human, food source, structures, and other life-sustaining services" (Ebert, Kerle, & Stein, 2009, p. 277). Pelling (2003) also suggests that the definition of physical vulnerability is the susceptibility and resiliency in the built environment. Physical vulnerability may be determined by aspects such as: population density levels, remoteness of a settlement, as well as building design and materials (Pelling, 2003; Sagala, 2006; UNISDR, 2004).

2.3.2 Social vulnerability. Social vulnerability refers to the inability of people, organizations, and societies to withstand adverse impacts from hazards due to characteristics inherent in social interactions, institutions and systems of cultural values (Lindell et al., 2007; UNISDR, 2011b). Cutter, Mitchell, & Scott (2002) characterize the factors influencing social vulnerability to natural hazards as: (1) lack of access to resources, including information and knowledge; (2) limited access to political power, governance and representation; (3) certain beliefs and customs; and (4) and physically weak individuals. Cutter (1996b), Lujala, Lein, & Rosvoldaune (2014), McLaughlin & Cooper (2010), and Wu, Yarnal, & Fisher (2002) urge emergency managers to address socially vulnerable groups: elderly people, impoverished people, and ethnic minorities. Social vulnerability is generally measured by comparing the proportion of socially

vulnerable residents in parts of a community (Cutter, Boruff, & Lynn, 2003).
For example, Cochran, Manuel, & Rapaport (2012) measure social vulnerability by comparing the prevalence of each indicator of social vulnerability in each dissemination area to the average for all dissemination areas in Nova Scotia. The unit of measurement is the standard deviation of results in Nova Scotia for that indicator. The indicators chosen are variables from the Canadian Census and National Household Survey that are proxies for social determinants of health, social and demographic attributes of a population that influence its health.

2.3.3 Economic vulnerability. Economic vulnerability evaluates the degree of vulnerability from disasters with parameters such as family income and housing prices (Lichter & Felsenstein, 2012). Penning-Rowsel & Chatterton (1977) use the value of buildings for residential areas while other researchers in the Global Facility for Disaster Reduction and Recovery (2010) have used Gross Domestic Product (GDP) of the products from agricultural, industrial, and commercial buildings to calculate economic vulnerability. Higher property values indicate higher recovery costs after disastrous events, therefore increasing their vulnerability. Typically, business sectors use this type of vulnerability to assess the risk of climate change and extreme weather events. For example, the Insurance Bureau of Canada completed an assessment of the economic impacts of weather effects at a municipal level for Mississauga, ON and for Halifax Regional Municipality (Insurance Bureau of Canada, 2015).

2.3.4 Environmental vulnerability. Environmental vulnerability emphasizes natural resource depletion and resource degradation from disastrous events (UNISDR, 2011b). Galbraith et al. (2002) and Beniston et al. (2014) establish that environmental vulnerability is measured by the extent of habitat loss by hazards, and its significance to local species and adjacent ecosystems. For example, a nuclear power station may release radioactive materials due to a meltdown induced by coastal flooding. The power station is deemed to be at high vulnerability because it may transform a large area to be uninhabitable and un-farmable for centuries once a meltdown occurs.

2.3.5 Exposure. Exposure means the number of people, property, systems, or other elements present in hazard zones that are at risk of being affected by a disaster (Douglas, 2007; UNISDR, 2011b). Under this definition, a single detached house would have lower exposure than an apartment, even if they have equal probability of flood occurrence. In this example, the apartment is more exposed than the house because it has more residents per unit. Because exposure is measurable, it can be calculated with Geographic Information System (GIS) techniques to identify how many residents or assets are located in a hazard-prone area (UNISDR, 2011b).

At a municipal level, data on exposure may be difficult to obtain. Although municipal governments focus on the number of people potentially affected and the resources required to ensure their safety during and after an event, data on the number of residents per building is not publically available (District of West Hants, 2013). Even if the data exists, it would be regarded as confidential and therefore inaccessible (Statistics Canada, 2015). Several alternatives exist to overcome the barrier by utilizing:

(1) Population density. Estimating the number of people living per unit, such as a dissemination area, from the information provided by the 5-year census (Statistics Canada, 2015).

(2) Dwelling unit counts. Estimating the number of residents in a building from the number of dwelling units in the building and multiplying it by a constant. For example, the definition of one dwelling is 2.25 persons in the Downtown Halifax Land Use By-law, in which the definition is used as a constant.

(3) Direct counts. Researchers may conduct a site survey or direct observation on their case study areas to identify the number of residents, units, or the areas of buildings.

(4) Land use density. Under land use vulnerability, exposure may be expressed as density. For example, a high-density residential zone would be deemed more vulnerable than a low-density residential zone because the municipality permits the placement of higher population density. Land uses do not always coincide with the actual population density due to pre-existing conditions or grandfathering, in which the exposure may be falsely inflated or deflated. However, high density zones still have potential to increase population density, which subsequently increase exposure.

Exposure refers to a quantity of the elements, as opposed to vulnerability, which focuses on the quality of the elements. Since exposure and vulnerability both focus on elements at risk, they may be discussed together rather than as separate entities. United Nations Disaster Relief Organization [UNDRO] (1991) justifies the combination of vulnerability and exposure by restating the definition of risk, which is the combination of the chance of hazard and its subsequent impacts. The impacts include both the quantity and quality of elements at risk. This study, therefore, includes exposure within land use vulnerability from the perspective of a municipality or other governing body, rather than individual landowners.

2.3.6 Comprehensive Vulnerability. The concept of vulnerability has become more comprehensive to include different perspectives in physical susceptibility, social inequalities, economic weaknesses, environmental degradation, and exposure (Bender, 2002; Birkman, 2007). Such comprehensiveness implies that stakeholders such as planners, EMO officials, policymakers, and citizens have different perspectives on the vulnerability of a place. A planner may determine an open, infrequently used space as an unimportant place, but local residents may regard the same site as culturally significant from a flooding perspective. Any place can be significant depending on the perspective used for evaluation (Collaborative Environmental Planning Initiative, 2006).

To prepare for the hazards, planners and decision makers need to consider various perspectives in terms of vulnerability, exposure, and other characteristics of an element at risk. Land uses are a tool for governments to mitigate the consequences of being exposed to hazards. Planners may control exposure by designating different zones of density, or consider social vulnerability by prohibiting community service uses like hospitals in flood risk areas, for example. With land use vulnerability, the stakeholders may consider different types of vulnerability and exposure of elements at risk while planning for land uses.

2.4 Land Use Vulnerability

Land use vulnerability is used to differentiate the risks associated with land uses by considering the impacts on land uses in terms of their relative susceptibility and resilience to flooding (Department of Communities and Local Government [DCLG], 2012). Land use vulnerability falls mostly under physical vulnerability (UNISDR, 2011a; Zheng, Takara, Tachikawa, & Kozan, 2008). In academia, research on land use vulnerability exists in different countries such as Greece (Kazakis, Kougias & Patsialis, 2015), Kenya (Ouma & Tateishi, 2014) and France (Boudou, Danière, & Lang, 2015). It is worth noting, however, that researchers focus on the materials of surface and the interrelationship between surface and groundwater as well as debris flow (Kazakis et al., 2015). They are more interested in land cover rather than land use and its socioeconomic characteristics.

In this type of research, land use vulnerability is measurable by the infiltration rate of groundwater and soil stability. While forest and lush vegetation favour infiltration, urban and pasture areas support the overland flow of water (Ouma & Tateishi, 2014; Kazakis et al., 2015). In other words, the type of land use may increase the peak discharge of water leading to flooding.

After gathering the land use classes of the study area from municipal zoning maps, Kazakis et al. (2015) reassigned the land use categories into five groups in order of their capacity to increase or decrease the rate of flooding. The categories were: Urban-Wetlands as the highest vulnerable use, Pastures, Agricultural, Sparsely Vegetated, and Mixed Forest having the lowest vulnerability. Ouma & Tateishi (2014) classified their land use categories in a slightly more urban-centric manner. They classified land use categories into Commercial as the highest vulnerable use, Industrial & Transport, Residential, Admin-Public Utilities-Education, and Agricultural uses being the least vulnerable use.

The researchers then used the methods of Multicriteria Evaluation (MCE) and Analytical Hierarchy Process (AHP) to define the vulnerability weighting of each land use, which they recommended to be used for regional studies of flood risk analysis (Ayalew & Yamagishi, 2005). However, these researches solely consider the infiltration of runoff water for land use vulnerability instead of socioeconomic factors. Consideration of transportation networks, land uses, settlements, buildings, and infrastructure is also included in some social and economic vulnerability assessments (Johnston et al., 2013; Lichter & Felsenstein, 2012; Lujala et al., 2014; Öyzurt & Ergin, 2010; SEPA, 2012).

The United Kingdom has some predominance in the research of land use vulnerability in urban setting; it is perhaps the only place in the world that recognizes and legislates the concept of land use vulnerability. The concept of land use vulnerability arose as early as Penning-Rowsel & Chatterton's (1977) research. The two professors established the relationship between water depth and building damage due to floods. They studied the relationship by classifying the buildings at risk into several land uses – residential, retail commercial, industrial, and so on. For each land use, they developed a questionnaire and asked the households to record the flood damage after a disastrous event, which included: water depth, ground floor height, building age, building material, social class, and damages in British pounds. They published their findings in their seminal paper known as the Blue Manual. The researchers correlated the characteristics of buildings and the average damage to floods – one of the characteristics being the land uses of buildings. Using the 'Blue Manual', the researchers calculated the risk of a building to flood events in terms of expected damage. Although their research focused on the physical susceptibility of buildings, it may have been the first attempt to recognize land use as one of the considerations in flood risk and vulnerability assessment. Other researchers in the United Kingdom, such as McLaughlin & Cooper (2010) and Johnston et al. (2014) incorporated Penning-Rowsel & Chatterton's work for measuring vulnerability of roads, railways, and buildings from exposure to coastal forces.

The Department of Communities and Local Government [DCLG] (2012) in Britain apply the concept of land use vulnerability in its flood risk analysis guideline, under the national planning policy framework. The DCLG recognizes that certain types of developments and their residents are at higher risk from flooding than others. The DCLG also considers the impact on the adjacent land uses of property and the community-as-a-whole when a disaster occurs. The classification, as listed on Table 1, focuses on the relative vulnerability of different development types for their users, the need to avoid potential adverse impacts, and wider community impacts caused by their damage or loss. For example, a police station is not more likely to suffer damage or less able to recover than a comparable office building. However, it is placed in a more vulnerable category than an office use because a higher value is placed on the wider community impacts which would be caused by its potential loss or damage during a flood event (SEPA, 2012). The DCLG's objectives of introducing land use vulnerability are: (1) to facilitate consideration of the impacts of flooding in land use planning; (2) to focus attention on the relative vulnerability of different developments for their users; and (3) to assist interpretation of the risk framework.

National governments, such as Scotland, Wales, and Northern Ireland, as well as local governments in the United Kingdom, have adopted the Flood Risk Vulnerability of Land Use Classification created by the British DCLG (SEPA, 2012). While there are many countries and municipalities across the world that conduct risk and vulnerability assessments for flood events, the researcher was unable to find any other municipalities that incorporate a list of land use classifications for flood risk in their planning processes.

Table 1 DCLG (2012) Flood Risk Vulnerability of Land Use Classification

Land Use Vulnerability Classification	List of Land Uses
Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) which must cross the area at risk. • Essential utility infrastructure which must be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly Vulnerable Uses	• Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use. • Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as "essential infrastructure").
More Vulnerable Uses	• Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non-residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

Land Use Vulnerability Classification	List of Land Uses
Less Vulnerable Uses	• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non-residential institutions not included in “more vulnerable”, and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand & gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water Compatible Uses	• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence military installations. • Shipbuilding, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

2.5 Existing Process of Quantification of Hazard and Vulnerability

Before quantifying risk, quantifying hazard and vulnerability is necessary. Hazard may be expressed as a ratio or ordinal variable as the term represents a probability of disastrous events. Since this study focuses on coastal flooding, hazard would specifically represents the probability of flood occurrence. Expressing hazard as a percentage value is possible; however, planning practitioners often categorize hazard into a few categories, typically ranging from 'frequently' to 'rarely' to simplify the process of quantification. For example, the British Department of Communities and Local Government [DCLG] (2012) defines four flood zones based on the probabilities of riparian and coastal flooding. In Nova Scotia, the Municipal Government Act defines two riparian flood zones, and its municipalities typically have three ranks for representing hazard: high, medium, and low probability (HRM, 2007; Town of Truro, 2013).

Most studies on vulnerability are qualitative in nature, but there are examples of quantifying vulnerability in recent decades (Fell et al., 2008). Quantification of vulnerability transforms varying units of measurement into a form that is easily understood and enables direct comparisons between elements at risk (McLaughlin & Cooper, 2010). Fell et al. (2008) and UNDRO (1991) suggest a method for quantifying vulnerability by computing a percentage of physical, economic, social, or environmental losses against the total value of land. For linear infrastructure, such as powerlines or roads, and essential services like hospitals, Dickie (2009) proposes the number of affected customers and duration of damage to be the measurable value.

Expressing vulnerability with an ordinal index is another method of quantification. Similar to using categories to classify the degree of hazard, Johnston, Slovinsky, & Yates (2014), Lujala et al. (2014), and Özyurt & Ergin (2010) use matrices and indices to rank vulnerability parameters from very low to very high. The researches of Van Leeuwen (2014) and Hindrichs (2015) regarding climate change risk on the Halifax waterfront also rank land use vulnerability using the Scottish Environment Protection Agency (SEPA) classification, which is an example of ordinal classification of vulnerability. While ordinal variables provide information on which land use is more vulnerable over another, the classification lacks detail on how much more vulnerable each land use is compared to others.

2.6 Policies on Flood Prone Areas in Nova Scotia

The Province of Nova Scotia and its municipalities, the case study area, has policies in place to mitigate flood risk. Analyzing how these municipalities currently conduct flood risk and vulnerability assessments would lead to understanding their consideration of land use vulnerability in their plans - both statutory and non-statutory. Understanding the limitation of existing policies or studies on land use vulnerability in the case study area is the goal of this section.

2.6.1 Provincial policies. The Municipal Government Act of Nova Scotia describes the focus areas of the provincial government in municipal planning, including managing flood risk areas. Through the Statement of Provincial Interests (SPI), the Province of Nova Scotia (2014) defines flood risk areas as the areas that will experience flooding at least, on average, once in one hundred years. The SPI also describes two zones within the areas: floodway and floodway fringe.

The Province of Nova Scotia (2014) proceeds to describe the specific regulation for these flood risk areas. In the floodway, where the probability of flooding in general is once in less than twenty years, development is prohibited – except for roads, open spaces, utility and service corridors, parking lots, and temporary uses. In the floodway fringe, where the probability is once in between twenty years and one hundred years, the Province prohibits the use of residential institutions including hospitals, senior citizen homes, homes for special care, and similar facilities where flooding could pose a significant threat to the safety of residents if evacuation became necessary. However, the construction of private residences, commercial, and industrial uses are not prohibited.

Nova Scotia solely considers riparian flooding regarding land protection, as opposed to coastal flooding. The province adopted the flood-related definitions for the SPI from the federal government. Environment Canada (1975) defines floodplain as the low-lying area adjoining a watercourse, while describing watercourse as a river reach or lake shoreline. With climate change increasing the frequency and the strength of hydrologic hazards, the provincial statement needs to expand its definition of flood risk areas. Some municipalities in Nova Scotia such as HRM, Cumberland County, and Lunenburg County have adopted a vertical or horizontal setback from the coastline as an adaptive measure to sea-level rise (Rideout, 2012).

2.6.2 Municipal plans and policies. The Province of Nova Scotia delegates the responsibility to plan land uses to its 50 municipalities. Nova Scotia Department of Municipal Affairs (2016) mandates that these municipalities each develop a Municipal Planning Strategy (MPS), a legal document that has status of law in a municipality to outline its visions for the future and its strategy for managing social and economic challenges. Each MPS is accompanied by a Land Use By-law (LUB) to enforce the visions defined within the MPS.

Other than MPSs and LUBs, the Province also requires its municipalities to submit a plan for their sustainability in order to receive Federal Gas Tax funds (Service Nova Scotia and Municipal Relations & Canada-Nova Scotia Infrastructure Secretariat, 2011). The purpose of the plan, named Integrated Community Sustainability Plan (ICSP), is to acknowledge social, cultural, environmental, and economic dimensions of sustainability in a comprehensive way (Grant, Beed & Manuel, 2016). The resulting funds enable municipalities to invest in environmentally sustainable infrastructure projects that contribute to cleaner water, air, and soil, as well as reducing greenhouse gas emissions. As of March 2010, every municipality had either amended their MPS or submitted their ICSP to satisfy the provincial requirement.

In 2011, the Province mandated the submission of Municipal Climate Change Action Plans (MCCAP) (SNSMR, 2012) and all municipalities completed their MCCAP by the end of 2013. The MCCAP identified priorities "to make sure people, property, special places and essential services aren't compromised by natural hazards exacerbated or introduced by climate change" (SNSMR, 2012, p. 6). The MCCAP process serves as a reminder of the connections between land uses, municipal services, and citizen safety (Town of Truro, 2013).

2.6.3 Risk and vulnerability assessment at a municipal level in Nova Scotia. Municipalities in Nova Scotia like HRM (2007) are aware of the need to delineate zones of vulnerability and to prioritize protection and relocation. Prioritization of protection is conducted so municipalities may develop appropriate policies to manage risks from climate change impacts. Some of the municipalities use the guidebook prepared by Elemental Sustainability Consulting (2012) to help them determine their level of risk by multiplying a probability score and a severity-of-impact score. The score for probability and severity-of-impact is between 1 and 5 points each, which means that the range of scores is between 1 and 25 points (SNSMR, 2012).

This risk analysis was used in the creation of Municipal Climate Change Adaptation Plans (MCCAP), in which municipalities assessed existing infrastructure and key facilities for their susceptibility to the effects of climate change (Region of Queens Municipality, 2014). Assessing vulnerability of elements at risk was one of the key steps in developing MCCAPs. It should be noted that most municipalities developed their own prioritization strategies by considering critical infrastructure, rather than land uses. The MCCAP documents from 26 municipalities that were accessible online at the time of this study have been grouped into 5 categories based on the similarities in their methodology.

(1) Prioritized. This method assigns a ratio score to each element at risk to assess vulnerability, allowing more detailed analysis during risk mapping. HRM, CBRM, and Region of Queens Municipality have classified municipal services and their infrastructure based on the level of susceptibility and the effect on larger areas in case of disruption of such services (Cape Breton Regional Municipality, 2014; HRM, 2007; Region of Queens Municipality, 2014).

(2) Essential and non-essential. This method classifies elements at risk into a prioritized group and non-prioritized group. In a state of emergency, those elements in the prioritized group would be protected before those elements in the non-prioritized group. Antigonish (County), Kings, Lunenburg, Bridgewater, and Mahone Bay classify all of the infrastructure and municipal services into essential and non-essential. During disaster events, the municipalities would prioritize the protection of essential services (County of Antigonish, 2013; County of Kings, 2013; District of Lunenburg, 2013; Town of Bridgewater, 2014; Town of Mahone Bay, 2013).

(3) Hazard. This method solely considers the exposure of elements to hazard in assessing risk; that is, any elements at risk would be protected equally regardless of the degree of physical, social, economic, or environmental losses after disasters. Antigonish (Town), West Hants, and East Hants would protect any services that are in their identified flood risk areas, regardless of their vulnerability (Town of Antigonish, 2013; District of East Hants, 2013; District of West Hants, 2014).

(4) Time-Hazard Priority. This method puts elements at risk - buildings or* infrastructure - that can be reinforced in the near future as higher priority. Services that are likely to be affected in the near future because of their fragility – for example, aging sewer systems – would also be protected first under this method. Chester, Barrington, and Digby focus on imminent threats. (District of Barrington, 2013; District of Chester, 2013; District of Digby, 2013).

(5) No Clear Priority. No clear patterns or rules are found in identifying vulnerable elements during risk analysis. Colchester, Pictou (Town), Richmond, Shelburne, and Yarmouth (Town and District) have no clear statement about vulnerability assessment or prioritization of infrastructure protection (County of Richmond, 2014; District of Shelburne, 2013; District of Yarmouth, 2013; Town of Pictou, 2013; Town of Truro, 2013; Town of Yarmouth, 2013).

2.6.4 Emergency management in Nova Scotia. The Province of Nova Scotia maintains the provincial Emergency Management Organization (EMO) and its subordinate committees in each municipality for a prompt and coordinated response to a state of emergency. The perspectives from which municipalities and the EMO assess risk are different. The Town of Truro (2013) and the District of West Hants (2013) state that the EMO is most concerned with people's safety during an emergency. That concern is immediate in nature, meaning that the EMO perspective focuses first on the lives of people before industry and infrastructure. Warburton & MacKenzie-Carey (2013) suggest that the EMO would be concerned with the interruption of municipal services only in cases where that interruption may trigger an emergency response, such as the loss of potable drinking water for an extended period of time.

While emergency plans are designed to protect citizens from highly probable hazards or near-term consequences of disastrous events, planners have a wider view of hazards (Town of Truro, 2013). Planners consider anything that poses a potential interruption of services – such as the ability to distribute an adequate supply of potable water, ability to manage and treat wastewater, and the ability to ensure accessible transportation networks – to be a threat (District of West Hants, 2013; Town of Truro, 2013). Likewise, hazards that may result in damage to costly infrastructure or in local job losses are also potential threats (District of West Hants, 2013). To summarize, emergency management officials are concerned with the interruption of services, while planners are concerned with the cause of the interruption or damage to services.

Understanding the perspective of the EMO is important in assessing vulnerability because EMO officials are in charge of providing a prompt and coordinated response during an emergency. Assessing vulnerability and planning for risk would affect the tasks of EMO officials.

2.6.5 Risk and vulnerability assessment tools. Lindell et al. (2007) recommend a Hazard Risk Vulnerability Assessment (HRVA) for municipalities to increase their understanding of how the characteristics of hazard produce physical and social impacts. The Town of Truro (2013) stresses the need for such tools. In the absence of the HRVA and MCCAP process, prioritization of emergency management plans for natural disasters would continue to be based solely on historical trends and experiences. The HRVA-MCCAP collaboration shifts both municipal and EMO perspectives away from planning based on historical events, to forward looking considerations of climate projections.

Only a couple of municipalities have recognized such assessment tools in Nova Scotia. Kosloski (2008) and Dickie (2009) conducted research on coastal zone management in relation to land use vulnerability for Halifax Regional Municipality (HRM). Kosloski's (2008) Risk and Vulnerability Assessment Tool (RVAT) assesses flood risk by mapping four different sources of vulnerability: natural environment, built environment, flooding, and cumulative vulnerability, which combines all aforementioned vulnerability types. Natural vulnerability accounts for elevation, slope, shoreline geomorphology, and tidal range of the case study area. In this case, a property would be more naturally vulnerable if it is located at a lower elevation, steep-sloped, and close to the coastline. Built environment vulnerability is composed of "critical facilities, land use, ownership, future land use, presence of infrastructure, essential services, and presence of potential hazardous use" (Kosloski, 2008, p. 21). Therefore, a home is naturally vulnerable if it is at a low elevation, whereas the home is 'built environment' vulnerable if it is next to a sewage plant. Flood vulnerability combines three different sea-level rise scenarios for the property and scores it based on the number of times it is flooded. Despite using different terminology from this paper, the RVAT still uses the concept of risk, hazard, and vulnerability.

Kosloski's (2008) RVAT may be the only research produced in Nova Scotia regarding land use vulnerability and its application in the planning process. However, limitations to the RVAT exist as Kosloski (2008) solely defines all residential and industrial uses as vulnerable due to the potential of human life loss and the potential to leak hazardous wastes into surrounding areas after flooding, respectively. Kosloski seldom mentions other land uses such as commercial or institutional uses in her research, nor classifies more specific types of residential and industrial uses – for example, by density or more detailed uses.

Kosloski considers physical vulnerability by identifying residents near coastal areas and environmental vulnerability by identifying industrial uses, also nearby coastal areas. However, it does not incorporate other perspectives such as social vulnerability or population density.

2.6.6 Geographic differences in perceiving vulnerability. Beniston et al. (2014) state that a vulnerability index acts as an early warning system for future disasters; the index identifies properties that are currently not threatened, but might be likely to become so. A problem arises when a comprehensive vulnerability classification system is written in the context of a particular place. For example, the Department of Communities and Local Government (DCLG) classification of land use vulnerability system was produced in the context of the United Kingdom. Hindrichs (2015) disagreed with the direct application of the DCLG land use classification in Halifax because an important land use in the British context may not be the case in another place under different cultural norms. Therefore, values used to determine vulnerability and priorities in the United Kingdom may not coincide with the values in the context of Canada or other places. In other words, vulnerability weightings cannot be simply transferred from one place to another.

Communities wishing to use the land use vulnerability classification should check its appropriateness to the local context prior to its application. In her research, Hindrichs (2015) created an independent classification for Halifax, similar to the ones adopted by the DCLG and the SEPA. A survey was distributed to four local planners, who then ranked land use vulnerability to flooding. Hindrichs discovered that the planners tended to rank residential uses as high vulnerability, but showed disagreement on the ranking of other land uses. One of the participating planners commented that the ranking depends on personal assumptions about certain types of land uses. Hindrichs' work reveals that not only local context must be considered while conducting land use vulnerability classification, but the differences in the interpretation of land uses between regions and planners must be considered as well.

2.7 Outcome of Literature Review

The general idea of risk is that it is the combination of hazard, exposure, and vulnerability. Hazard is the likelihood of disaster occurrence – flooding, in this case. Exposure refers to the amount of people, properties, or other elements present in hazard zones that are subject to potential losses. Vulnerability indicates the degree of susceptibility to potential harm from exposure to hazards, and the lack of ability to cope with hazards, arising from various physical, social, economic, and environmental factors. Discussions of vulnerability have previously been limited to physical susceptibility; however, it is now becoming more comprehensive to include exposure, social inequalities, as well as physical, institutional, and economic weaknesses.

With this in mind, assessing vulnerability from a land use perspective may be especially ideal as land use often encompasses the four major types of vulnerability. Additionally, assessing vulnerability from a land use planning perspective could be more useful in application for municipalities as zoning is a tool that planners use to mitigate flood risk. With land use vulnerability, the community stakeholders may consider different types of vulnerability and exposure of elements at risk in a comprehensive way and use it to adapt current planning tools.

Research on land use vulnerability dates back at least 40 years, however, most of this research has been based in the United Kingdom. As a result, the governments that incorporate the concept of land use vulnerability in their planning process have also been within the United Kingdom. Other places touch on land use vulnerability through consultant reports.

In Nova Scotia, the provincial government restricts development in some land uses on floodways through the Statements of Provincial Interest. This may be interpreted as having the concept of land use vulnerability.

Municipalities in Nova Scotia attempt to mitigate flood risk by aiming towards building more sustainable communities and stating their intentions in documents such as the MPS, LUB, ICSP, and MCCAP. However, none of the municipalities incorporate the concept of land use vulnerability in their planning processes. In 2008, a study was conducted in Halifax regarding land use vulnerability, but it was limited in that it only considered residential and industrial uses as vulnerable land uses. The study did not consider any other land uses.

Land use vulnerability will help planners prepare communities for disasters while planning land uses. A risk assessment that incorporates land use vulnerability is an effective tool for planners because of its focus around land use planning and its comprehensiveness to touch on major types of vulnerabilities and exposure. A real-life application may be the prevention of a redevelopment if such change-of-use may increase the property's vulnerability to coastal flooding in the nearby area.

It is evident that tools incorporating the concept of land use vulnerability are available in some parts of the world, particularly the United Kingdom. However, it remains to be seen whether other communities can apply these tools without making adjustments to consider local cultural, political, and social differences. Such differences in other regions may influence the process of deciding on what land uses are more vulnerable than others – leading to poor implementation of these tools. This is impossible to know without testing the appropriateness of using external tools.

Chapter 3 Research Statements

The concept of land use vulnerability will be helpful to the planners and emergency management officials in Nova Scotia during the planning of flood risk mitigation through land use tools exist from other jurisdictions. However, it is unknown whether implementing a tool developed outside of the target region is appropriate or not. For this research, I tested the appropriateness of these tools by developing a land use vulnerability classification with professionals in Nova Scotia.

3.1 Problem Statement

Cultural, social, or political differences in other regions may play a role in developing a land use vulnerability classification. This may prevent other communities from applying the classification to assess flood vulnerability in their communities.

3.2 Purpose Statement

The purpose of this research is to test the similarity of perspectives among professionals in another place other than the United Kingdom in terms of the classification of land uses from the perspective of vulnerability to coastal flooding.

3.3 Research Question

How do Nova Scotian municipal planners and emergency management officials weight the relative vulnerability of land use to coastal flooding and sea level rise? How does this compare to the British officials?

3.4 Research Objectives

The objectives of this research are:

1. to develop a classification of land use vulnerability to coastal flooding in the context of Nova Scotia.
2. to discover potential variances in weighting land use vulnerability to coastal flooding among working professionals in the municipalities in Nova Scotia; and
3. to highlight any noticeable dynamics of a focus group in weighting land use vulnerability to coastal flooding in Nova Scotia.

Chapter 4 Methodology

This chapter describes the step-by-step details of how the researcher derived land use vulnerability classification in Nova Scotia. The main method of data collection was online surveys distributed to municipal planners and emergency management officials. Additionally, a focus group was held with professionals in these fields to further explore questions similar to those on the survey. Participants were asked to assign weights to various land uses based on their perspectives of vulnerability in order to determine the relative priority of a land use under a flooding event.

The research consulted planners and emergency management officials as they are familiar with this type of work. Identifying people and community assets that could be at risk is both part of planning practice as well as emergency response planning. The provincial government requires all Nova Scotian communities to have emergency response plans in place. However, as identified in the literature review, these municipalities have not gone through a process of classifying land use vulnerability. The detailed description of the method in this chapter will be helpful to those who wish to replicate the land use vulnerability classification process in their community.

4.1 Approach

The study approach used a mix of quantitative and non-spatial qualitative methods. The mixed methods were used to derive a classification system for land use vulnerability relative to sea level rise and flooding. A spatial analysis case study was used to demonstrate how the classification system works.

4.1.1 Expected value theorem. This study used the Expected Value Theorem, one of the fundamental statistics theories, to formulate the relationship among risk, hazard, and vulnerability. The theorem explains that the expected value of an event is a weighted average of the possible values that the event can take on and the probability that the event assumes that value, as shown in equation 1 (Ross, 2007).

(1) Expected Value = Probability of Event A x Value of Event A

In the case of flooding events, the expected value would be the combination of the annual probability of a flooding event and the value of property lost due to flooding. Hazard may be measured with a storm return period, which is an estimate of the likelihood of a flood event. For example, a 100-year storm would have 1% chance of occurring in any given time. In Halifax, Nova Scotia, the municipality uses a 50-year storm return period as the threshold probability to determine areas at risk of flooding from storm surges (Forbes et al., 2009).

Vulnerability represents the impact of a hazard on the element at risk. In other words, vulnerability may be expressed in the potential value that may be lost once a hazard occurs. Therefore, a relationship between risk and vulnerability may be defined by simply substituting variables in Equation 1, as shown in equation 2:

(2) Risk = Probability of Hazard x Land Use Vulnerability

4.1.2 Multicriteria evaluation (MCE). Nyerges & Jankowski (2010) state that multicriteria evaluation is used when decision makers need to compare multiple data in different formats. Multi-criteria evaluation follows three steps: standardization, transformation, and aggregation. First, data are converted to a special numeric scale (such as 0-1, 0-100, 0-255). Then, the standardized data are weighted according to their priority, which are then combined to yield a final result. This study solely focused on transformation, also known as weighting, to classify land uses in terms of vulnerability.

This study considered three common procedures for weighting of decision maker preferences into numeric values: ranking, rating, and pairwise comparisons. Ranking starts by participants arranging criteria in an order of importance. If there are 10 land uses, then the most vulnerable land use is given a vulnerability score of 10. The difference between the highest and the next highest level is a linear difference of one value. There is no consideration that the difference in vulnerability between two adjacent land uses on the ranking list could be perceived as being greater than 1. It is also possible for ties. Its simplicity attracts researchers to derive criterion weights using ranking method, but it also serves as a disadvantage. Ranking may inform researchers of a relative priority, but not the degree of importance. Using ranking as a method of deriving vulnerability lowers the precision of risk as a ratio variable.

A technique for adding non-linear scaling is the use of a rating system. Rating requires participants to distribute points among criteria, indicating higher priority for criteria by assigning them more points. The number of points given may vary. If 100 points were to be distributed amongst three land uses – residential, commercial, and institutional – and if participants distribute 75 points to residential uses, then its rating is weighted by the 75 points divided by 100 points, or 75%. If a commercial use is given

20 points, its weight is 20%, with the remaining percentage given to institutional use. Rating conveys the idea of distributing resources before and during emergencies and is similar to how governments distribute funding to different community resources, which is not always equal (Schneider & Logan, 1981).

Another technique that can be used to generate non-linear weighting is the Analytical Hierarchy Process (AHP) (Saaty, 2010). AHP uses pairwise comparison, which involves iteratively comparing pairs of criteria and deriving the relative priority of one criterion against another for every possible combination (Nyerges & Jankowski, 2010). The summation of the scores for each criterion follows to identify an overall priority.

Rating was selected as the method of weighting as the procedure achieves a balance of simplicity and complexity in conducting the research. While pairwise comparison has a solid theoretical base, computation would be exponentially complex and time consuming; therefore, it is unfeasible with a larger numbers of potential land uses. The research on land use vulnerability conducted by the British Department of Communities and Local Government [DCLG] (2012), which identifies 33 land uses, would have at least 561 combinations for experts to evaluate. Existing studies on land use vulnerability, like the one by the DCLG (2012), often use a ranking system. While researchers would appreciate its simplicity, the outcomes of the research would not be as precise as the outcomes of research using the rating method because the increment of unit in ranking is not as meaningful as it is in rating.

4.2 Developing a Survey

This research used a survey methodology to collect the thoughts of professionals in Nova Scotia about land use vulnerability by asking the respondents to assign weight to land uses according to their professional opinion. Surveys are a commonly used method of collecting information and opinions from a sample of individuals using an ordered list of questions (National Oceanic and Atmospheric Administration [NOAA], 2015). The Office for Coastal Management of NOAA (2015) explains that public and professional perceptions strongly influence decision making in coastal management and surveys help identify the relationship between the community and, in this research, the land uses.

The questionnaire used in this survey first included questions about the participant's professional information: location of workplace, years of experience, and involvement in planning or emergency management. Then, professionals were asked to assign weights to 6 broad categories of land use to rate their vulnerability - Residential, Commercial, Industrial, Institutional, Government, and Infrastructure. This was done by distributing 100 points amongst the 6 land uses. Then the respondents were asked to assign weights to various sub-category land uses within each category of land use - 41 in total. Similar to the previous question, respondents were asked to distribute 100 points amongst the various subcategory land uses under each land use category. The full survey can be found in Appendix A. The researcher then identified patterns or variations between respondents. The questionnaire further allowed the participants to explain their thoughts and reasoning behind their weighting through a comment section in the survey.

4.2.1. Land use types. The Province of Nova Scotia (2014) delegates the responsibility for land use zoning to municipalities, thus not all land use definitions are consistent among the various municipalities. In order to ensure that all survey respondents had the same foundational understanding of land use to base their vulnerability weightings, definitions were provided for each land use on the survey. To classify different land uses in Nova Scotia, the researcher identified all permitted uses in each zone listed in the Halifax Peninsula Land Use By-law and the Nova Scotia Model Land Use By-law (Halifax Regional Municipality, 2016; Service Nova Scotia and Municipal Relations, 2002). As shown in Table 2, the researcher grouped these uses into subcategories such as Food Retail Services, Service Stations, and Office Buildings, which were then grouped into broader categories such as Commercial uses.

While the researcher made attempts to use the land use categories listed in the Halifax Peninsula Land Use By-law and Nova Scotia Model Land Use By-law as they are, there were some circumstances that made this difficult. A study in psychology by Miller (1956) which was cited in the multiple criteria evaluation like what is described by Nyerges & Jankowski (2010) suggests that lists that have more than seven choices are significantly more difficult to process simultaneously. Thus, the researcher chose to offer between five and nine. In categorizing land uses, some uses were amalgamated with others to reduce the number of choices. For example, the Agricultural land use subcategory was listed under the Industrial land use category. Typically, agricultural use is in a separate land use category for most of the rural municipalities in Nova Scotia. Another case was the Rooming House land use subcategory. Typically, rooming houses are categorized under low density residential zones but have similar population densities to that of medium residential zones. That being said, rooming houses also have a history of being socially vulnerable (Lee, 2016), thus a new, independent subcategory was made.

Table 2 A List of Land Use Categories and Subcategories in the Survey

Category	Subcategory	Examples
Residential	Low Density	Detached houses
	Medium Density	2-4 storey residential buildings such as semi-detached, duplex houses, and townhouses
	High Density	Residential buildings with 5 or more stories such as apartments and condominiums
	Boarding & Rooming Houses	Boarding & rooming houses
Commercial	Personal Services	Barber ships, hairdressers, beauty parlours, dry cleaning distribution stations, laundromats, florist ships, health clubs, and funeral services
	Food Stores	Convenience stores, grocery stores, and supermarkets
	Food Retail Services	Restaurants, bakeries, fast food joints, and drinking establishments
	Service Stations	Gas stations and vehicle repair shops
	Accommodations	Hotels, inns, and hostels
	Entertainment Services	Bowling alleys, movie theatres, night clubs, and amusement centres
	Repair Shops	Plumbing, electrical, and electronic repair shops
	Wholesale & Distribution Businesses	Costco, beverage, and food warehousing
	Office Buildings	Professional services, law firms, and banks
Industrial	Agricultural	Farms, pastures, orchards, and stables
	Industrial	Factories and manufacturing plants
	Marine Industrial	Cargo storages, sea product processing, and shipbuilding
	Docks & Wharves	Docks and wharves

Category	Subcategory	Examples
Institutional	Education I	Primary schools, secondary schools, universities, and research facilities
	Education II	Libraries and museums
	Private Care Facilities	Daycares, senior homes, and special care facilities
	Residential Institutions	University residences and prisons
	Religious Centres	Churches, monasteries, mosques, and temples
	Historic Sites & Monuments	Heritage buildings, monuments, historic towers and lighthouses
	Civic Halls & Community Facilities	Legion halls, rotary clubs, NGO offices, and community centres
Governmental	Administration	Government offices, postal offices, and law courts
	Military	Military bases and armouries
	Safety & Security	Police stations, fire stations, EMO headquarters
	Medical I	Hospitals & EMS stations
	Medical II	Clinics, pharmacies, dentists, optometrists, private doctor's offices, and other medical offices.
	Recreational I	Arenas, stadiums, and sports halls
	Recreational II	Parks, playgrounds, recreation fields, trails, cemeteries, and golf courses
	Environmental Conservation Areas	Protected wetlands, forest, and watercourses

Category	Subcategory	Examples
Infrastructure	Major Roads	Highways and arterial roads
	Minor Roads	Collector and local roads
	Parking Spaces	Underground parking facilities, ground-level parking lots, and indoor parking garages
	Public Transit	Transit terminals, and transit fleet storage facilities
	Railroads	Railyards and railroads
	Electricity	Power lines, utility poles, and power generating stations
	Water Utilities	Water, sewer, stormwater pipes, pumps, lifting stations, and water treatment plants
	Coastal & Riparian Protection	Dykes and dams
	Waste Management Facilities	Landfills and recycling centres

4.2.2. Pretest. The questionnaire was tested before distribution. The researcher sent the online link to three personal connections who were municipal staff working for a city in New Brunswick having similarities to the planning process in Nova Scotia. The position of the three staff members were municipal planning officer, chief engineer, and GIS technician. They filled out the questionnaire individually, followed by a meeting with the researcher to resolve confusion around filling out the questionnaire. Then the respondents held a second group meeting to decide on collective weightings for each land use. After concluding the group meeting, the participants submitted their online survey results, the group results, and their feedback to the researcher. The feedback was used to make minor modifications.

The researcher received one comment and one question at the first meeting with the planning staff. This comment was that the participant was uncomfortable assigning a priority to a land use over another because it was “like asking which child would you choose to save when you have two, but can only save one” (personal communication, March 11, 2016). The participants reported that they had never participated in research like this, and that they had not been given an opportunity to think about land use vulnerability. A question arose as the participants tried to distinguish the words Hazard, Vulnerability, and Risk. The question was:

> Do we have to consider our particular situation here in the vulnerability index attribution or do we have to assume everything is at risk? As an example, in our situation, the Hospital is not at risk, [so] should it have a score of zero in the relative vulnerability compare to the park – which we know is at risk for sure. Sure, hospitals are more important than parks. But in our case, we would not have prioritized the hospital over our park as the park is at risk and the hospital is not. (personal communication, March 11, 2016)

To answer the participant's question, the park – located by the coastline – is at high risk because the probability of the coastal flooding occurrence is high, and the Hospital – located on top of a hill – is not at risk because the probability of the coastal flooding occurrence is almost nil. Because the probability is defined under hazard, it should not be considered in weighting land use vulnerability. However, this is an indication that the participants may have confused the definition of vulnerability with hazard. As a result, the final version of questionnaire included a note to assume all land uses have an equal probability of being flooded while participating in the survey.

In the group discussion, the respondents decided to use the average scores of their individual weightings for all group weightings since they could not reach a conclusion after a three-hour meeting. Their feedback after the group discussion focused on the different perspectives of each participant. One participant pointed out that some land uses on the survey did not exist in the municipality while the other two participants assumed that all the land uses on the survey existed in the municipality then proceeded to prioritize uses accordingly. This seemed to have an effect on weightings, and it had to be addressed before survey distribution. It was decided that the process has to be context specific – that is, each participant could consider the situation in their community rather than assuming all land uses exist. There are some land uses that require expertise and knowledge to understand relative vulnerability. Therefore, if a land use did not exist in their community, it was to be weighted zero as the participants did not have enough information or experience to make a decision on weighting – although they may have had experience from their previous career. As a result, the following statement was attached as a reminder to each question:

> You should weight the land uses that you find in your community. For example, if you do not have a public transit system in your community, please weight that zero. If your community only has low and medium density residential zones, those two land uses should receive weighting, but high density should not. You are assigning weightings in the land uses based on your local context. You may read the description of each land use by resting your cursor on the name of land use. Vulnerability is a measure of priority in the protection of lands in terms of their susceptibility and resilience to flooding, as well as their impacts to wider community caused by their damage or loss.

4.2.3 Online survey. The online survey was distributed via e-mails to planners and members of EMO Committees in each municipality in Nova Scotia. At the time, up to 225 planners were registered under the Licensed Professional Planners Association of Nova Scotia – the official licensing body for the planning profession in the Province (N. Rogers, personal communication, September 22, 2016). Fewer EMO officials worked at the municipal level in Nova Scotia, although the Nova Scotia EMO did not wish to reveal the exact number. The contact information of each EMO official and planner was obtained from the website of municipalities and the potential participants received the online link to the questionnaire via e-mail.

Opinio, an online survey development website supported by Dalhousie University, was used to host the online survey. On the form where the participants were asked to weight the vulnerability of each land use by distributing 100 points per question, a verification system was included so that the total number of points submitted actually added up to 100 points. Implementing the system prevented potential mistakes from occurring during the summation of points. In total, 27 professionals responded to the survey.

To comply with Research Ethics policies, the survey began with a general description of the study and possible risks by participating in the study. The full text of questionnaire, approved by the Research Ethics Board of Dalhousie University, are on Appendix A.

4.3 Focus Group Method

A focus group approach differs from a survey because focus groups create an interactive social space for discussion (Grudens-Schuck, Allen, & Larson, 2004, as cited in Grant, MacKay, Manuel, & McHugh, 2010). Focus groups bring four to eight participants together to discuss questions with the moderation from, ideally, a trained facilitator (Krueger & Casey, 2009). Grant et al. (2010) agree that focus groups are appropriate where there is a need to generate socially constructed meanings shaped by the dynamic interactions of the members. Focus groups are an appropriate size for constructive interaction and encourage mutual learning among participants (Grant, 2011).

That being said, focus groups have the potential to cause the 'bandwagon effect' – that is, following the decision of another participant regardless of their own opinions – in unproductive directions. To prevent the bandwagon effect, Grant (2011) suggests inviting facilitators to shape focus groups into more productive group sessions. Skilful facilitators can help to catalyse discussions and generate insightful data, but they must be able to manage dominant participants, to draw in the rest of participants, and to productively direct conversations.

The researcher facilitated a focus group session after receiving the results from the online survey. The session was a useful exercise to take a closer look at what might happen in a decision-making process in a municipal government.

Five professionals from municipalities within a county agreed to participate in this focus group session. The site was chosen as it was one of the counties where all of its municipal planners and emergency management officials had participated in the online survey. Among the five professionals, one of them was the EMO official in charge of the 5 municipalities while the rest of them were planners. Two of the participants worked in a town while the rest worked in rural districts. Two of the participants had worked in their professions for less than 10 years while the rest of them worked for more than 10 years in their field.

The focus group took place at the council chambers in one of the town halls in the county on May 17, 2016 between 14:00 and 16:30. The participants were informed that the session would be audio-recorded and some of their statements may be used in this research as direct quotations without identification. All participants signed a consent form confirming and agreeing to participation under such conditions. The researcher took a note of some of the statements made in the focus group discussion.

Before assembling into a group, the researcher asked each participant to fill out the consent form as shown in Appendix B and the questionnaire individually. The questionnaire was identical to the questionnaire used in the online survey. Although the participants have already filled out the survey, it served as a reminder of their choices in weightings – since the focus group was held one month after the survey closed. Then, the researcher asked the participants to weight the vulnerability of land uses as a group. This process was divided into two parts: first, the participants weighted each land use category, such as residential, commercial, and institutional, with a total of 100 points, then they weighted land use subcategories under each category, also with a total of 100 points.

Due to time constraints, the weighting method had to be revised to a ranking method in order to arrive at a group consensus. Instead of distributing points, the participants were asked to rank land uses in a group from the most vulnerable to the least vulnerable. The results received from individual survey-based weightings of land uses were subsequently converted into rankings to normalize the results with group ranking for analysis.

In a group, each participant went around the table and revealed their rankings on each land use. After stating their rankings, the participants initiated discussion among themselves – usually stating the reasoning behind their weightings. After discussions that ranged from 10 seconds to 10 minutes, all participants agreed on the rankings for each land use. The outcome of this session was a list of land use vulnerability rankings from individuals and from the entire group.

4.4 Analysis

4.4.1 Deriving vulnerability index. The researcher analyzed the data collected from the planners and the EMO officials through the online surveys to find the average weighting for each land use. The answers from the questionnaires were inputted into an Excel spreadsheet for analysis. Prior to the analysis, a standardization of the weightings indexing was required for simplification, so the weighted vulnerability of each land use was expressed as a value between 0 and 1, rather than from 0 to 10,000. Equation 3 shows that each land use subcategory was weighted by multiplying the weighting of its category by its subcategory weighting. Then, the score of the land use with the highest vulnerability weighting was used as a coefficient value, H. The coefficient was used to standardize the weighting by dividing the weighting of other land use weightings. For example, if the residential land use category received 70 points, and a low density residential use – a subcategory of residential uses – received 30 points, then the new weightings for the low density residential was the multiple of 70 and 30, or 2,100 points. If the coefficient were to be 3,000 points, then a low density residential use has a vulnerability index of 2100 over 3000, or 0.7. The average weighting from the 27 respondents became the final vulnerability index for each land use.

$$(3)\ Vn = \frac{Pc\ Ps}{H}$$

V_n = Vulnerability Index for land use *n*
H = Coefficient determined from a land use that received the highest points by combining P_c and P_s
P_c = Points that land use *n* received in land use category
P_s = Points that land use *n* received in land use subcategory

4.4.2 Kendall's Coefficient of Concordance. In addition to calculating the average vulnerability index, the researcher also focused on the variance. The variance reflects the degree of consensus among the respondents in deciding land use vulnerability. Kendall's coefficient of concordance was used to analyze the collected data. "Kendall's coefficient of concordance (W) is a measure of the agreement among several judges who are assessing a given set of objects" (Legendre, 2005, p. 228). Legendre (2005) explains that if the coefficient is 1, then all the respondents assigned the same weighting to the list of choices. If the W is 0, then there is no agreement. "The Kendall coefficient of concordance can be used to assess the degree to which a group of variables provides a common ranking for a set of objects" (Legendre, 2010, p. 169). Generally, Kendall's coefficients of 0.9 or above are considered 'very good', in which all participants generally agree on the same vulnerability ranking or rating to the list of land uses (Version 17.3.1; Minitab, 2013).

The researcher hypothesized that location, experience, and profession of respondents may have an influence on the responses. These were analyzed separatey. In the location analysis, the respondents were grouped by the type of municipalities: county or rural district, town, or regional municipality. In the area of expertise analysis, the respondents were grouped into Planners and EMOs. In the experience analysis, the respondents were grouped into professionals with 10 years or less years of experience and more than 10 years of experience. An additional analysis was conducted for the focus group results by comparing the responses received before and after the group session. This analysis determined the diversity of opinion among the participants, and the extent to which individuals compromised their own perspectives to come to a group consensus.

4.5 Application of Land Use Vulnerability Index

The vulnerability index for each land use may be applied to a land use map to make a flood risk map visualizing the vulnerability and the risk of properties to coastal flooding. Such visualization will assist professionals and decision makers in developing a climate change adaptation plan by identifying any clusters of properties or structures at high risk of flooding.

To calculate the risk index for each property, the values of hazard and vulnerability are needed. Hazard is the inverse of storm return period with the consideration of climate projections. For example, if a building intersects with the maximum water level during a 50-year storm, then the hazard score of building is 1/50, or 0.02. The researcher derived the equation for hazard with the following considerations. The equation for deriving Halifax storm return levels in metres for present day is y = 0.1088ln(x) + 1.2756, where x is a storm return period in years (Bernier et al., 2007, as stated in Forbes et al., 2009). Because this study focused on the effect of storm surges in 2100, sea-level rise had to be considered. The projected mean sea level in 2100 is 1.10 metres above the Canadian Geodetic Vertical Datum of 1928 (CGVD28). Hindrichs' (2015) method was used to obtain results, in which she combined the sea level rise from 1928 to 2001 (+ 0.20 m), the projected sea level rise from 2001 to 2100 in the RCP8.5 Projection by the IPCC's Fifth Assessment Report (+0.74 m), and historical subsidence or sinking of land (+0.16 m). The final hazard score for a property may be expressed as shown in Equation 4.

$$(4)\ y = \frac{1}{e^{\frac{x-2.3756}{0.1088}}}$$

x = Elevation in metres

y = Hazard Score for a property in Halifax, NS

GIS may be used to compile values for hazard and vulnerability. Each property, typically represented as a building layer, should be assigned a hazard score according to its elevation and a vulnerability score according to its land use. It should be noted that the land use is derived from the property's designated zoning, and may differ from the actual use, in case of grandfathering. In the case of mixed-use buildings or a variation of building uses by floor, the land use with the highest vulnerability weighting dictates the vulnerability score (SEPA, 2012). Both the hazard and vulnerability scores can be multiplied to create a risk score of each building or property. The step-by-step GIS process to visualize the risk and vulnerability to coastal flooding, accompanied with an example of outcome map and its associated land use map is presented in Appendix C.

Chapter 5 Results

This section outlines the results of this research by using the aforementioned methodology. The results and analyses are presented in a series of tables.

The first table, Table 2, shows the Land Use Vulnerability Index for Nova Scotia, which reflects the average weightings given by the 27 respondents in Nova Scotia. Table 3 shows the Coefficient values for various land uses to reflect the degree of agreement among the respondents during weighting. The next set of tables, Tables 4 to 17, show the average weightings, their variances, and the coefficient (W) value for each land use category when deciding the weightings for land use subcategories. The last set of tables, Tables 18 to 20, show how the group responses were different from each individual's response.

5.1 Survey Respondents

As of April 2016, there were 51 municipalities in Nova Scotia. All municipalities were contacted to sample at least one planner and EMO official from each jurisdiction. Their contact information was found in the official websites of municipalities, and the potential participants received the online link to the questionnaire via work e-mails. If each municipality has its own planner and an EMO official, 102 professionals would have been contacted. However, the researcher realized that some municipalities share resources; one professional may work for multiple jurisdictions in rural areas. After eliminating duplicate positions, 54 professionals were reached. For respondents working in more than one jurisdiction, they could answer the questionnaire more than once, so long as they stated that the survey is answered from the perspective of which municipality.

27 respondents filled out the online survey for this research. All respondents were working in a municipal government and working in coastal municipalities. 17 respondents were planning professionals while 10 respondents were emergency management professionals. 5 respondents were from regional municipalities, 7 from towns, and 15 from rural counties or districts. 12 respondents have worked in their field, regardless of location, for more than 10 years while 15 respondents worked in their field for 10 or less years.

5.2 Vulnerability Index

The first objective of this research was to establish the degree of vulnerability for types of land use in the context of Nova Scotia according to planers and emergency management officials. This has been achieved by consolidating the averages of the vulnerability weightings given to each land use from the 27 survey responses. Table 3 lists the normalized vulnerability weighting for each land use. The score of 0 represents the lowest vulnerability index score and the score of 1 represents the highest possible vulnerability score. This allows the reader to directly compare the vulnerability weightings of any land uses in the table.

Table 3 Land Use* Vulnerability Index for Nova Scotia.

Residential		**Commercial**	
Low Density	1.00	Food Stores	0.13
Medium Density	0.30	Food Retails	0.10
Boarding & Rooming Houses	0.12	Personal Services	0.09
High Density	0.12	Accommodations	0.09
		Service Stations	0.08
		Offices	0.07
		Repair Shops	0.06
		Entertainments	0.04
		Wholesales	0.03
Industrial		**Institutional**	
Docks & Wharves	0.17	Historic Sites	0.11
Industrial	0.14	Private Cares	0.09
Agricultural	0.12	Religious Centres	0.09
Marine Industrial	0.12	Education, I	0.08
		Community Centre	0.07
		Education, II	0.05
		Residential Institutions	0.04
Governmental		**Infrastructural**	
Safety & Security	0.13	Major Roads	0.23
Medical, I	0.10	Water Utilities	0.17
Environmental Conservation	0.10	Minor Roads	0.15
Recreational, II	0.08	Electricity	0.12
Administration	0.07	Coastal Protection	0.10
Medical, II	0.06	Waste Management	0.08
Recreational, I	0.06	Railroads	0.05
Military	0.05	Parking Spaces	0.04
		Public Transit	0.02

*The definitions of each category of land uses may be found on section 4.2.1. and on Questions 7 to 13 embedded in the survey.

5.3 Levels of Agreement among Professionals

The second research objective was to discover the degree of variation perceived in land use vulnerability among professionals working for municipalities in Nova Scotia. As stated in the methodology section, the researcher employed Kendall's Coefficient of Concordance, or simply the Coefficient, to determine the degree of agreement. Averages and variances for each land use category and for each factor are included for additional information.

To determine if each variable – work location, area of expertise, and years of experience – influenced the group agreement for a set of land use vulnerability weightings, the researcher analyzed the data under the assumption that the data distribution is multi-modal. Multi-modal distribution means that if a certain variable significantly influenced the vulnerability weightings, regrouping responses into groups under that variable would substantially increase agreement within those groups - measured by the coefficient.

When the coefficient is zero, it indicates completely differing views among respondents. Conversely, a coefficient of one indicates unanimous agreement regarding the vulnerability weighting of a land use. The coefficient is a representation of probability of unanimous agreement; for example, a coefficient of 0.5 means that the group has one-in-two chance of reaching unanimous agreement. Table 4 is a summary of coefficients for the overall land use categories as well as the subcategories. The results are organized into columns that represent groups under the following variables: Location, Experience and Profession. These results are discussed in more detail in the following sections.

Table 4 Kendall's Coefficient of Concordance Values of All Responses by Category

	Overall	Location		
		Regional Municipalities	Towns	Counties & Districts
Residential	0.52	0.32	0.46	0.64
Infrastructural	0.43	0.52	0.57	0.44
Commercial	0.31	0.45	0.37	0.20
Institutional	0.24	0.20	0.20	0.38
Overall	0.21	0.50	0.14	0.30
Governmental	0.14	0.27	0.24	0.31
Industrial	0.05	0.67	0.09	0.07
	Experience		Profession	
	10 or less years	More than 10 years	Planning	Emergency Management
Residential	0.42	0.67	0.43	0.74
Infrastructural	0.50	0.40	0.42	0.55
Commercial	0.45	0.26	0.28	0.41
Institutional	0.25	0.34	0.19	0.44
Overall	0.22	0.21	0.35	0.14
Governmental	0.26	0.19	0.18	0.17
Industrial	0.08	0.12	0.03	0.10

*Kendall's Coefficient of Concordance Values of 0 indicates completely differing views among respondents, while 1 indicates unanimous agreement.

5.3.1 Average vulnerability scores, variance, and coefficient for land use categories. Table 5 and 6, as well as Tables 7-18, show the finer details behind the summary of agreement coefficients shown in Table 3. Table 4 includes the average score given to each land use category, the variance between scores for each land use category, as well as the coefficient for each variable group – Location, Experience, and Profession. Table 6 includes the median score given to each land use category, and the range between scores for each land use category.

Table 4 shows the range of the Coefficient overall, by categories, which is ranged from 0.52 (Residential) to 0.05 (Industrial). As shown in Table 5, the overall coefficient for the land use categories was 0.2066, indicating a lack of agreement among professionals overall. When the respondents were regrouped by each variable – Location, Experience, and Profession, not all coefficients necessarily increased. In a couple of cases, the coefficient actually decreased. This indicates that none of the three variables were particularly strong predictors of agreement for the overall land-use categories. When divided geographically, the coefficient increased noticeably among professionals in *Regional Municipalities* and increased slightly for *Rural Counties and Districts* professionals but decreased for *Towns* professionals. When divided by experience, the coefficient did not change noticeably for either experienced or non-experienced professionals. When divided by profession, the coefficient increased amongst *Planning* professionals but decreased amongst *EMO* professionals.

Planning and *EMO* professionals showed general agreement on the vulnerability of Commercial, Institutional, Industrial, and Government land uses; however, there was substantial disagreement on the vulnerability of Residential and Infrastructure land uses. This is demonstrated by the variance of scores given to each land use in Table 5. For Infrastructure land uses, responses varied between 1 and 50 out of a maximum score of 100, resulting in a variance of 167. For Residential land uses, scores varied between 8 and 75, resulting in a variance of 348.

Table 5 Average Vulnerability Scores (A), Variances (V), and Coefficient (W) for Land Use Categories

General	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Residential	**31**	348	**32**	286	**33**	498	**30**	296
Commercial	**14**	56	**11**	14	**16**	74	**14**	57
Industrial	**11**	52	**11**	24	**7**	41	**13**	56
Institutional	**11**	42	**12**	16	**8**	11	**12**	60
Governmental	**13**	65	**14**	54	**12**	72	**13**	66
Infrastructural	**20**	167	**20**	40	**24**	251	**18**	157
W =	**0.2066**		**0.5000**		**0.1424**		**0.2998**	
General	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Residential	**29**	257	**34**	444	**29**	283	**37**	387
Commercial	**14**	61	**14**	51	**15**	64	**12**	29
Industrial	**11**	53	**11**	50	**8**	24	**16**	54
Institutional	**11**	29	**10**	57	**10**	42	**12**	31
Governmental	**15**	81	**11**	39	**14**	63	**12**	60
Infrastructural	**20**	97	**19**	255	**24**	175	**12**	50
W =	**0.2240**		**0.2072**		**0.3538**		**0.1391**	

Table 6 Median Vulnerability Scores (M) and Range (R) for Land Use Categories

General	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Residential	**25**	31	**20**	40	**25**	67	**25**	55
Commercial	**10**	14	**10**	10	**15**	25	**10**	25
Industrial	**10**	11	**15**	10	**5**	18	**10**	25
Institutional	**10**	11	**15**	10	**10**	9	**10**	30
Governmental	**10**	13	**20**	15	**10**	27	**10**	28
Infrastructural	**20**	20	**20**	20	**25**	44	**15**	47
General	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Residential	**25**	55	**30**	67	**20**	67	**40**	55
Commercial	**10**	25	**15**	25	**15**	25	**10**	20
Industrial	**10**	30	**10**	25	**10**	18	**15**	25
Institutional	**10**	15	**10**	30	**10**	30	**10**	15
Governmental	**10**	58	**10**	17	**10**	27	**10**	23
Infrastructural	**20**	37	**13**	49	**20**	49	**10**	22

5.3.2 Average vulnerability scores, variance, and coefficient for residential land use subcategories. The researcher divided each land use category into subcategory land uses. Professionals then assigned the proportional values for vulnerability to each of the subcategories, similar to the categories. The average scores, variances and the coefficients amongst the respondents for the 4 residential subcategories are listed on Table 7. The median scores and ranges for the residential subcategories are listed on Table 8.

When weighting residential land use subcategories, professionals gave more weight on average to *Low Density* followed by *Medium Density*, contributing the high vulnerability index scores for these land uses in Table 3. However, an exceptionally high variance for the *Low Density* subcategory at 663 suggests that there were greatly differing opinions among respondents on the vulnerability of low density residential areas. Despite high variances in the *Low Density* subcategory, the overall coefficient for the *Residential* land use subcategories was 0.5183, higher than the overall survey coefficient of 0.2066. This suggests that there may have been outliers in the dataset – perhaps a few respondents assigned little to no weightings on low density residential use.

Emergency management officials reached the highest coefficient of 0.7359 on residential uses. This is an indication that EMO officials have similar perspectives in which land uses are more vulnerable over others in the residential land use category. Nevertheless, not all coefficient values increased when responses were regrouped by each variable – Location, Experience, and Profession. In subcategory level, an increase in the coefficient of one variable group was counterbalanced by a decrease in the coefficient of other groups in the same variable. For example, while the *EMO* group had the highest coefficient of 0.7359, the *Planning* group in the same variable category saw their coefficient decreased to 0.4256. This indicates that the variables, while showing agreement amongst certain groups, are not strong predictors of overall agreement. It may mean that some variables are mixed, but if a variable significantly influenced the weighting of land use vulnerability, all variable groups would have resulted in higher coefficient. This pattern is repeated in other land use subcategories.

Table 7 Averages Vulnerability Scores (A), Variances (V), and Coefficient (W) for Residential Land Use Subcategories

Residential	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Low Density	**58**	663	**50**	890	**50**	564	**64**	550
Medium Density	**23**	142	**23**	169	**25**	124	**22**	137
High Density	**9**	124	**14**	134	**11**	78	**7**	128
Boarding & Rooming Houses	**10**	106	**13**	76	**13**	168	**7**	70
W =	**0.5183**		**0.3235**		**0.4606**		**0.6360**	

Residential	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Low Density	**47**	517	**70**	552	**52**	647	**69**	524
Medium Density	**27**	58	**18**	199	**26**	134	**18**	114
High Density	**12**	159	**7**	63	**12**	133	**5**	80
Boarding & Rooming Houses	**14**	129	**5**	37	**11**	124	**8**	71
W =	**0.4178**		**0.6708**		**0.4256**		**0.7359**	

Table 8 Median Vulnerability Scores (M) and Range (R) for Residential Land Use Subcategories

Residential	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Low Density	**60**	85	**40**	75	**50**	60	**70**	75
Medium Density	**24**	45	**20**	40	**25**	31	**24**	40
High Density	**5**	35	**20**	25	**10**	25	**0**	35
Boarding & Rooming Houses	**5**	40	**15**	23	**8**	39	**5**	25
Residential	**Experience**				**Profession**			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Low Density	**40**	60	**80**	85	**55**	75	**80**	74
Medium Density	**25**	25	**13**	45	**25**	40	**20**	40
High Density	**5**	35	**5**	25	**8**	35	**0**	27
Boarding & Rooming Houses	**10**	40	**5**	20	**5**	40	**5**	23

5.3.3 Average vulnerability scores, variance, and coefficient for commercial land use subcategories. As shown on Table 9 and Table 10, the coefficient for Commercial land use subcategories was 0.3055, which is slightly higher than the overall coefficient of 0.2066. Professionals from regional municipalities reached the highest coefficient of 0.4548. Similar to other land use subcategories, an increase in the coefficient of one variable group was counterbalanced by a decrease in the coefficient of other groups in the same variable. Overall, there was low agreement amongst respondents when considering the variables of Location, Experience and Profession. In general, respondents seem to have perception that commercial uses offering essential commodities such as food, fuel, and accommodations are most vulnerable than other types of commercial uses. However, the researcher was unable to identify any variable as a source of influence in weighting commercial land use subcategories.

Table 9 Averages Vulnerability Scores (A), Variances (V), and Coefficient (C) for Commercial Land Use Subcategories

Commercial	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Personal Service	**13**	75	**11**	24	**10**	50	**14**	97
Food Stores	**17**	62	**15**	20	**15**	96	**19**	53
Food Retails	**14**	69	**13**	16	**13**	73	**15**	83
Service Stations	**13**	23	**19**	124	**11**	55	**13**	33
Accommodations	**12**	35	**14**	64	**12**	62	**12**	65
Entertainment	**5**	17	**6**	12	**6**	12	**4**	19
Repair Shops	**9**	34	7	13	**12**	69	**9**	21
Wholesales	**5**	43	**6**	22	**6**	56	**5**	43
Offices	**11**	58	**8**	40	**16**	100	**10**	29
W =	**0.3055**		**0.4548**		**0.3707**		**0.1978**	
Commercial	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Personal Service	**10**	28	**16**	108	**11**	54	**16**	99
Food Stores	**17**	54	**17**	71	**18**	85	**17**	20
Food Retails	**11**	33	**17**	93	**14**	96	**14**	21
Service Stations	**15**	79	**11**	35	**12**	83	**15**	24
Accommodations	**13**	52	**11**	79	**14**	89	**9**	9
Entertainment	**6**	15	**4**	18	**5**	17	**5**	17
Repair Shops	**11**	44	**8**	17	**9**	47	**9**	13
Wholesales	7	51	**4**	26	**6**	49	**4**	29
Offices	**11**	60	**11**	54	**11**	75	**11**	30
W =	**0.4494**		**0.2617**		**0.2754**		**0.4106**	

Table 10 Median Vulnerability Scores (M) and Range (R) for Commercial Land Use Subcategories

Commercial	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Personal Service	**10**	40	**10**	15	**10**	20	**10**	35
Food Stores	**15**	39	**15**	10	**15**	29	**20**	30
Food Retails	**10**	45	**10**	10	**10**	25	**10**	40
Service Stations	**10**	40	**15**	30	**10**	22	**11**	20
Accommodations	**10**	35	**10**	20	**10**	25	**10**	35
Entertainment	**5**	11	**5**	9	**6**	10	**5**	11
Repair Shops	**10**	30	**10**	9	**10**	29	**10**	15
Wholesales	**0**	20	**10**	10	**0**	20	**0**	20
Offices	**10**	33	**5**	18	**10**	28	**10**	20

Commercial	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Personal Service	**10**	20	**11**	35	**10**	30	**10**	35
Food Stores	**15**	29	**18**	35	**20**	39	**15**	15
Food Retails	**10**	25	**14**	35	**10**	45	**15**	15
Service Stations	**10**	35	**11**	20	**10**	40	**17**	15
Accommodations	**10**	25	**10**	35	**10**	35	**10**	10
Entertainment	**5**	10	**4**	11	**5**	11	**5**	10
Repair Shops	**10**	29	**10**	13	**10**	30	**10**	10
Wholesales	**10**	20	**0**	12	**1**	20	**0**	14
Offices	**10**	31	**10**	27	**10**	33	**10**	15

5.3.4 Average vulnerability scores, variance, and coefficient for industrial land use subcategories. In general, respondents evenly distributed scores among the various *Industrial* land use subcategories. As shown on Table 11 and Table 12, the coefficient for Industrial land use subcategories was 0.0468, the lowest coefficient out of all the subcategories. This indicates that respondents' weightings of each Industrial land use subcategory was highly variable, and therefore, not in agreement. This is echoed in the variances of weightings for each subcategory, which range from 251 to 1005 overall.

Coefficients increased between 64% and 1337% when accounting for *Location* and *Experience*. Agricultural use was weighted highest in rural areas while Industrial uses were weighted highest in small towns. Marine Industrial uses were weighted highest in regional municipalities. Respondents with less than 10 years of experience weighted agricultural use the highest, while respondents with more than 10 years of experience weighted docks & wharves the highest. However, the coefficient for almost all groups never reached higher than 0.1200 with the exception of respondents from regional municipalities who reached a coefficient of 0.6727. This indicates that regional municipality planners are relatively more in agreement when assessing the vulnerability of various industrial land uses such as Agricultural, Industrial, Marine Industrial, and Docks & Wharves.

Table 11 Averages Vulnerability Scores (A), Variances (V), and Coefficient (W) for Industrial Land Use Subcategories

Industrial	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Agricultural	**30**	1005	**18**	146	**29**	1562	**35**	957
Industrial	**25**	565	**11**	44	**41**	1346	**22**	76
Marine Industrial	**17**	251	**33**	76	**15**	293	**13**	186
Docks & Wharves	**28**	489	**38**	96	**15**	203	**30**	640
W =	**0.0468**		**0.6727**		**0.0867**		**0.0766**	
Industrial	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Agricultural	**36**	1079	**22**	781	**30**	1190	**29**	646
Industrial	**26**	483	**24**	666	**26**	786	**26**	226
Marine Industrial	**15**	222	**20**	269	**17**	294	**16**	164
Docks & Wharves	**23**	300	**34**	657	**27**	605	**29**	263
W =	**0.0769**		**0.1200**		**0.0378**		**0.0998**	

Table 12 Median Vulnerability Scores (M) and Range (R) for Industrial Land Use Subcategories

Industrial	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Agricultural	**15**	100	**20**	35	**5**	100	**25**	80
Industrial	**20**	99	**10**	20	**20**	99	**20**	45
Marine Industrial	**20**	50	**30**	25	**5**	40	**10**	40
Docks & Wharves	**25**	80	**30**	20	**10**	40	**25**	80
Industrial	**Experience**				**Profession**			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Agricultural	**25**	100	**13**	80	**10**	100	**20**	80
Industrial	**20**	85	**18**	99	**15**	99	**20**	40
Marine Industrial	**10**	40	**20**	50	**10**	50	**20**	40
Docks & Wharves	**20**	60	**30**	80	**20**	80	**25**	50

5.3.5 Average vulnerability scores, variance, and coefficient for institutional land use subcategories. In general, respondents evenly distributed scores among the various *Institutional* land use subcategories. However, variances of weightings for all subcategories remain relatively high, especially for religious centres and historic sites – 214 and 638 respectively on Table 13, indicating that these may be more polarizing issues than others.

As shown on Table 13 and Table 14, the coefficient for the Institutional land use subcategory was 0.2378, which is most similar to the overall land use category coefficient of 0.2066. The coefficients increased slightly to 0.2530 for respondents with *10 years or less of experience* and 0.3403 for respondents with *more than 10 years of experience* when the responses were regrouped and analyzed under the variable *Experience*. While respondents with less than 10 years of experience weighted post-secondary educational use and residential institutional use more heavily, respondents with more than 10 years of experience weighted religious uses more heavily than the respondents with more less than 10 years of experience. The coefficient for any variable group never reached higher than 0.4429.

Table 13 Averages Vulnerability Scores (A), Variances (V), and Coefficient (W) for Institutional Land Use Subcategories

Institutional	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Education, I	**18**	187	**9**	54	**16**	166	**22**	199
Education, II	**9**	49	**6**	14	**12**	89	**9**	34
Private Care	**18**	119	**15**	100	**17**	85	**20**	133
Residential Instit.	**6**	66	**9**	54	**7**	105	**5**	48
Religious Centres	**12**	214	**10**	50	**8**	41	**14**	333
Historic Sites	**21**	638	**35**	1320	**28**	995	**12**	80
Community Cent.	**16**	71	**16**	104	**12**	51	**17**	60
W =	**0.2378**		**0.1973**		**0.2005**		**0.3782**	
Institutional	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Education, I	**18**	103	**18**	292	**17**	263	**20**	45
Education, II	**12**	47	**6**	33	**8**	61	**11**	19
Private Care	**17**	56	**20**	189	**16**	133	**23**	61
Residential Instit.	**9**	84	**3**	24	**6**	80	**6**	41
Religious Centres	**9**	28	**16**	416	**12**	325	**11**	23
Historic Sites	**20**	583	**21**	706	**26**	923	**11**	19
Community Cent.	**16**	62	**16**	82	**15**	91	**17**	33
W =	**0.2530**		**0.3403**		**0.1855**		**0.4429**	

Table 14 Median Vulnerability Scores (M) and Range (R) for Institutional Land Use Subcategories

Institutional	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Education, I	**20**	65	**5**	20	**20**	35	**20**	65
Education, II	**10**	30	**5**	10	**8**	30	**10**	20
Private Care	**15**	50	**15**	30	**20**	30	**15**	40
Residential Instit.	**0**	30	**5**	20	**0**	30	**0**	20
Religious Centres	**10**	80	**10**	20	**8**	20	**10**	80
Historic Sites	**10**	100	**10**	95	**15**	99	**10**	40
Community Cent.	**15**	30	**20**	30	**12**	22	**20**	30
Institutional	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Education, I	**20**	35	**15**	65	**15**	65	**20**	25
Education, II	**10**	30	**5**	20	**8**	30	**10**	15
Private Care	**15**	30	**18**	50	**10**	50	**20**	25
Residential Instit.	**10**	30	**0**	15	**0**	30	**5**	15
Religious Centres	**10**	20	**10**	80	**10**	80	**10**	15
Historic Sites	**15**	98	**10**	100	**15**	100	**10**	15
Community Cent.	**15**	30	**20**	30	**19**	30	**15**	20

5.3.6 Average vulnerability scores, variance, and coefficient for governmental land use subcategories. On average, the weighting of *Government* land use subcategories was relatively evenly distributed.

As shown on Table 15 and Table 16, the coefficient for the *Governmental* land use subcategory was 0.1384, which is much lower than the overall land use category coefficient of 0.2066. The coefficient increased when survey responses re-grouped for all variable groups, between 22% and 124%; however, the coefficient for any variable group never reached higher than 0.3096, indicating a low level of agreement in each group.

When grouped into variables, large differences can be observed in the average weighting of some *Government* land use subcategories. For example, *Regional Municipality* professionals assigned much more weight on average to *Military* land uses (23 compared to 1 and 4) while *Towns* and *Counties & Districts* professionals assigned more weighting on average to *Safety & Security* land uses (25 and 18 respectively, compared to 6). The average weightings for *Medical* and *Environmental Conservation* land uses also varied when accounting for the variable of *Location*. It is, however, difficult to identify a clear pattern or a reason for such large differences.

Table 15 Averages Vulnerability Scores (A), Variances (V), and Coefficient (W) for Governmental Land Use Subcategories

Governmental	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Administration	**11**	57	**7**	26	**9**	44	**13**	62
Military	**7**	138	**23**	296	**1**	8	**4**	36
Safety & Security	**17**	187	**6**	54	**25**	333	**18**	97
Medical, I	**15**	131	**10**	50	**22**	233	**13**	72
Medical, II	**10**	34	**9**	34	**11**	70	**9**	16
Recreational, I	**9**	34	**8**	26	**7**	33	**11**	27
Recreational, II	**13**	106	**13**	46	**14**	132	**13**	113
Env.Conservation	**18**	360	**24**	54	**11**	80	**20**	552
W =	**0.1384**		**0.2683**		**0.2414**		**0.3096**	
Governmental	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Administration	**11**	46	**10**	70	**9**	50	**14**	50
Military	**6**	77	**7**	214	**6**	175	**7**	73
Safety & Security	**22**	180	**11**	135	**19**	247	**15**	75
Medical, I	**19**	135	**10**	80	**14**	181	**16**	42
Medical, II	**9**	33	**10**	34	**9**	44	**11**	13
Recreational, I	**9**	25	**9**	45	**9**	39	**10**	20
Recreational, II	**10**	58	**18**	127	**15**	146	**11**	26
Env.Conservation	**13**	129	**25**	573	**19**	476	**15**	143
W =	**0.2598**		**0.1871**		**0.1834**		**0.1695**	

Table 16 Median Vulnerability Scores (M) and Range (R) for Governmental Land Use Subcategories

Governmental	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Administration	**10**	30	**5**	15	**10**	20	**10**	30
Military	**0**	50	**25**	50	**0**	8	**0**	20
Safety & Security	**15**	60	**5**	20	**30**	58	**15**	40
Medical, I	**15**	40	**10**	20	**30**	40	**15**	30
Medical, II	**10**	25	**10**	15	**10**	25	**10**	15
Recreational, I	**10**	20	**10**	15	**10**	17	**10**	20
Recreational, II	**10**	45	**10**	20	**10**	30	**10**	45
Env.Conservation	**10**	100	**25**	20	**10**	25	**10**	100
Governmental	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Administration	**10**	20	**10**	30	**10**	20	**10**	25
Military	**0**	30	**0**	50	**0**	50	**5**	25
Safety & Security	**20**	55	**10**	40	**15**	60	**14**	25
Medical, I	**20**	40	**10**	30	**10**	40	**15**	25
Medical, II	**10**	25	**10**	20	**10**	25	**10**	10
Recreational, I	**10**	20	**10**	20	**10**	20	**10**	20
Recreational, II	**10**	30	**17.5**	45	**10**	45	**10**	20
Env.Conservation	**10**	40	**20**	95	**15**	100	**10**	40

5.3.7 Average vulnerability scores, variance, and coefficient for infrastructural land use subcategories. In general, respondents assigned more weight to roads, followed by the utility lines delivering electricity and water services, as shown on Table 17 and Table 18.

The coefficient for the Infrastructure land use subcategory was 0.4316, which is higher than the overall land use category coefficient of 0.2066. Coefficients increased for most variable groups and professionals from small towns reached the highest coefficient of 0.5748. This suggests that professionals are relatively more in agreement when considering the vulnerability of infrastructure land uses to coastal flooding events.

Table 17 Averages Vulnerability Scores (A), Variances (V), and Coefficient (W) for Infrastructural Land Use Subcategories

Infrastructure	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	A	V	A	V	A	V	A	V
Major Road	**20**	170	**13**	80	**24**	267	**21**	131
Minor Road	**17**	172	**13**	14	**20**	380	**17**	120
Parking Spaces	**5**	30	**3**	4	**4**	11	**7**	42
Public Transit	**2**	13	**4**	13	**2**	13	**1**	12
Railroads	**4**	26	**9**	24	**2**	12	**3**	24
Electricity	**14**	60	**16**	10	**12**	48	**14**	78
Water Utilities	**18**	96	**16**	27	**22**	163	**16**	74
Coastal Protect.	**12**	168	**14**	14	**12**	272	**11**	168
W. Management	**8**	44	**11**	50	**3**	13	**10**	38
W =	**0.4316**		**0.5206**		**0.5748**		**0.4376**	

Infrastructure	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	A	V	A	V	A	V	A	V
Major Road	**23**	173	**18**	152	**23**	176	**16**	112
Minor Road	**13**	37	**22**	294	**19**	240	**14**	43
Parking Spaces	**4**	15	**6**	46	**6**	39	**4**	12
Public Transit	**3**	19	**1**	3	**2**	15	**1**	10
Railroads	**4**	25	**4**	28	**4**	26	**3**	24
Electricity	**14**	35	**14**	91	**12**	52	**18**	62
Water Utilities	**18**	110	**17**	78	**19**	123	**17**	57
Coastal Protect.	**15**	235	**9**	63	**10**	146	**15**	184
W. Management	**7**	35	**10**	50	**6**	35	**12**	33
W =	**0.4997**		**0.4045**		**0.4210**		**0.5533**	

Table 18 Median Vulnerability Scores (M) and Range (R) for Infrastructural Land Use Subcategories

Infrastructure	Overall		Location					
			Regional Municipalities		Towns		Counties & Districts	
	M	R	M	R	M	R	M	R
Major Road	**20**	55	**10**	25	**25**	55	**20**	35
Minor Road	**12**	65	**12**	10	**15**	65	**10**	39
Parking Spaces	**5**	20	**4**	5	**5**	10	**5**	20
Public Transit	**0**	10	**5**	10	**0**	10	**0**	10
Railroads	**0**	15	**10**	15	**0**	10	**0**	14
Electricity	**12**	30	**15**	8	**10**	25	**10**	30
Water Utilities	**15**	50	**15**	15	**20**	40	**15**	30
Coastal Protect.	**10**	50	**15**	10	**8**	50	**10**	40
W. Management	**10**	20	**15**	19	**0**	10	**10**	20
Infrastructure	Experience				Profession			
	10 or less years		More than 10 years		Planning		Emergency Management	
	M	R	M	R	M	R	M	R
Major Road	**20**	55	**13**	35	**20**	55	**15**	35
Minor Road	**14**	25	**11**	55	**15**	65	**10**	20
Parking Spaces	**5**	12	**5**	20	**5**	20	**5**	12
Public Transit	**0**	10	**0**	5	**0**	10	**0**	10
Railroads	**0**	14	**0**	15	**0**	15	**0**	14
Electricity	**15**	25	**12**	30	**10**	25	**15**	20
Water Utilities	**15**	43	**18**	30	**15**	50	**15**	25
Coastal Protect.	**10**	50	**9**	20	**10**	50	**15**	40
W. Management	**5**	20	**10**	20	**5**	20	**15**	20

5.4 Focus Group Results

The third objective of this research was to identify the effects of focus groups in deciding land use vulnerability for municipalities in Nova Scotia. In this focus group session, professionals were able to interact with one another before collectively agreeing to a final vulnerability weighting between 0 to 100 points on a land use. In total, five participants took part in a focus group in a rural district of Nova Scotia.

The focus group method provided a different data collection environment from the online survey. As Grant et al. (2010) states, deciding vulnerability of land uses in a focus group session ensures that each professional is working under the same set of assumptions in an environment of interactive learning. However, focus groups may also provide constraints that hinder healthy discussion, such as causing bandwagon effects in unproductive directions and allowing an outspoken minority to dominate the group discussion. As focus groups most closely resemble how decision making is performed in governments, these are factors that could affect how coastal flooding responses are played out in real life. For this reason, it was integral to analyze the differences between focus group and online survey results. The following analyses determined if focus group participants had higher or lower disagreement with a group result compared to the online survey and, if so, whether there was any dominance during group discussions.

In order to analyze these differences, participants were first instructed to fill out the online survey individually before filling out the same survey as a group. All participants filled out the online survey prior to the focus group. They filled out the survey again in the focus group before a group discussion, so their answers may have changed. A modified version of Spearman's Rank Correlation Coefficient (rs) was used to identify the degree of changes between their weightings from the online survey and from the focus group. The rs was 0.67, where 1 is identical rankings and -1 is fully opposite rankings, indicating that the participants' weighting did change from when they filled out their online survey – but not by much.

Due to time constraints, the focus group was asked to rank the vulnerability of land uses, rather than assign weights. The weightings from the individual surveys were then converted to rankings for the analysis. The results from the individuals and the focus groups were compared by subtracting each individual's rankings from the group's rankings.

The researcher conducted two analyses on the focus group data. The first analysis determined if deciding the weighting of a certain land use had higher disagreement amongst the participants than other land uses, as shown on Tables 18 and 19. Because having a higher number of land uses in a category meant a higher likelihood of having larger difference in ranking, an average difference in ranking for each land use category has been provided to determine the relative difference. The resulting value expresses the differences between an individual and a group rankings – for the purpose of this research, this value will be referred to as the Group Influence Factor, or GIF. A GIF by land use may be derived from Equation 5:

$$(5) \quad Group\ Influence\ Factor\ by\ Land\ Use = \sum_{i=1}^{m} \left(\sqrt{(ai - ag)^2}\right) i$$

m = the total number of participants
a_i = a rank determined individually by a participant before the focus group
a_g = a rank decided by the group

5.4.1 Group influence factors by land use categories. As shown in Table 19, in deciding rankings for general land uses, residential uses were the most controversial to rank followed by infrastructure uses. A further analysis indicated that the individual rankings for residential uses were highly varied. The participants with planning backgrounds ranked infrastructure uses highest and residential uses the lowest. However, the participant with an emergency management background ranked vice versa: residential uses highest and infrastructural uses lowest. This observed behaviour coincides with the literature review from the Nova Scotia Emergency Management Offices, which find that while EMO officials are most concerned with the immediate safety of residents, planners consider any interruption of municipal services to be a threat to their community.

Table 19 Group Influence Factors by Land Use Categories

Land Use Category	Group Influence Factors
Residential	12.5
Infrastructure	6.5
Institutional	5.5
Commercial	4.0
Public	4.0
Industrial	2.5

As shown in Table 20, in deciding rankings for land use subcategories, a larger degree of disagreement occurred in land uses when deciding the Commercial land use subcategories and the Infrastructure land use subcategories. The largest difference occurred in the Coastal Protection use, which includes dykes and dams. Three of the five focus group participants agreed that this use is highly vulnerable as its destruction would worsen the effect of storm surge to adjacent communities. However, the other two participants thought otherwise, stating that coastal protection structures would be designed to withstand sea-level rise, storm surges, and any flooding events. In the end, the three participants convinced the other two participants, and they reached consensus that Coastal Protection use is vulnerable.

The Food Store use also showed a higher degree of disagreement. Two focus group participants stated that a land use allowing the storage of large amounts of groceries would be especially essential for a small community during isolation by flooding, but other participants did not see the use as important as it is a private use. However, the two participants were able to convince the rest of their peers to see food stores as vulnerable, and decide on the group result.

Table 20 Group Influence Factors by Land Use Subcategories

Land Use Subcategory	GIF	Land Use Subcategory	GIF
Residential		**Commercial**	
Low Density	5.5	Personal Service	8.0
Medium Density	3.5	Food Stores	9.5
High Density	3.0	Food Retails	4.0
Boarding/Rooming Houses	2.0	Service Stations	6.5
		Accommodations	5.0
		Entertainment	0.5
		Repair Shops	8.5
		Wholesales	0.5
		Offices	4.5
Average	*3.5*	*Average*	*5.2*
Industrial		**Institutional**	
Agricultural	0.5	Education, I	1.5
Industrial	1.0	Education, II	3.5
Marine Industrial	2.5	Private Care	1.0
Docks & Wharves	2.0	Residential Institution	2.0
		Religious Centres	4.5
		Historic Sites	1.0
		Community Centre	1.5
Average	*1.5*	*Average*	*2.1*
Governmental		**Infrastructural**	
Administration	1.5	Major Road	2.5
Military	3.5	Minor Road	8.0
Safety & Security	6.0	Parking Spaces	3.5
Medical, I	4.5	Public Transit	2.5
Medical, II	2.0	Railroads	8.5
Recreational, I	1.0	Electricity	6.5
Recreational, II	5.5	Water Utilities	7.5
Env. Conservation	7.0	Coastal Protection	10.5
		Waste Management	5.5
Average	*3.9*	*Average*	*6.1*

5.4.2 Group influence factors by participants. The second analysis, as shown on Table 21, identifies verbal dominances of discussion or any skewing of rankings from the focus group. The difference in a land use vulnerability rank by participant may be derived from Equation 6. The equation is similar to Equation 5 where the group's ranking for each land use is subtracted from the corresponding ranking from individual survey results:

$$(6)\quad Group\ Influence\ Factor = \sum_{i=1}^{m} (|\ ai - ag\ |)i$$

m = the total number of land uses per category
a_i = a rank determined individually by a participant before the focus group
a_g = a rank decided by the group

Because this research is focused on the degree of difference in rankings, knowing whether a participant ranked the vulnerability of a land use higher or lower than the final group ranking is unnecessary. Therefore, an absolute value of the difference between the individual and the group ranking was used. The resulting value expresses the differences between an individual ranking and a group ranking for all land uses – for the purpose of this research, this value will be referred to as the Group Influence Factor, or GIF. For example, a GIF of 53 from Participant No. 2 is the sum of the differences between the participant's rankings compared to the group's rankings when ranking 6 categories and 41 subcategories of land uses. The higher the GIF value, the more the individual's opinions have been influenced by the group.

Relatively low GIF values for Participant No. 1 and No. 3 – of 1 and 8, respectively – indicate that they were very persuasive in convincing other focus group participants to accept their own rankings. Participant No. 5, with a GIF of 94, experienced the greatest disparity between their individual rankings and group rankings. Considering that the range of possible GIF values for this research is between 0 – no disagreement between individual and group results – and 170 – largest possible disagreement with the group result, having a GIF of 94 by one participant and a GIF of 1 by another participant in the same group strongly suggests that dominance of conversation occurred and a verbal minority existed in this focus group session. The results from lack of discussion may not be truly reflective of the group opinion.

Table 21 Group Influence Factors by Participants

Participant	No. 1	No. 2	No. 3	No. 4	No. 5
Overall	0	8	0	10	17
Residential	0	5	4	0	5
Commercial	0	8	0	14	25
Industrial	0	2	0	0	4
Institutional	0	7	2	0	6
Governmental	1	8	1	1	20
Infrastructural	0	15	1	12	17
Total	**1**	**53**	**8**	**37**	**94**

While all participants were not afraid to state their opinion and respected others during discussion, there were times where a discussion carried on without a definite conclusion as a group. The researcher thinks that the dominance of group discussion occurred to some degree, based on the dialogue where one of the participants said "OK, OK, I'll give in. Let's go with that ranking", which concluded the discussion for one of the land uses. Such action of forfeiting occurred in discussing some other land uses. Avoiding discussions have the effect on the final result of vulnerability in which that the result does not accurately reflect a popular opinion of the group or represent learning amongst the peers.

5.5 Supplementary Results

5.5.1 Personal values on land use vulnerability. Prior to weighting land use categories and subcategories, survey respondents ranked four factors in the order that they personally value the most when prioritizing protection of land uses. The four factors and their associated land use categories included: Human Life (Residential), Local Economy & Private Services (Commercial, Industrial), Government, Health, and Protection Services (Institutional, Governmental), and Infrastructure (Infrastructural).

This question would determine whether personal values were influential to respondents' professional weightings. Since the group characteristics of respondents, such as location, expertise and profession, were not influential enough to increase the degree of agreement, the influence of respondent's individual value on weighting of land use vulnerability needs to be tested.

A modified version of Spearman's Rank Correlation Coefficient (rs) was used to identify correlations between personal values and weightings. In this method, rs is 1 when observations are identical between the two sets of rankings, and -1 when observations are fully opposed between the two sets of rankings (Spearman, 1904). The correlation test indicated that the rs value was 0.22 – showing a relatively low degree of agreement between what the respondents personally valued in terms of protecting certain land uses and their actual weighting of land use vulnerability.

It is worth noting that the Kendall's Coefficient of Concordance (W) for survey respondents on their personal values was 0.58 – which is above the average value of 0.50 for reaching an agreement. The relatively high Coefficient indicates that the respondents have similar values when prioritizing the protection of land use. Most respondents ranked Human Life as the most important value, followed by Government, Health, and Protection Services; Infrastructure, and; Local Economy & Private Services.

The high value of W and the low value of rs mean that, although the respondents seem to share common values as to what to protect, their opinions differ when they decide on the weightings on land use categories and subcategories. Other factors may be influencing the weightings.

5.5.2 Survey comments. Comments were collected at the end of the online survey asking respondents to express any assumptions in assigning weightings to the land uses or any thoughts that influenced their weightings. Table 22 categorizes all the comments received from the 27 respondents. Many respondents considered personal or past experiences in deciding vulnerability of land uses. Others considered the wider community impact should a land use be out of commission when weighting land use vulnerability, as the survey intended. However, confusion arose when some respondents assumed local context to weighting each land use rather than considering each land use generally and equally exposed. A few respondents expressed other factors that may have influenced weightings such as seasonal changes of land uses.

Table 22 Survey Comments

Classification	Comments
Wider Community Impact	We looked at the impact on each section and how valuable they are to our Municipality and how much of an issue it would be if they were put out of commission.
	Rating of the various land use categories was based on the impact they would have should we lose something within those land uses. For example, Fire and Emergency services, the buildings can be replaced, but we need them to be protected and functioning during and after a crisis. In my jurisdiction, none of the fire stations meet post disaster requirements as established by the Building code of Canada.
Exposure as consideration	I completed the survey with the mindset of an emergency planner. Protection of critical infrastructure and services plays a high priority in my opinion whereas a non-emergency municipal staff member may place more emphasis on water/waste infrastructure. I ranked items as if they all had equal risk exposure, as opposed to the reality of exposure as it relates to actual location.
	The notion of vulnerability is a bit confusing, especially when attempting to rank land uses which, in reality, are located such that they are less vulnerable. I with the definition of vulnerability and the recommended way to approach this (reality of location vs 'all things equal')
Personal & Past Experience	My assignment of values is based on existing land use patterns in our community that have been susceptible to flooding in the past and have sustained flood damage.
	Definitions of categories, my understanding of their current vulnerability, my personal opinions on their importance during a catastrophe.
	History is also part of the vulnerability equation, so it may have been nice to see a questioning series around what may have already occurred in an area or at least distinguishing between what has happened and what may happen.
	Often, I would get confused with the importance of the item vs. the vulnerability of the item. Vulnerability derived from previous, experienced observation of events...does not reflect potential more sever events (both in number of occurrences and increased impacts).
Other factors in vulnerability	Our area is most sensitive to coastal flooding caused by a medium to large magnitude synoptic scale (winter-type) storm or hurricane with a slow southerly approach and the centre passing near to the west. The combined physical processes of a major storm like this would overwhelm the entire community.
	I focused on coastal flooding however inland flooding is a risk in our Municipality as well.
	The only area to mention is that a fairly significant portion of the properties in high risk areas are occupied seasonally and thus the risk to life would increase during the summer months when these areas are more active.

Chapter 6 Discussion

Reaching an agreement in a group is difficult, even for professionals, and this is a well-documented issue in planning described as 'muddling through' (Lindblom, 1959). Assigning proportional vulnerability among land uses is no exception. As this research progressed, the researcher identified large variances in professionals' opinions on vulnerability of land uses from both the individual surveys and in the focus group. While a large variance does not mean the invalidity of this research, other researchers must be cautious in using the averages of such data to be applied elsewhere.

6.1 Answering the Research Questions

6.1.1 Vulnerability index. The first research objective was to weight the degree of vulnerability for each land use in the context of Nova Scotia at a municipal level. By taking an average of the weightings from 27 respondents in Nova Scotia, a list of vulnerability indexes for each land use, optimized for Nova Scotia, was created.

Table 23 Land Use Vulnerability Classification between the SEPA (2012) and Nova Scotia in the order of the Most Vulnerable to the Least Vulnerable

	SEPA Classification	Nova Scotia Equivalent
Highly Vulnerable Uses*	Major Roads Electricity Water Utilities Safety & Security Boarding & Rooming Houses	Low Density Residential Medium Density Residential Major Roads Water Utilities Docks & Wharves
More Vulnerable Uses*	Medical I Residential Institutions Private Care High Density Residential Medium Density Residential Low Density Residential Accommodations Entertainment Medical II Education I Education II	Minor Roads Industrial Safety & Security Food Stores Agriculture Marine Industrial Boarding & Rooming Houses Electricity High Density Residential Historic Sites Medical I

	SEPA Classification	Nova Scotia Equivalent
Less Vulnerable Uses*	Waste Management Personal Service Food Stores Food Retails Service Stations Repair Shops Wholesales Offices Industrial Recreational I Recreational II Administration Community Centres Religious Centres Historic Sites Agriculture	Environmental Conservation Coastal Protection Food Retails Private Care Personal Service Accommodations Religious Centres Service Stations Recreational II Waste Management Education I Administration Offices Community Centres Medical II Repair Shops
Water Compatible Uses*	Military Marine Industrial Docks & Wharves Environmental Conservation Minor Roads Railroads Public Transit Coastal Protection Parking Spaces	Recreational I Education II Military Railroads Parking Spaces Entertainment Residential Institution Wholesales Public Transit

*SEPA Classification. It is not applicable to the uses in the Nova Scotia equivalent.

Both the SEPA classification and the classification determined from this research weight Major Roads and Water Utilities high on the list, as shown on Table 23. However, there are land uses that were weighted substantially different between the two classifications – such as Low Density Residential (valued higher in Nova Scotia), Agriculture (valued higher in Nova Scotia), and Entertainment uses (valued higher in the SEPA classification).

To measure the correlation between the rankings of two sets of rankings, Spearman's Rank Correlation Coefficient was used. The Spearman correlation ranges from +1 to -1, where the sign indicates positive or negative correlations, respectively, and the value indicates the similarity of rankings. The Spearman correlation is high when the two sets of rankings have a similar rank, and low when the sets of rankings have a dissimilar rank (Spearman, 1904). The Spearman's Coefficient of the two sets of rankings on Table 23 is 0.2758. The value indicates that, while the SEPA classification and the classification derived from this research has a positive correlation, the correlation between these sets of rankings is relatively low.

Hindrichs (2015) suggests the possibility of regional differences for vulnerability weighting. The relatively low correlation indicates that this research echoes some of Hindrichs' findings. However, other factors that resulted in a low Spearman's Coefficient may also exist. One possibility includes that the respondents from Nova Scotia were a heterogeneous group with substantially different views on vulnerability by subpopulations. If so, then stratification is required before survey sampling.

As shown on Tables 5-18, the average weightings indicate that there were some cases of differing views among subpopulations in a variable. For example, the professionals who had worked 10 years or less weighted, on average, 47 points to Low Density Residential Use while the professionals who worked more than 10 years assigned 70 points on average. High differences in average weightings by subpopulation may indicate the need for stratification. However, there is also a chance of outliers and large disagreement amongst their own subpopulation, which is indicated in the analysis of variance and the Coefficient.

6.1.2 Variance and agreement. The second research objective was to discover potential variances among professionals in how they assigned proportional vulnerability to land uses in Nova Scotia. The objective was to determine if professionals have similar perspectives of land use vulnerability and, if so, identify any variables that may have influenced the weighting process. For example, professionals in a rural community may weight agricultural use as more vulnerable compared to professionals in an urban area who may be unfamiliar with agricultural use. If such variables are identified, then the survey may require stratified sampling and proportionate allocation. For instance, if location is a strong influencer to weighting, then researchers need to ensure that each subpopulation – rural districts, towns, and regional municipalities –

has a representation proportional to that of the total population of municipal planning and emergency professionals in Nova Scotia. This is to improve the representativeness of the sample and to yield average weightings with less variability. Creating a separate set of land use vulnerability weightings for each subpopulation is also an option.

The overall agreement among professionals is low, as measured with Kendall's Coefficient of Concordance. The coefficient of land use categories was 0.2066 when the highest possible value was 1.0000. The coefficient of 0.2066 indicates that the participants in this group have 20.66% chance of agreeing with other participants in weighting the vulnerability of a land use. This seems to echo the literature review; stakeholders such as planners, EMO officials, policymakers, and citizens have different perspectives on the value of a place (Collaborative Environmental Planning Initiative, 2006).

Table 4 shows the Coefficients of agreement among subpopulations for different land use categories. Out of 56 coefficients, only 9 of them, or 16%, are over 0.5000, indicating that the respondents in this research are more prone to disagreement than agreement when weighting vulnerability of land uses to flooding events. Even within each subpopulation – such as working in a town municipality, working for more than 10 years, and working in a planning department – the respondents have different opinions.

6.1.3 Three variables and their subpopulations. This research determined that the three variables tested failed to influence the vulnerability weightings substantially. Whether a participant lived in a rural area or an urban area, had worked for more or less than 10 years, and worked in planning or emergency management, these variables had no direct correlation in weighting the vulnerability of a land use. There were few exceptions, such as high agreement among EMO officials on residential uses, but the degree of agreement was not as high for other land uses.

One possibility is that the researcher failed to identify the variable and associated subpopulations that affect vulnerability weighting. Variables such as gender, birthplace, place of education, field of study during university may influence the weighting, but the researcher chose not to focus on these variables during the development of survey. Therefore, their influences are unknown until tested.

Another possibility is that vulnerability weighting is an independent result. Each professional may have different views on land use vulnerability, and countless variables and a complex combination of these factors may have affected the views of respondents. Personal experience, place of education, background knowledge in a specific field, working experience, location of hometown, location of workplace, philosophy in life, and other factors may be a variable that influences the weighting, but it would be difficult to account for such diverse personal variables.

Failing to prove strong correlations between the three variables and land use vulnerability weighting also means that each community is likely to have different perspectives on the vulnerability of land uses and may need to conduct independent exercises to create weightings of land use vulnerability to reflect their local visions. This mimics the federal government of Canada's approach in the development of the MCCAPs – each municipality or a few adjacent municipalities gathered together to develop their own strategy to mitigate the risk associated with climate change, rather than creating a plan for province as a whole.

6.1.4 Personal Opinions. Based on the comments received from the survey, personal thoughts, assumptions and experience played a role in influencing the weightings of land use vulnerability. A substantial number of respondents based their opinion on their past experiences. This coincides with a decision made earlier by the researcher to ask respondents to assign a weighting of zero if they were unfamiliar with the vulnerability of a land use.

Despite each survey question asking respondents to weight land uses assuming they have an equal chance of being flooded, some respondents expressed difficulty in extracting their answers from the influence of their local context - where risk of flooding varied between each land use. This was observed from the pretest as well as comments received from the online survey. One comment remarked that the notion of vulnerability is confusing when attempting to weight a land use that is vulnerable in characteristics but is located in less exposed location. Other respondents commented that they assumed for equal exposure.

6.1.5 Focus group. The last research objective was to highlight dynamics of the focus group. The divergence of opinions on relative vulnerability and the subsequent compromises made in reaching a group consensus echoes the hypotheses formed in the literature review. Deciding on weightings as a group is more than taking an average of individual weightings. Some of the reviewed literature suggest that participants have an opportunity to learn the perspective of others and to be enlightened before making a final decision on weighting (Grudens-Schuck et al., 2004).

The main question still remains as to whether the participants enlightened one another, pressured others to change, or concealed their opinions during discussion. A large variability in GIF values among participants in Table 21 shows that the views of some participants did not reflect in the group result and suggests frequent persuasion or verbal dominance. Because of the large range of vulnerability weightings by each participant prior to the focus group, shown in Table 21, this focus group was clearly unable to avoid verbal dominance during discussion.

This behaviour coincides with the research of Grant et al., (2010) which warned of the bandwagon effect in a focus group – that is, following other participant's decision regardless of personal opinions. To prevent such dominance in discussion from happening again, a highly-trained facilitator should lead the discussions regarding land use vulnerability in focus groups, as opposed to a student researcher like in the case of this focus group. As Grant (2011) suggests, skillful facilitators must be able to manage dominant participants, to draw in reserved individuals, and to direct conversations in productive directions. If well executed, they can help to catalyse discussions and generate insightful data.

6.2 Future Consideration

Based on the results, it seems apparent that a community should develop its own set of land use vulnerability index in order to reflect its local environment. Indeed, this requires preparation. Before creating vulnerability weightings, a community needs to (1) encourage focus group sessions as a primary method of data collection in order to foster a learning environment; (2) invite a variety of stakeholders to the focus group to accommodate as many different perspectives as possible; and (3) reduce the bandwagon effect and verbal domination by having a trained facilitator host the session in a way that is productive, positive, and reflective of the community. Following the three aforementioned considerations are crucial in obtaining a list of vulnerability ratings that is truly reflective of the community vision.

6.2.1. Delphi Method. As for the online survey, the Delphi Method could be used in the future. According to Rowe & Wright (2001), the Delphi Method involves distributing surveys to professionals where they submit their weightings as well as their reasoning for the weightings. The results are summarized and distributed to the same professionals for them to learn other perspectives and to change answers if their perspectives have changed (Skulmoski, Hartman, & Krahn, 2007). The general recommendation is to perform two to three iterations, subject to the willingness of the experts to participate (Campos-Climent, Apetrei, & Chaves-Avila, 2012).

This method was designed to minimize the influence of dominant individuals, group pressure, irrelevant communication and to reduce statistical noise – much like a focus group session (Strand, Carson, Navrud, Ortiz-Bobea & Vincent, 2017). Subsequently, the method reduces variability in the survey results, and incorporates some of the positive effects of focus groups into online surveys.

The method has the advantage of group techniques – by involving different people, creativity, different points of view – but without any of the limitations imposed by a group's political, social and personal influence (Strand et al., 2017). However, after the mid-1970s, methodological development stalled as the method was criticized as unscientific and producing speculative results (Sackman, 1975). Its main limitation lies in the potentially emotional and subjective responses, since these can be conditioned by the beliefs, feelings and expectations of the participants (Campos-Climent et al., 2012).

An objective of a Delphi study, often implicit, is to achieve an outcome close to a group consensus if one appears to exist, while at the same time not unduly influencing participants to change their predictions if there are strongly held differences in beliefs (Strand et al., 2017). Therefore, the Delphi method is a suitable tool for subjective issues that require the analysis of qualitative variables and subsequent predictions (Campos-Climent et al., 2012).

The method is especially useful for producing information not readily obtainable in other ways, which is the case for this research (Strand et al., 2017). In a way, the data collection method used in the research was a modified version of the Delphi Method. The individual anonymous survey was followed by the focus group meeting to finalize scores, similar to environments in the municipal planning process. A major limitation of the focus group was dominant individuals influencing weightings. In future researches, the Delphi method may be able to overcome this limitation.

6.2.2. Treatment of Zero Values. Respondents were asked to weight a land use subcategory as zero when there is no such land use in their community. The reasoning was stated in the Pretest section, where some land uses require expertise and knowledge to understand relative vulnerability. Therefore, non-existent land uses were weighted zero as the respondents often did not have enough information or experience to decide on a weighting.

However, it was still possible for the respondents to legitimately weight other land uses as zero for non-existent vulnerability. Because these two types of zeroes were treated the same in the subsequent analysis, there was no way to distinguish between these two.

This may serve as a limitation, as giving a weighting of zero because of non-existent vulnerability and non-existent availability is different. It is possible to include a technical feature to distinguish zeros due to non-existent vulnerability and non-existent availability in an online survey, which may be easily integrated into future research.

6.3 Limitations

A major limitation to this research is having a relatively small sample size for both the survey and the focus group. 27 professionals in Nova Scotia filled out the survey, representing roughly one-tenth of the entire population of planning or emergency management professionals in the province. A small sample size may also have reduced diversity within the sample to cause self-selection bias. Either way, a larger sample size would strengthen the results on vulnerability weighting and the coefficient rate of agreement.

The researcher's inexperience in facilitating focus groups is also a limitation. The literature review suggested that a skilled facilitator is helpful to manage the flow of discussion better (Grant et al., 2010). Otherwise, the focus group may be subjected to bandwagon effects leading to unproductive directions.

Another limitation may arise from the respondents' lack of knowledge on the research topic. There were no exclusion criteria in the recruitment; any planning or emergency management officials working in a municipal government in Nova Scotia could participate. While none of the respondents worked in an inland municipality like the Town of Berwick, lack of familiarity with coastal flooding was not an exclusionary criterion to the survey. It was possible that a professional who had no previous experience with coastal environments or planning in a coastal context may have participated in the survey. The survey also asked whether the respondents had previous experience in emergency management – serving in an EMO Committee, working as an emergency management official, participating in drafting municipal emergency plans, and other related activities. 63% of respondents stated yes to the question, but that did not exclude any of the others from participating in the survey.

The choice of land use categories presented a limitation. For instance, Agriculture was a land use subcategory under the Industrial category. It was categorized in this way to reduce the number of categories to weight, but Agricultural use is typically an independent category. The amalgamation of two distinctive uses may have confused some professionals, especially those working in a rural municipality and may have affected their weighting. Such amalgamation may be justified, but it needs to be made clear to the respondents. The use of the Halifax Peninsula Land Use By-law as one of the two sources to create land use categories may have served as a challenge for rural respondents, as the By-law is heavily urban-centric.

6.4 Final Thoughts of Future Research

Moving forward, this research may be improved by (1) increasing the sample size; (2) incorporating the Delphi method in the survey; and (3) facilitating a focus group in each municipality. The researcher may also consider the following question: (4) How would non-professional community members evaluate the vulnerability of land uses? The general public may show more obvious patterns in determining vulnerability of land uses based on their income, age, and other social characteristics.

Chapter 7 Conclusion

There was high variability among professionals in weighting vulnerability, as proven by the low coefficient in most of the land use subcategories. The high variability of weightings indicates that there is disagreement within the professional community when assessing the vulnerability of land uses to flooding. In a focus group setting, the results show that much compromise is often necessary to reach group consensus on vulnerability. This is concerning as coastal communities faced with imminent storm events induced by climate change may soon be making group decisions in a context where differences are high, even among the professionals. It is very likely that some perspectives may be compromised. In a way, this research reminds community stakeholders to prepare for the upcoming catastrophic events because the process of developing a preparation plan may be more complex than they once thought.

This research also reminds professionals and other researchers in planning-related fields about respecting the local setting. Each community is likely to have different perspectives in weighting land use vulnerability as physical landscape, culture, social values, and other characteristics of communities may play a role in determining the vulnerability of each type of land use. Accounting for all the characteristics of community and factors influencing the vulnerability of a land use is nearly impossible, as they are large in size, unknown, and intertwining. If a community wishes to implement an analytical tool of risk of land uses to storm surges and sea level rise, it should consider making corrections for the local environment or creating its own vulnerability weighting rather than copying existing systems developed elsewhere.

Bibliography

Ayalew, L. & Yamagishi, H. (2005). The application of GIS-based logistic regression for landslide susceptibility mapping in the Kakuda-Yahiko Mountains, Central Japan. *Geomorphology, 65*, 15–31. doi: 10.1016/j.geomorph.2004.06.010

Bender, S. (2002). Development and Use of Natural Hazard Vulnerability: Assessment Techniques in the Americas. *Natural Hazards Review, 3*(4), 136-138.

Beniston, M., Bolliger, J., Foppen, R., Jenni, L., Lehmann, A., Maggini, R., … Zimmermann, N. (2014). Assessing species vulnerability to climate and land use change: the case of the Swiss breeding birds. *Diversity and Distributions, 20,* 708-719. doi: 10.1111/ddi.12207

Bernier, N. B., Thompson, K. R., Ou, J. and Ritchie, H. (2007). Mapping the return periods of extreme sea levels: allowing for short sea level records, seasonality, and climate change. *Global and Planetary Change, 57*, 139-150.

Birkman, J. (2007). Risk and Vulnerability Indicators at Different Scales: Applicability, Usefulness and Policy Implications. *Environmental Hazards, 7,* 20-31.

Boudou, M., Danière, B., & Lang, M. (2015). Assessing Changes on Urban Flood Vulnerability through Mapping Land Use from Historical Information. *Hydrology and Earth System Sciences Discussions, 12*, 6151-6177. doi: 10.5194/hessd-12-6151-2015

Cao, M., & Woodward, F. I. (1998). Dynamic responses of terrestrial ecosystem carbon cycling to global climate change. *Nature, 393*(6682), 249-252.

Cape Breton Regional Municipality. (2014). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.cbrm.ns.ca/images/Planning/ MCCAP_Final_Report_adopted_by_Council.pdf

Campos-Climent, V., Apetrei, A., & Chaves-Avila, R. (2012). Delphi Method Applied to Horticultural Cooperative. *Management Decision, 50*(7), 1266-1284. doi: 10.1108/00251741211247003

Cardona, O. D., Van Alast, M. K., Birkmann, M., Fordham, M., McGregor, G., Perez, R., Pulwarty, R. S., Schipper, E. L. F., & Sinh, B. T. (2012). Determinants of risk: exposure and vulnerability. *Managing the Risks of Extreme Events and*

Disasters to Advance Climate Change Adaptation, 65-108. Cambridge University Press: Cambridge, UK.

Chang, S. E. (2003). Transportation Planning for Disasters: an Accessibility Approach. *Environment and Planning A, 35*, 1051-1072.

City of Moncton. (2013). *Adaptation and Flood Management Strategy*. Retrieved from https://www.moncton.ca/Assets/Residents+English/Environment/ Climate+Change+Adaptation+Plan.pdf

Cochran, M., Manuel, P., & Rapaport, E. (2012). Yarmouth: A Case Study in Climate Change Adaptation. *Part 2 Section 5: Social Vulnerability to Climate Change in Yarmouth, Nova Scotia*. Retrieved from www.atlanticadaptation.ca

Collaborative Environmental Planning Initiative [CEPI]. (2006). *Bras d'Or Lakes Traditional Ecological Knowledge Workshop Proceedings*. Retrieved from http://www.dfo-mpo.gc.ca/Library/327652-AppA.pdf

County of Antigonish. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.antigonishcounty.ns.ca/wp-content/uploads/2015/02/MCA-MCCAP-2013.pdf

County of Kings. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.kings2050.ca/blog/2013/12/municipal-climate-change-action-plan-released/

County of Richmond. (2014). *Municipal Climate Change Adaptation Plan*. Arichat: County of Richmond.

Cutter, S. (1996a). Vulnerability to Environmental Hazards. *Progress in Human Geography*, *20*(4), 529-539.

Cutter, S. (1996b). Societal Vulnerability to Environmental Hazards. *International Social Science Journal, 47*(4), 525-536.

Cutter, S., Boruff, B., & Lynn, S. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly, 84*(2), 242-261. doi: 10.1111/1540-6237.8402002

Cutter, S., Mitchell, J. T., & Scott, M.S. (2002). Revealing Vulnerability of People and Places: A Case Study of Georgetown County, South Caroline. *Annals of the Association of American Geographers, 90*(4), 713-737.

Department of Communities and Local Government [DCLG]. (2012). *Technical Guidance to the National Planning Policy Framework*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6000/2115548.pdf

Department of Municipal Affairs [DMA]. (2016). *Municipal Planning Strategy and Land Use By-laws*. Retrieved from https://novascotia.ca/dma/planning/strategy-and-land-use-by-laws.asp

Dickie, J. (2009). *Risk and Vulnerability Assessment Tool – Halifax Regional Municipality*. Middleton, NS: Applied Geomatics Research Group.

District of Barrington. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.barringtonmunicipality.com/municipal-documents/110-municipal-planning-strategy/file.html

District of Chester. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.chester.ca/inform/strategic-plan/2015-02-04-19-35-41/file

District of Digby. (2013). *Municipal Climate Change Adaptation Plan*. Digby: District of Digby.

District of East Hants. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from https://www.easthants.ca/content/municipality-of-east-hants-mccap-final-document

District of Lunenburg. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.modl.ca/municipal-services/planning/sustainability/climate-change-adaptation

District of West Hants. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.westhants.ca/municipal-climate-change-action-plan.html

District of Shelburne. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.municipalityofshelburne.ca/municipal-climate-change-action-plan.html

District of Yarmouth. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from https://www.district.yarmouth.ns.ca/index.php/welcome/mccapreport

Douglas, J. (2007). Physical Vulnerability Modeling in Natural Hazard Risk Assessment. *Natural Hazards and Earth System Sciences, 7,* 283-288.

Ebert, A., Kerle, N., & Stein, A. (2009). Urban Social Vulnerability Assessment with Physical Proxies and Spatial Metrics Derived from Air and Space-borne Imagery and GIS Data. *Natural Hazards, 48*(2), 275-294.

Ejenma, E., Sunday, V., Okeke, O., Eluwah, A., & Onwuchekwa, I. (2014). Mapping Flood Vulnerability Arising from Land Use, Land Covers Change along River Kaduna, Kaduna State, Nigeria. *Journal of Humanities and Social Science, 19*(7), 155-160. Retrieved from http://iosrjournals.org/iosr-jhss/papers/Vol19-issue7/Version-4/Y01974155160.pdf

Elemental Sustainability Consulting. (2012). *The Municipal Climate Change Action Plan Assistant: Learning from Others*. Retrieved from https://novascotia.ca/dma/pdf/mun-municipal-climate-change-action-plan-assistant.pdf

Emanuel, K. (2005). Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years. *Nature, 436*, 686-688. doi: 10.1038/nature03906

Environment Canada. (1975). *Flood Damage Reduction Program*. Retrieved from https://ec.gc.ca/

Fell, R., Corominas, J., Bonnard, C., Cascini, L., Leroi, E., & Savage, W. (2008). Guidelines for Landslide Susceptibility, Hazard and Risk Zoning for Land Use Planning. *Engineering Geology, 102*(3-4), 85-98. Retrieved from http://www.sciencedirect.com/science/journal/00137952/102

Folke, C. (2006). Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change-Human and Policy Dimensions, 16,* 253–267.

Forbes, D. L., Manson, G. K., Charles, J., Thompson, K. R., & Taylor, R. B. (2009). *Halifax Harbour Extreme Water Levels in the Context of Climate Change: Scenario for a 100-year Planning Horizon*. Retrieved from https://www.halifax.ca/regionalplanning/documents/OF6346final.pdf

Galbraith, H., Jones, R., Park, R., Clough, J., Herrod-Julius, S., Harrington, B., & Page, G. (2002). Global Climate Change and Sea Level Rise: Potential Losses of

Intertidal Habitat for Shorebirds. *Waterbirds, 25*(2), 173-183. doi: 10.1675/1524-4695(2002)025[0173:GCCASL]2.0.CO;2

Gleckler, P. J., Durack, P. J., Stouffer, R. J., Johnson, G. C., & Forest, C. E. (2016). Industrial-Era Global Ocean Heat Uptake Doubles in Recent Decades. *Nature Climate Change, 6*. doi: 10.1038/nclimate2915

Global Facility for Disaster Reduction and Recovery [GFDRR]. (2010). *Economic Vulnerability and Disaster Risk Assessment in Malawi and Mozambique: Measuring Economic Risks of Droughts and Floods*. Retrieved from http://www.preventionweb.net/files/15520_gfdrrecon.vulnerabilitydrrmalawimoz.pdf

Goddard, P., Yin, J., Griffies, S., Zhang, S. (2015). An Extreme Event of Sea-Level Rise along the Northeast Coast of North America in 2009-2010. *Nature Communications, 6*(2). doi: 10.1038/ncomms7346

Grant, J. L. (2011). Storytelling, Group Dynamics, and Professional Cultures: Lessons from a Focus Group Study. *Planning Theory & Practice, 12*(3), 407-425. doi: 10.1080/14649357.2011.617497

Grant, J. L., Beed, T., & Manuel, P. M. (2016). Integrated Community Sustainability Planning in Atlantic Canada: Green-Washing an Infrastructure Agenda. *Journal of Planning Education and Research,* 1-13. doi: 10.1177/0739456X16664788

Grant, J. L., MacKay, K. C., Manuel, P. M., McHugh, T. F. (2010). Barriers to Optimizing Investments in the Built Environment to Reduce Youth Obesity: Policy-maker Perspectives. *Canadian Journal of Public Health, 101*(3), 237-240.

Grudens-Schuck, N., Allen, B. L., & Larson, K. (2004, May). *Focus group fundamentals: methodology brief*. Retrieved from: http://www.extension.iastate.edu/Publications/PM1969B.pdf

Guisepi, R. (1998). *The Rise of Civilization in the Middle East and Africa*. Retrieved from http://history-world.org/rise_of_civilization_in_the_midd.htm

Halifax Regional Municipality. (2007). *Climate Change Risk Management Strategy*. Retrieved from https://www.halifax.ca/climate/documents/ClimateChangeRiskManagementStrategyforHRMDecember2007.pdf

Halifax Regional Municipality. (2016). Halifax Peninsula Land Use By-law. Retrieved from http://new.halifax.ca/planning/documents/HalifaxPeninsula_LUB.pdf

Hindrichs, H. (2015). *A Methodology for Visualizing the Vulnerability of Buildings to Sea Level Rise on the Halifax Waterfront*. (Unpublished bachelor dissertation). Dalhousie University, Canada.

Insurance Bureau of Canada. (2015). *The Economic Impacts of the Weather Effects of Climate Change on Communities*. Retrieved from http://assets.ibc.ca/Documents/Studies/IBC-The-Economic-Impacts.pdf

Intergovernmental Panel on Climate Change [IPCC]. (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. (2008). *Fourth Assessment Report*. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. (2013). *Fifth Assessment Report*. Cambridge: Cambridge University Press.

Intergovernmental Panel on Climate Change [IPCC]. (2014). Chapter 5: Coastal systems and low-lying areas. *IPCC Working Group II: Assessment Report Five*. Retrieved from http://www.ipcc.ch/report/ar5/wg2/

Johnston, A., Slovinsky, P. & Yates, K.L. (2014). Assessing the vulnerability of coastal infrastructure to sea level rise using multi-criteria analysis in Scarborough, Maine (USA). *Ocean and Coastal Management, 95*, 176-188. doi: 10.1016/j.ocecoaman.2014.04.016

Kazakis, N., Kougias, I., & Patsialis, T. (2015). Assessment of Flood Hazard Areas at a Regional Scale Using an Index-Based Approach and Analytical Hierarchy Process: Application in Rhodope-Evros Region, Greece. Science of the Total Environment, 538, 555-563. doi: 10.1016/j.scitotenv.2015.08.055

Kosloski, A. (2008). *Planning for Climate Change and Coastal Zone Management: Land Use Vulnerability, Hazard, and Exposure in Halifax Harbour, Halifax Regional Municipality*. Retrieved from https://www.cip-icu.ca/PDF/Report6-A-Kosloski.pdf

Krueger, R. A., & Casey, M. A. (2009). *Focus Groups: A Practical Guide for Applied Research* (3rd ed.). Thousand Oaks, CA: Sage.

Lauire, P. (2003). Disaster Development and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation. *Natural Hazards, 28*(2-3), 211-228.

Lee, U. (2016). *Are Rooming Houses Disappearing in Halifax.* (Unpublished bachelor dissertation). Dalhousie University, Canada.

Legendre, P. (2005). Species Associations: the Kendall Coefficient of Concordance Revisited. *Journal of Agricultural, Biological, and Environmental Statistics, 10*(2), 226-245. doi: 10.1198/108571105X46642

Legendre, P. (2010). Coefficient of Concordance. In Salkind, N. (Ed.), *Encyclopedia of Research Design, Vol. 1* (pp. 164-169). Los Angeles: Sage Publication.

Lichter, M. & Felsenstein, D. (2012). Assessing the Costs of Sea-Level Rise and Extreme Flooding at the Local Level: A GIS-Based Approach. *Ocean & Coastal Management, 59*, 47-62.

Lindblom, C. E. (1959). The Science of Muddling Through. *Public Administration Review, 19*(2), 79-88. doi: 10.2307/973677

Lindell, M. K., Prater, C., & Perry, R. W. (2007). *Introduction to Emergency Management*. Hoboken, NJ: Wiley.

Lujala, P., Lein, H. & Rosvoldaune, R. (2014). Quantifying vulnerability to flooding induced by climate change: The case of Verdal, Norway. *Norwegian Journal of Geography, 68*(1), 34-49. doi: 10.1080/00291951.2013.870600

Makoka, D., & Kaplan, M. (2005). *Poverty and Vulnerability: An Interdisciplinary Approach.* Bonn, Germany: Universitat Bonn.

McCarthy, J., Canziani, O., Leary, N., Dokken, D. & White, K. (2001). Climate Change 2001: Impacts, adaptation and vulnerability. *Contribution of working group II to the third assessment report of the intergovernmental panel on climate change.* Cambridge, UK: Cambridge University Press.

McGranahan, G., Balk, D., & Anderson, B. (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment & Urbanization, 19*(1), 17-37. doi: 10.1177/0956247807076960

McLaughlin, S. & Cooper, A. (2010). A multi-scale coastal vulnerability index: A tool for coastal managers. *Environmental Hazards, 9*(3), 233-248. doi: 10.3763/ehaz.2010.0052

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97. doi:10.1037/h0043158.

Milne, G. A., Gehrels, W. R., Hughes, C. W., & Tamisiea, M. E. (2009). Identifying the Causes of Sea-Level Change. *Nature Geoscience, 2*, 471-478. doi: 10.1038/ngeo544

Minitab [Computer software]. (2016). State College, PA: Minitab, Inc.

Mirza, S. (2007). *Danger Ahead: The Coming Collapse of Canada's Municipal Infrastructure*. Retrieved from http://www.fcm.ca

National Oceanic and Atmospheric Administration [NOAA]. (2009). *NOAA and Inundation*. Retrieved from http://inundation.noaa.gov/

National Oceanic and Atmospheric Administration [NOAA]. (2015). Introduction to Survey Design and Delivery. *Social Science Tools for Coastal Program*. Retrieved from https://coast.noaa.gov/data/digitalcoast/pdf/survey-design.pdf

Naudé, W. (2011). Climate Change and Industrial Policy. *Sustainability, 3,* 1003-1021. doi: 10.3390/su3071003

Nyerges, T., & Jankowski, P. (2010). *Regional and Urban GIS: a Decision Support Approach*. New York: Guilford Press.

Ojigi, M. C. & Shaba, A. H. (2012). Integration of Synthetic Aperture Radar (SAR) imagery and Digital Terrain Model for determining flood water threshold in Sokoto and environs, Nigeria. *Proceedings of the Geo-information society of Nigeria and Nigerian Cartographic Association*, 291-303. Ile Ife, Nigeria: Obafemi Awolowo University.

Ouma, Y. O. & Tateishi, R. (2014). Urban Flood Vulnerability and Risk Mapping Using Integrated Multi-Parametric AHP and GIS: Methodological Overview and Case Study Assessment. Water, 6, 1515-1545. doi: 10.3390/w6061515

Oxford Dictionary. (2015). *Hazard*. Retrieved November 12, 2015, from http://www.oxforddictionaries.com/definition/english/hazard

Özyurt, G. & Ergin, A. (2010). Improving coastal vulnerability assessments to sea-level rise: A new indicator-based methodology for decision-makers. *Journal of Coastal Research, 26*, 265-273. doi: 10.2112/08-1055.1

Peduzzi, P. (2001). *Feasibility study report on global risk and vulnerability index – Trends per year*. Geneva: United Nations.

Peduzzi, P., Dao, H., Herold, C., & Mouton, F. (2002). *Global risk and vulnerability index trends per year phase II: development, analysis and results*. New York: United Nations.

Pelling, M. (2003). *The Vulnerability of Cities: Natural Disaster and Social Resilience*. London: Earth Scan.

Penning-Rowsel, E., & Chatterton, J. (1977). *The Benefits of Flood Alleviation*. Lexington: Lexington Books.

Pinkerton. (2014). *Risk vs Threat vs Vulnerability, and Why You Should Know the Differences*. Retrieved from http://www.pinkerton.com/blog/risk-vulnerability-threat-differences#sthash.joNSkARv.dpuf

Pirazzoli, P. A. (1997). *Sea-Level Changes: The Last 20,000 Years*. Hoboken, NJ: Wiley.

Province of Manitoba. (n.d.). *Climate Change Adaptation through Land Use Planning*. Retrieved from http://www.gov.mb.ca/ia/plups/pdf/cca.pdf

Province of Nova Scotia. (2014). *Municipal Government Act: R.S.N.S., 1998, c. 18*. Retrieved from http://nslegislature.ca/legc/statutes/ municipal%20government.pdf

Region of Queens Municipality. (2014). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.regionofqueens.com/municipal-climate-change-action-plan

Rideout, E. (2012). *Setbacks and Vegetated Buffers in Nova Scotia: A Review and Analysis of Current Practice and Management Options*. Retrieved from http://myweb.dal.ca/sh732360/Sterling_Lab_Site/Research_Projects _files/setbacks%20%20vegetated%20buffers%20in%20nova%20scotia %20report_final_may%2022%202012-1.pdf

Ross, S. (2007). *Introduction to probability models*. San Diego: Academic Press.

Rowe, G. & Wright, G. (2001). Expert Opinions in Forecasting: The Role of the Delphi Technique. *Principles of Forecasting,* 30, 125-144. doi: 10.1007/978-0-306-47630-3_7

Saaty, Thomas L. (2010). *Principia Mathematica Decernendi: Mathematical Principles of Decision Making*. Pittsburgh, PA: RWS Publications.

Sackman, H. (1975). Delphi Critique: Expert Opinion. Forecasting and Group Process. D.C. Heath: Lexington, MA.

Sagala, S. (2006). *Analysis of Flood Physical Vulnerability in Residential Areas*. (Unpublished master dissertation). International Institute for Geo-information Science and Earth Observation, the Netherlands.

Sallenger, A. H., Doran, K. S. & Howd, P. A. (2012). Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Natural Climate Change, 2,* 884–888.

Scottish Environment Protection Agency [SEPA]. (2012). *Land Use Vulnerability Guidance*. Retrieved from http://www.sepa.org.uk/media/143416/land-use-vulnerability-guidance.pdf

Service Nova Scotia and Municipal Relations & Canada-Nova Scotia Infrastructure Secretariat. (2011). *Municipal Climate Change Action Plan Guidebook: Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds*. Retrieved from http://www.fcm.ca/Documents/tools/PCP/municipal_climate_change _action_plan_guidebook_EN.pdf

Service Nova Scotia and Municipal Relations [SNSMR]. (2002). Model Land Use By-law. *Local Government Resource Handbook*. Retrieved from http://novascotia.ca/ dma/pdf/mun-local-government-resource-handbook-5-6.pdf

Service Nova Scotia and Municipal Relations [SNSMR]. (2012). *Climate Change Action Plan Assistant: Learning From Others*. Retrieved from http://novascotia.ca/dma/pdf/mun-municipal-climate-change-action-plan-assistant.pdf

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi Method for Graduate Research. *Journal of Information Technology Education,* 6, 1-21.

Spearman, C. (1904). The proof and measurement of association between two things. *American Journal of Psychology, 15*, 72-101. doi:10.2307/1412159.

Strand, J., Carson, R. T., Navrud, S., Ortiz-Bobea, A., & Vincent, J. R. (2017). Using the Delphi Method to Value Protection of the Amazon Rainforest. *Ecological Economics, 131*, 475-484. doi: 10.1016/j.ecolecon.2016.09.028

Town of Antigonish. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.townofantigonish.ca/doc_download/882-town-of-antigonish-municipal-climate-change-action-plan-2013

Town of Bridgewater. (2014). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.bridgewater.ca/

Town of Mahone Bay. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.townofmahonebay.ca/

Town of Pictou. (2013). *Municipal Climate Change Adaptation Plan*. Retrieved from http://www.townofpictou.ca/assets/PDFs/Town-Hall/20.mccap-dec30.pdf

Town of Truro. (2013). *Municipal Climate Change Adaptation Plan*. Truro: Town of Truro.

Town of Yarmouth. (2013). *Municipal Climate Change Adaptation Plan*. Yarmouth: Town of Yarmouth.

United Nations Development Programme [UNDP]. (2004). *Reducing Disaster Risk: a challenge for development*. New York, United Nations.

United Nations Disaster Relief Organization [UNDRO]. (1991). *Mitigating Natural Disaster: Phenomena, Effects and Options*. New York: United Nations.

United Nations International Strategy of Disaster Reduction [UNISDR]. (2004). *Living with Risk*. United Nations: New York.

United Nations International Strategy for Disaster Reduction [UNISDR]. (2011a). *Global Assessment Report on Disaster Risk Reduction*. Geneva: United Nations.

United Nations International Strategy for Disaster Reduction [UNISDR]. (2011b). *On-line terminology*. Retrieved from http://www.preventionweb.net/english/professional/terminology/

United Nations International Strategy of Disaster Reduction [UNISDR]. (2012). *Reducing Vulnerability and Exposure to Disaster*. Retrieved from http://www.unisdr.org/files/29288_apdr2012finallowres.pdf

Van Leeuwen, C. (2014). *Halifax Harbour's changing vulnerability to storms*. (Unpublished bachelor thesis). Dalhousie University, Canada.

Warburton, A. & MacKenzie-Carey, H. (2013). *Using an EMO-Based Hazard Risk Vulnerability Assessment Process for Municipal Climate Change Action Plan Development*. Halifax: Province of Nova Scotia.

Webster, P. J., Holland, G. J., Curry, J. A., Chang, H. R. (2005). Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. *Science, 309*(5742), 1844-1846. doi: 10.1126/science.1116448

Wright, R. (2006). *A Short History of Progress*. Toronto: House of Anansi Press.

Wu, S., Yarnal, B. & Fisher, A. (2002). Vulnerability of coastal communities to sea-level rise: a case study of Cape May County, New Jersey, USA. *Climate Research, 22*, 255-270. doi: 10.3354/cr022255

Zheng, N., Takara, K., Tachikawa, Y., Kozan, O. (2008). Analysis of Vulnerability to Flood Hazard Based on Land Use and Population Distribution in the Huaihe River Basin, China. *Annuals of Disaster Prevention Research Institute, Kyoto University, 51*(B), 83-91. Retrieved from http://www.dpri.kyoto-u.ac.jp/nenpo/no51/ronbunB/a51b0p08.pdf

Appendix A Online Survey Questionnaire

Land Use Vulnerability and Sea Level Rise

Consent Form for the Survey

A Methodology for Evaluating the Risk of Land to Storm Surges and Sea Level Rise in the Perspective of Land Use Vulnerability in Nova Scotia

Lead researcher: Byung Jun Kang, a graduate student in Master of Planning Studies
School of Planning, Faculty of Architecture &Planning, Dalhousie University. Halifax, NS.
Contact via cellphone at 1 (506) 543-5619 or via e-mail at by946733@dal.ca.
Supervisor: Dr. Eric K. Rapaport, Associate Professor (Supervisor)
School of Planning, Faculty of Architecture &Planning, Dalhousie University. Halifax, NS
Contact via work phone at 1 (902) 494-7801 or via e-mail at eric.rapaport@dal.ca.

Funding: This study is funded by a research grant from Drs. Eric K. Rapaport and Patricia M. Manuel, both professors in the School of Planning, at Dalhousie University.

Introduction

We invite you to take part in a research study being conducted by Byung Jun Kang, a graduate student at Dalhousie University, as part of the Master of Planning Studies program. Choosing whether or not to take part in this research is entirely your choice. The information below tells you about what is involved in the research, what you will be asked to do and about any benefit, risk, inconvenience or discomfort that you might experience.

You should discuss any questions you have about this study with the lead researcher. The contact information is attached above. Please ask as many questions as you like at any time.

Purpose and Outline of the Research Study

The average temperature of the globe has increased since the industrialization. The results of climatic change affect built environment, with the increase in unpredictability of frequency and strength of meteorological disasters, like hurricanes. While the need for disaster prevention rises, insufficient municipal budgets limit such efforts to protect coastal residents. The alternative to increasing the budgets is to improve on the efficiency of resource distribution. Conducting a risk analysis would prioritize preventative actions based on scientific research and logical consensus, rather than from political influences and past experiences only.

The risk of land use is useful in identifying built forms and essential services vulnerable to climate change. Not only will it identify residents exposed to the disasters, but it will also identify essential services that support people's lives in post-disaster environment. Access to food, fuel, and public safety are some of the examples of essential services.

Risk is expected damage over a given period of time. The risk of land use to floods may be expressed as the combination of hazard and vulnerability. Hazard is an annual probability of flood events, while vulnerability refers to loss when the flood actually occurs. There are abundant studies on measuring hazard in atmospheric science literature. While there is an adequate number of studies on social vulnerability and economic vulnerability, the literature rarely mentions land use vulnerability. The existing researches on the land use vulnerability rely on qualitative analyses or quantitative analyses in lesser detail.

The study area for this research is Nova Scotia, Canada. More than 60% of its residents live twenty or less kilometres from the coastline, and a majority of its rural residents depend on a small number of providers of essential services –whether it is a sole gas station or one main road going through a rural town. Classifying land uses may identify properties at higher risk than the others, so a community can prepare a plan to lessen the possible damage from climate change.

The goal of this thesis project is to develop a quantitative risk measure. The measure requires two variables: hazard and vulnerability. Deriving hazard value is straightforward. Hazard can be measured using storm return periods of a study area, which indicates the annual probability of flood in the area. Therefore, developing the other vulnerability quotient would be the next logical step to achieve the goal.

A new rating system for measuring land use vulnerability will allow the quantification of the vulnerability. I will use two methods of data collection to develop the rating of land use vulnerability. The first method is a survey of experts in planning and emergency management in Nova Scotia, and the second method is focus groups with a small sample of the experts. In the survey, each expert will rate the vulnerability of each land use to indicate the relative importance of one land use to others. In the focus groups, participants will go through the same procedure as described in the survey, but they will decide on the ratings through consensus.

The outcome of the survey is a rating of land use vulnerability in the Nova Scotia context. By using these numeric ratings in combination with hazard values, Nova Scotian communities can determine risk.

Who Can Take Part in the Research Study?

You are eligible to participate in this study if you are practicing planning or emergency management in a municipal government in Nova Scotia.

What You Will Be Asked to Do

You will be asked to answer this survey after reading this consent form. The expected time of completion is between 10 and 30 minutes. Once you complete the survey, return the survey by clicking submit button.

Possible Benefits, Risks and Discomforts

Participating in the survey likely has no directly associated benefit. However, the result from this survey may further the ability to more accurately assess the risk for adaptation and emergency planning purposes.

The survey has the settings similar to an office environment, so the risks associated with this study are minimal.

Reimbursement

No reimbursement will be provided for participating in this survey.

Privacy

Participating in the survey will not reveal your identity to other participants.

Anonymity
Your identity is protected from other participants of the survey. We will not collect your name, email address, phone number or the IP address that identifies your computer account if you wish to participate in the survey.
Confidentiality
We will not disclose any information about your participation in the survey to anyone. Instead of your name, a pseudonym of your choice will be assigned to identify an individual questionnaire.
The data you provide will be stored in a password protected computer, which only the research team has access to it. Instead of your name, a unique ID numbers will be assigned to identify an individual survey. In reports or publications, we will never discuss about a single questionnaire –your data will be aggregated with other participant's data. Your contact information will also be unlinked from your questionnaires and stored separately from the raw data in the computer.
Data Retention
Information that you provide to us will be kept private. Only the research team at Dalhousie University, listed in the beginning of consent form, will have access to this information. We will describe and share our findings in the lead researcher's thesis and its associated presentations. We will be very careful to only talk about group results so that no one will be identified. This means that you will not be identified in any way in our reports. You will not record your name on the individual survey so the identification of survey participants is not possible. All electronic records will be kept secure in an encrypted file on the researcher's password-protected computer. After the completion of research, the data will be disposed.
If You Decide to Stop Participating
You are free to stop participating in the survey part of this study before the submission. Not returning this survey will indicate that you do not wish to participate in the survey and the focus group session scheduled in the future. Please note that your name is not recorded in the survey; therefore, the withdrawal of your data may not be possible, unless you provide a pseudonym for your questionnaire.
How to Obtain Results
You may obtain the results to read about the findings of this study. No individual results will be provided. You can obtain the full thesis by contacting the lead researcher –the contact information is included at the beginning of this consent form.
Questions
We are happy to talk with you about any questions or concerns you may have about your participation in this research study. If desired, please contact Byung Jun Kang (506 543-5619 or by946733@dal.ca) or Eric Rapaport (902 494-7801, eric.rapaport@dal.ca). If you are calling long distance, please call collect. We will also tell you if any new information comes up that could affect your decision to participate.
If you have any ethical concerns about your participation in this research, you may also contact Research Ethics Board, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca. The code number is REB # 2016-3804.

Consent

By submitting this survey completed, you agree that you have read the consent form and agree to participate in the survey portion of this study voluntarily.

Questionnaire (Part I) - Information

Q1: Please enter your custom pseudonym (ID or username). Remember your username if you wish to edit your answers on this questionnaire after you click "Finish". Try not to use identifiable information, such as your name, your e-mail, or your place of work. (For exmaple, "Bobby from Halifax" is not a preferable username.)

To edit your answers before clicking "Finish": click "save" at the bottom; an e-mail should be sent to you with a link to edit your answers before submission.
To edit your answers after clicking "Finish": contact the lead researcher (by946733@dal.ca) with your ID and the list of answers that you wish to change. Note that the researcher will ask you three verification questions (your place of work, years of work, and profession).

Q2: Which municipality are you affiliated with? Select all that applies by left-clicking while holding "Control (Ctrl)" or "Command" key.Municipality is a local unit in Nova Scotia that you are currently working in. For example: Halifax Regional Municipality, Town of Shelburne, District of Chester,...

- ☐ Cape Breton Regional Municipality
- ☐ County of Antigonish
- ☐ County of Cumberland
- ☐ County of Kings
- ☐ County of Richmond
- ☐ District of Argyle
- ☐ District of Chester
- ☐ District of Digby
- ☐ District of Guysborough
- ☐ District of Shelburne
- ☐ District of West Hants
- ☐ Halifax Regional Municipality
- ☐ Town of Amherst
- ☐ Town of Antigonish
- ☐ Town of Bridgewater
- ☐ Town of Digby
- ☐ Town of Lockeport
- ☐ Town of Mahone Bay
- ☐ Town of Mulgrave
- ☐ Town of Oxford
- ☐ Town of Pictou
- ☐ Town of Shelburne
- ☐ Town of Stewiacke
- ☐ Town of Truro
- ☐ Town of Windsor
- ☐ Town of Yarmouth
- ☐ County of Annapolis
- ☐ County of Colchester
- ☐ County of Inverness
- ☐ County of Pictou
- ☐ County of Victoria
- ☐ District of Barrington
- ☐ District of Clare
- ☐ District of East Hants
- ☐ District of Lunenburg
- ☐ District of St. Mary's
- ☐ District of Yarmouth
- ☐ Region of Queens Municipality
- ☐ Town of Annapolis Royal
- ☐ Town of Berwick
- ☐ Town of Clark's Harbour
- ☐ Town of Kentville
- ☐ Town of Lunenburg
- ☐ Town of Middleton
- ☐ Town of New Glasgow
- ☐ Town of Parrsboro
- ☐ Town of Port Hawkesbury
- ☐ Town of Stellarton
- ☐ Town of Trenton
- ☐ Town of Westville
- ☐ Town of Wolfville
- ☐ Other Municipalities

Q3: Which department in the municipality are you affiliated with? For larger municipalities, you may additionally enter your Division or Team.This is the name of organization within your municipality that you currently belong. For example: Planning and Development Department, Urban Design Division, Heritage Conservation Team.*Required field

	Name
Department*	
Division	
Team	

Q4: How long have you worked in your profession?This is the number of years that you have been working as a municipal planner, emergency management official, or an employee in a related field. This period includes all of your work experiences related to planning or emergency management. For example: 4 years.

I have worked as a planner/emergency management official for ______ years

Q5: Have you worked in the field of emergency preparedness/management planning?Emergency preparedness/management planning includes, but not limited to: serving in an Emergency Management Organization (EMO) Committee, working as an emergency management official, and participating in drafting municipal emergency plans.

○ Yes ○ No ○ Other - Please specify below

Other - Please specify

Questionnaire (Part II) - General Land Use Category

Rate the land uses assuming they have an EQUAL chance of being flooded!

Q6: In deciding the priority of protection for land uses, which of the following factors do you personally value the most? Please rank the following in the order of priority.(1 = high priority; 4 = low priority)

	Rank
Human life (Households)	○ 1 ○ 2 ○ 3 ○ 4
Local economy & Private services	○ 1 ○ 2 ○ 3 ○ 4
Government, Health, Protection services	○ 1 ○ 2 ○ 3 ○ 4
Infrastructure	○ 1 ○ 2 ○ 3 ○ 4

Q7: General Land Use Categories(You should rate land uses that you find in your community. For example, if you do not have a public transit system in your community, please rate that zero. If your community only has low/medium density housings, those two land uses should receive a rating value, but high density should not. You are rating the land uses based on your local context.)Please distribute 100 points amongst the six (6) general land use categories in their relative vulnerability by indicating the number of points beside each category. You may read the description of each land use by resting your cursor on the name of land use. Vulnerability is a measure of priority in the protection of lands in terms of their susceptibility and resilience to flooding, as well as their impacts to wider community caused by their damage or loss.

Name	Points Assigned	Description
Residential Use		Houses, apartments, condominiums, and rooming houses
Commercial Use		Retail stores and offices
Industrial Use		Factories, harbours, and farms
Public & Private Institutional Use		Educational, private cares, residential institutions (university residences, prisons), and cultural use
Government Use		Government buildings, safety & security, medical, recreational, and environmental use
Infrastructure Use		Roads, rails, parking lots, public transit, electrical/water utilities, dams, waste management

Questionnaire (Part III) - Specific Land Use Category

Q8: Residential Uses(You should rate the land uses that you find in your community. For example, if you only have low density housing and medium density, those two land uses should each receive a rating value and high density should not.)Please distribute 100 points amongst the specific land use categories under this general category in their relative vulnerability. You may read the description of each land use by resting your cursor on the name of land use. Vulnerability is a measure of priority in the protection of lands in terms of their susceptibility and resilience to flooding, as well as their impacts to wider community caused by their damage or loss.

Name	Points Assigned	Description
Low Density		Detached houses
Medium Density		2-4 story residential buildings. i.e. Semi-detached, duplex houses, and townhouses
High Density		Residential buildings with 5 or more stories. i.e. Apartment and condominiums
Boarding & Rooming Houses		Boarding & Rooming Houses

Q9: Commercial Uses

Personal Services		Barber shops, hairdressers, beauty parlours, dry cleaning distribution stations, laundromats, florist shops, health clubs, funeral services...
Food Stores		Convenience stores, Grocery stores, & Supermarkets
Food Retail Services		Restaurants, Bakeries, Fast food joints, & Drinking establishments
Service Stations		Gas stations & Repair shops
Accomodations		Hotels, Inns, Hostels
Entertainment Services		Bowling alleys, Movie theatres, Night clubs, Amusement centres
Repair Shops		Plumbing, Electrical, & Electronic
Wholesale & Distribution Businesses		Costco, Beverage, & Food Warehousing
Office Building		Professional services, Law firms, Banks

Q10: Industrial Uses(Reminder: You should rate the land uses that you find in your community. For example, if there are no docks and wharves in your community, it should not receive a rating value.)Please distribute 100 points amongst the specific land use categories under this general category in their relative vulnerability. You may read the description of each land use by resting your cursor on the name of land use.

Name	Points Assigned	Description
Agricultural		Farms, Pastures, Orchards, Stables...
Industrial		Factories, Manufacturing plants...
Marine Industrial		Cargo storages, Sea product processing, and Shipbuliding
Docks & Wharves		Docks and Wharves

Q11: Private and Public Institutional Uses(Reminder: You should rate the land uses that you find in your community. For example, if there are no university residences or prisons in your community, they should not receive rating values.)Please distribute 100 points amongst the specific land use categories under this general category in their relative vulnerability. You may read the description of each land use by resting your cursor on the name of land use.

Name	Points Assigned	Description
Education, Type I		Primary school, Secondary school, Universities, and Research facilities
Education, Type II		Libraries and Museums
Private Care Facilities		Daycares, Senior homes, and Special care facilities
Residential Institutions		University residences and Prisons
Religious Centres		Churches, Monasteries, Mosques, and Temples
Historic Sites & Monuments		Heritage buildings, monuments, historic towers/lighthouses...
Civic Halls & Community Facilities		Legion halls, Rotary clubs, NGO's offices, and Community centres

Q12: Government Uses(Reminder: You should rate the land uses that you find in your community. For example, if there are no military land uses in your community, it should not receive a rating value.)Please distribute 100 points amongst the specific land use categories under this general category in their relative vulnerability. You may read the description of each land use by resting your cursor on the name of land use.

Name	Points Assigned	Description
Administration		Government offices, Postal offices, and Law Courts
Military		Military bases and armouries
Safety & Security		Police stations, Fire stations, EMO headquarters
Medical, Type I		Hospitals & EMS stations
Medical, Type II		Clinics, Pharmacies, Dentists, Optometrists, Private doctor's offices, and other Medical offices
Recreational, Type I		Arenas, Stadium, and Sports Halls
Recreational, Type II		Parks, Playgrounds, Recreation fields, Trails, Cemeteries, and Golf Courses
Environmental Conservation Areas		Protected wetlands, forest, watercourses

Q13: Infrastructure Uses(Reminder: You should rate the land uses that you find in your community. For example, if there are no public transit system in your community, it should not receive a rating value.)Please distribute 100 points amongst the specific land use categories under this general category in their relative vulnerability. You may read the description of each land use by resting your cursor on the name of land use.

Name	Points Assigned	Description
Major Roads		Highways and Arterial roads
Minor Roads		Collector and Local roads
Parking Spaces		Underground parking facilities, ground-level parking lots, and Indoor parking garages
Public Transit		Transit terminals and Transit fleet storage facilities
Railroads		Railyards and Railroads
Electricity		Power lines, Utility poles, and Power generating stations
Water Utilities		Water/Sewer/Stormwater pipes, Pumps, Lifting stations, and Water treatment plants
Coastal & Riparian Protection		Dykes and dams
Waste Management Facilities		Landfills and recycling centres

Questionnaire (Part IV) - Conclusion

Q14: After filling out the questionnaire, I would like to provide you an opportunity to express any assumption you have when assigning rates to the land uses. Please describe any thoughts you had that influenced your rating of the land uses.

Q15: Is there any additional information you would like to express to the researcher about the survey or ideas you have regarding land use vulnerability?.

Appendix B Consent Form for the Focus Group

Signature Page

Project Title: A Methodology for Evaluating the Risk of Buildings to Storm Surges and Sea Level Rise in the Perspective of Land Use Vulnerability in Nova Scotia

Lead researcher: Byung Jun Kang, a graduate student in Master of Planning Studies School of Planning, Faculty of Architecture & Planning, Dalhousie University. Halifax, NS.
Contact via cellphone at 1 (506) 543-5619 or via e-mail at by946733@dal.ca.

Signature

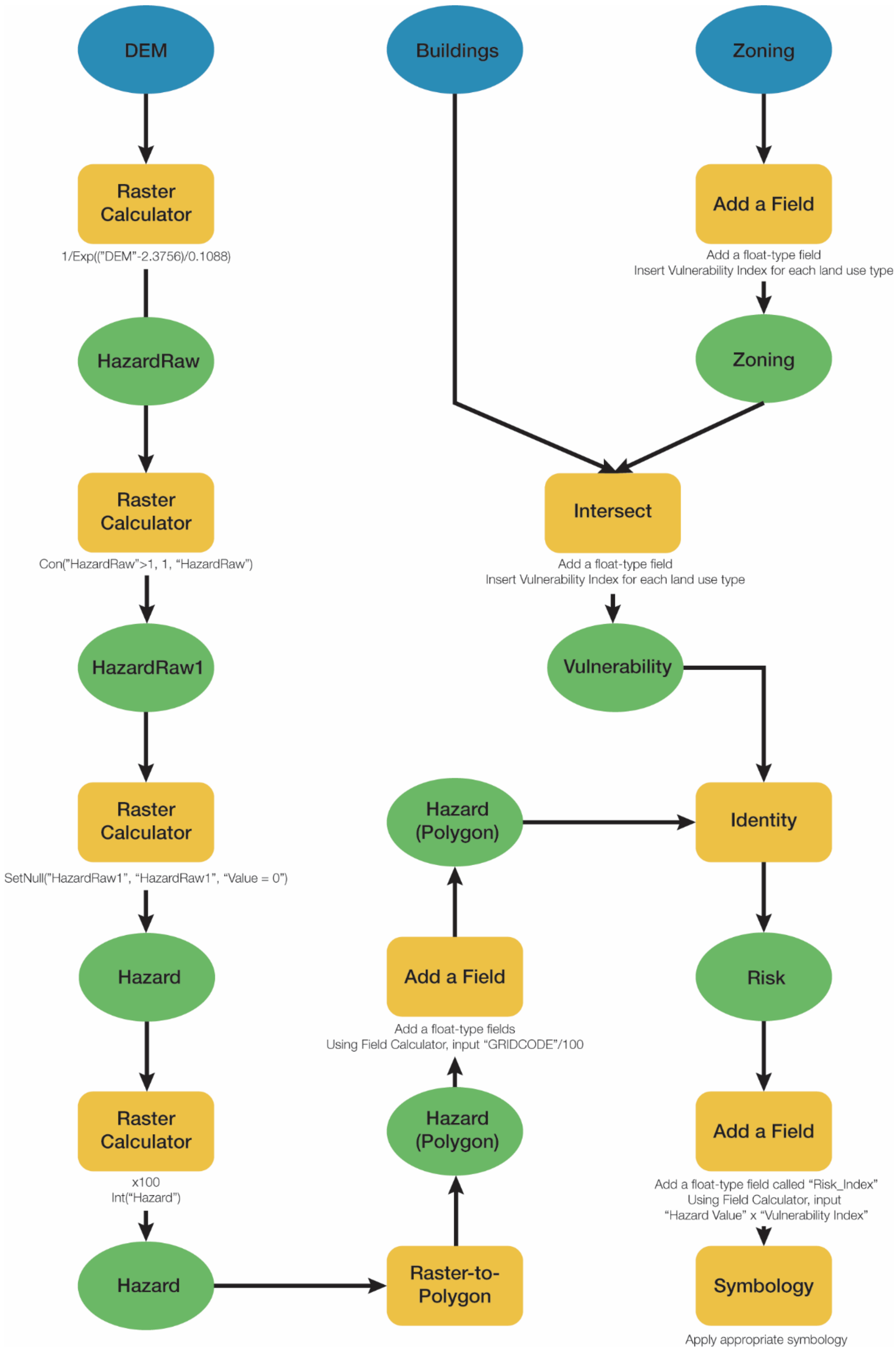
Signature is only required for those who wish to participate in the focus group. Returning this survey without your signature indicates that you do not wish to participate in the focus group session, but still consent to use your data for the study.

Consent

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand that I have been asked to take part in one focus group session that will occur at a location acceptable to me, and that those interviews will be audio-recorded. I understand direct quotes of things I say may be used without identifying me. I agree to take part in this study and authorize the lead researcher to contact me again for scheduling the exact time and date for the focus group. I understand that my participation is voluntary and that I am free to withdraw from the study at any time.

______________________________	______________________________
Name	Signature
______________________________	______________________________
Contact information (e-mail address preferred)	Date

Appendix C GIS Visualization



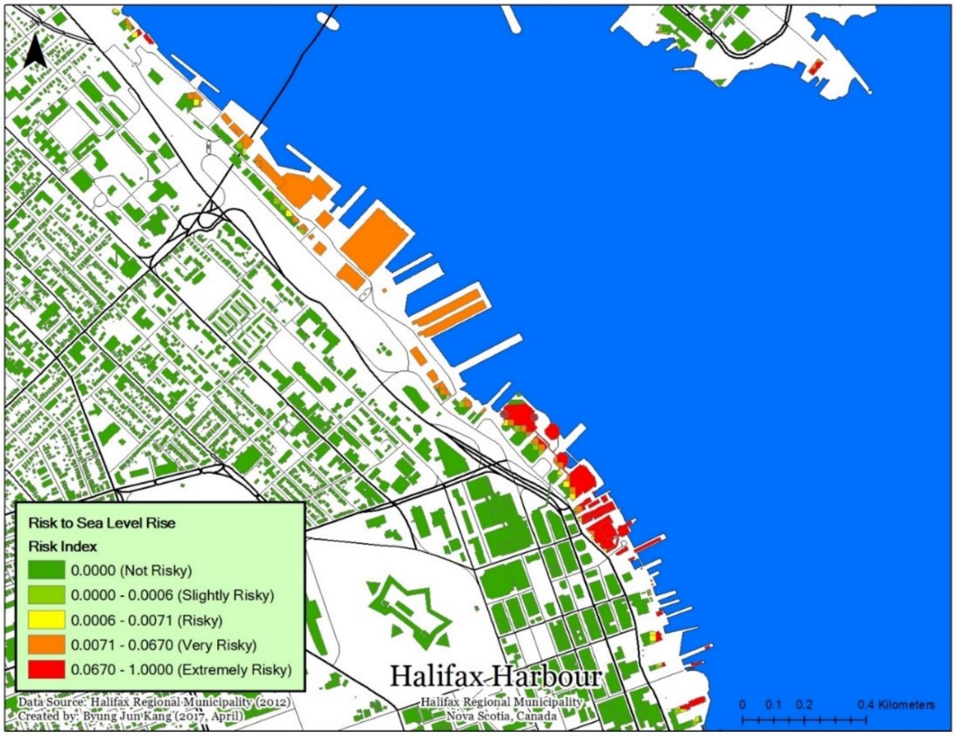


Figure 1: A map of buildings in eastern Halifax Peninsula with their risk index displayed in various hues.

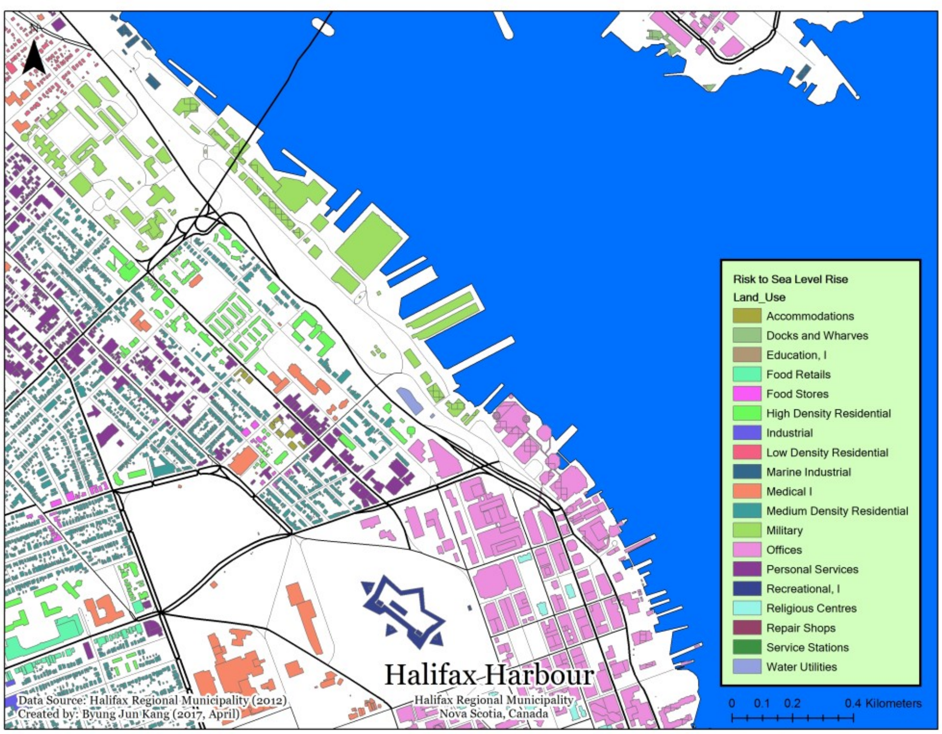


Figure 2: A map of buildings in eastern Halifax Peninsula with their land uses displayed in various hues.