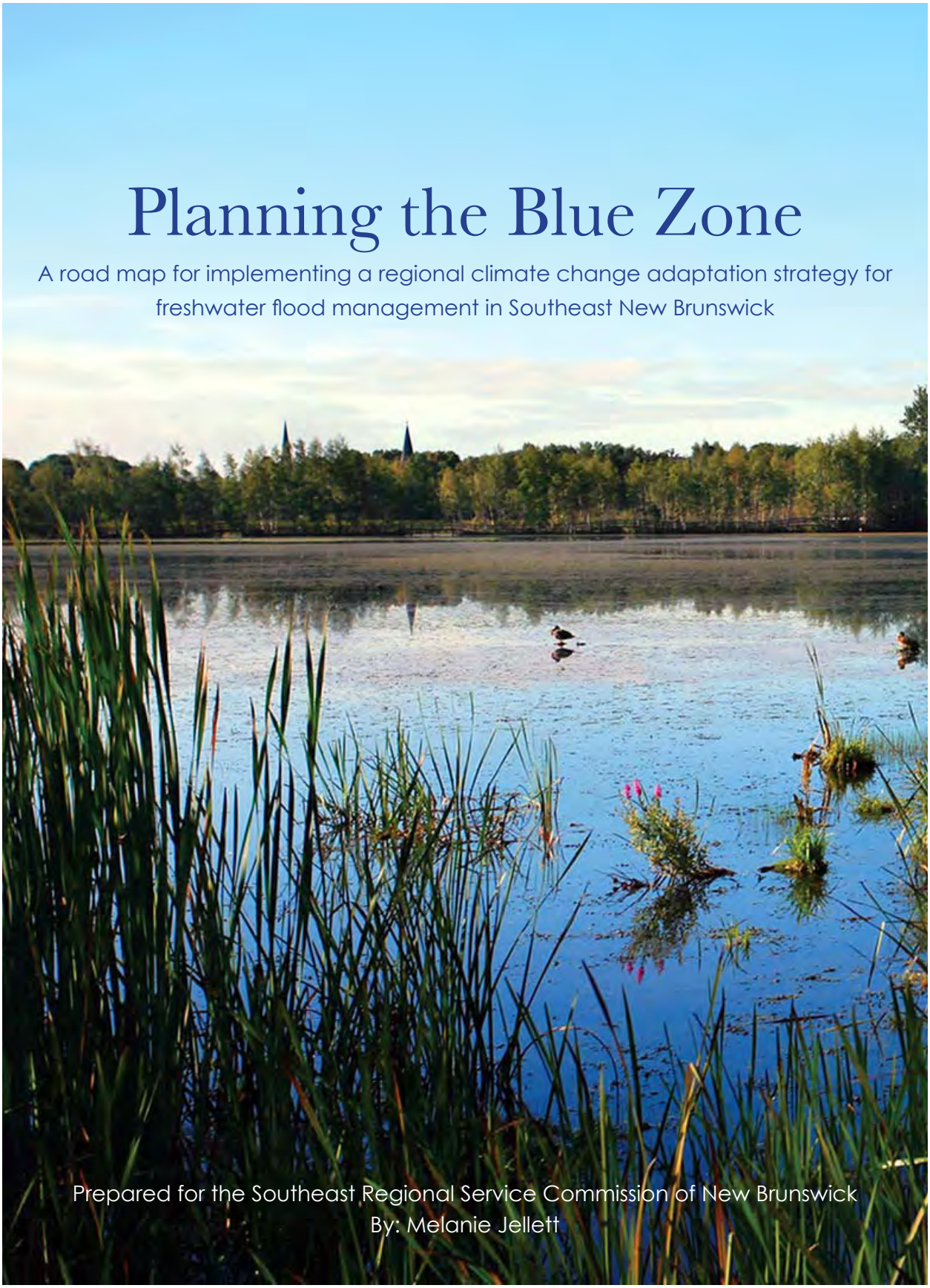
Planning the Blue Zone

A road map for implementing a regional climate change adaptation strategy for freshwater flood management in Southeast New Brunswick



Prepared for the Southeast Regional Service Commission of New Brunswick
By: Melanie Jellett

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2017

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New Nouveau Brunswick

Your Environmental Trust Fund at Work

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DISCLAIMER

This report has been written for the purposes of providing an overview and recommendations to the Southeast Regional Service Commission on how freshwater ecosystem services can be incorporated into regional land-use planning. The content of this study is the responsibility of its author and does not necessarily reflect the SERSC's views or the views and opinions of those acknowledged above. Every effort has been taken to ensure the accuracy of the information contained in this study.

FOREWORD

There is growing evidence of the economic and social benefits derived from integrating the services provided by nature into planning and decision-making. The purpose of this report is to provide the Southeast Regional Service Commission (SERSC) of New Brunswick with an overview of ecosystem services, particularly those services related to freshwater flood risk and climate change. The report will also seek to identify key players and approaches that demonstrate how ecosystem services, both in theory and in practice, are evolving and can be incorporated into land-use planning.

The ecosystem service concept is an emerging global topic that is engaging businesses, investors, policymakers, non-profits, planners, academic institutions, and government. Despite the attention that research on ecosystem services has attracted in recent years, its use in real-life decision-making processes is still very limited, especially at the planning regulatory level.[1] This report will provide a platform from which the SERSC can discuss and evaluate how to best incorporate natural assets that relate to climate change adaptation into the regional planning process in southeastern New Brunswick.

[1] Geneletti, 2012.

PART 1 INTRODUCTION

1.1 ECOSYSTEM SERVICES AND HOW THEY RELATE TO FRESHWATER FLOODING AND PLANNING

Canada has long-established patterns of land use and development. In New Brunswick, the majority of the population has settled along the coast or along the region's rivers. These coastlines and the adjacent wetlands are within the impact zone of climate change.[2] As a result, these communities are becoming increasingly vulnerable. More frequent and powerful storms with stronger winds and increased periods of rapid precipitation are challenging the safety of inland and coastal communities.[3]

Flood events are among the most serious natural hazards in Canada.[4] New Brunswick has approximately 60,000 km of streams and rivers. Roughly 2,500 lakes and ponds are bounded by thousands of kilometres of ocean coast[5], making the province particularly vulnerable to major freshwater flood events. According to Environment Canada, these flood events are largely triggered by heavy rainfall events (43%), but also as a result of high tide/storm surge (8%), ice jams (7%), snowmelts (7%) or a combination of these (35%)[6]. As a result, flooding can cause major damage to development, lead to infrastructure failure and create areas that are impassable during storm events.

[2] Manuel et al., 2016.

[3] Manuel et al., 2016.

[4] Province of New Brunswick, 2014.

[5] Province of New Brunswick, 2014.

[6] Environment Canada, 2012.

The financial cost associated with flood damages can be substantial to both buildings and infrastructure. Non-market goods like traffic patterns, sentimental items, and emotional and psychological health as well as stress levels can also be adversely impacted by flood events. A recent study assessing both the market and non-market costs in Fredericton looked at the annual average cost of flooding in the city under various climate scenarios and found that under a best-case scenario, flood damage resulted in a combined annual cost of $958,600.[7] This study and other related research clearly highlights that in both economic and social terms, flood damage is costly to local communities.

Intensifying human impact on ecosystems worldwide—and on the supply of services they provide—have highlighted the need to create more sustainable interactions with the environment.[8] The term "ecosystem services" emerged in the early 1980s to describe a framework for understanding human interaction with local ecosystems and the benefits those ecosystems provide to human well-being.[9]

In 2005, the Millennium Ecosystem Assessment (MA) produced a landmark report that found that the rapid advancements in human well being had taken a severe toll on the planet's natural ecosystems by causing "a substantial and largely irreversible loss in the diversity of life on Earth".[10] The assessment presented powerful evidence that human actions were leading to declines in the majority of ecosystems services.[11]

For many, the MA was a wake-up call. The assessment made a clear connection about the importance of natural ecosystems to human well being, and the role ecosystem services play in disaster risk reduction has since become widely acknowledged. Concerns related to how ecosystems will respond to climate change have led to greater efforts to understand ecosystem capacity and resilience

[7] Lantz et al., 2012.

[8] Balmford & Bond, 2005.

[9] Mooney & Ehrlich, 1997.

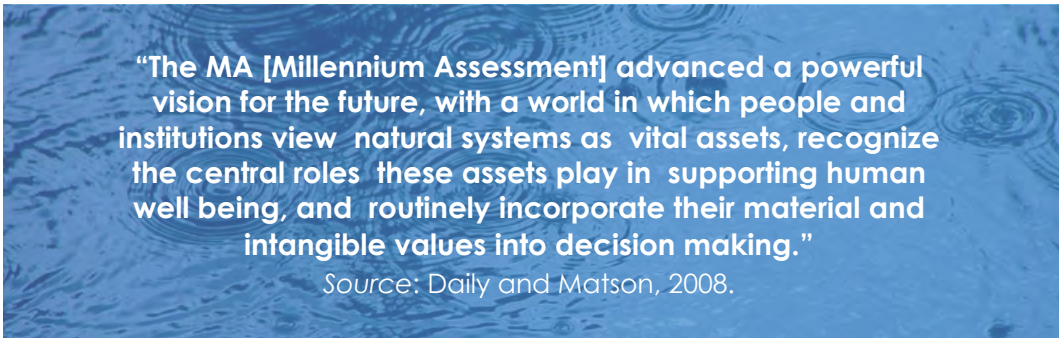
[10] Millennium Assessment, 2005.

[11] Guerry et al., 2015.

at local to global scales.[12] When resilient and properly managed, ecosystems can play a crucial role in mitigating and adapting to the effects of climate change that face the region in the future.[13]

> When healthy and properly managed, ecosystems can play a crucial role in mitigating and adapting to the effects of climate change that our regions will face in the future.
> *Source*: Shrubsole, 2000

Related to the ecosystem service concept, the concept of natural capital has emerged as a strategy to compare and value ecosystem service delivery with the traditional municipal service delivery. This concept is becoming of greater importance as country's built infrastructure is beginning to deteriorate. Infrastructure built in the 1950s, '60s and '70s, at a time when the Federal Government invested heavily in the country's infrastructure (storm, sewage and water pipes, roads etc.), is in need of repair. Federal investment during this period attempted to control flooding through infrastructure, which led to a false sense of security in areas "protected" by this infrastructure, which is now highly degraded.[14]



Since the 1970's, decades of underinvestment, particularly in the '80s and '90s, has led to chronic depreciation of built infrastructure–ultimately leading to service failures and directly impacting the quality of life of residents who have for some time depended on constructions.[15] Moreover, the design of this infrastructure was

[12] Berkes, 2000.; Folke C, et al.; 2002., Biggs R, et al. 2012, and Guerry et al. 2015.

[13] Shrubsole, 2000.

[14] Shrubsole, 2000.

[15] Mackenzie, 2013

based on historical climates (precipitation, sea levels etc.) and is generally not sufficient to meet the current and future threats imposed by climate change.

Communities in flood prone areas are increasingly feeling the impact from decades of insufficient infrastructure investment. Between 2000 and 2014 the cost associated with flooding in New Brunswick totalled $137 million, making flood-risk a heavy burden for the provinces relatively small tax base.[16] Municipalities across Canada are becoming aware of the need to change the way infrastructure is built and managed, to ensure future economic sustainability. Some municipalities in Canada and abroad have begun to consider ecosystem services in providing or complementing engineered municipal services. Through engineering studies of natural assets, ecosystem services are being presented as effective alternatives to engineered infrastructure in providing municipal services and can do so at a lower long-term cost. In addition, ecosystems have the benefit of being inherently resilient to changing climate, are carbon neutral and have a multitude of other positive externalities.

Land use planning is well-suited to meet the long term challenges imposed by climate change and flood risk in New Brunswick by utilising improved land-use strategies.[17] As one example: low impact development, natural infrastructure, and effective land-use regulations can all help protect and preserve the functionality of floodplains which have a mitigating effect during flood events.

[16] Shrubsole, 2000

[17] Manuel et al., 2016

FIGURE 1: APPROACHES TO FLOODING AND INFRASTRUCTURE IN CANADA

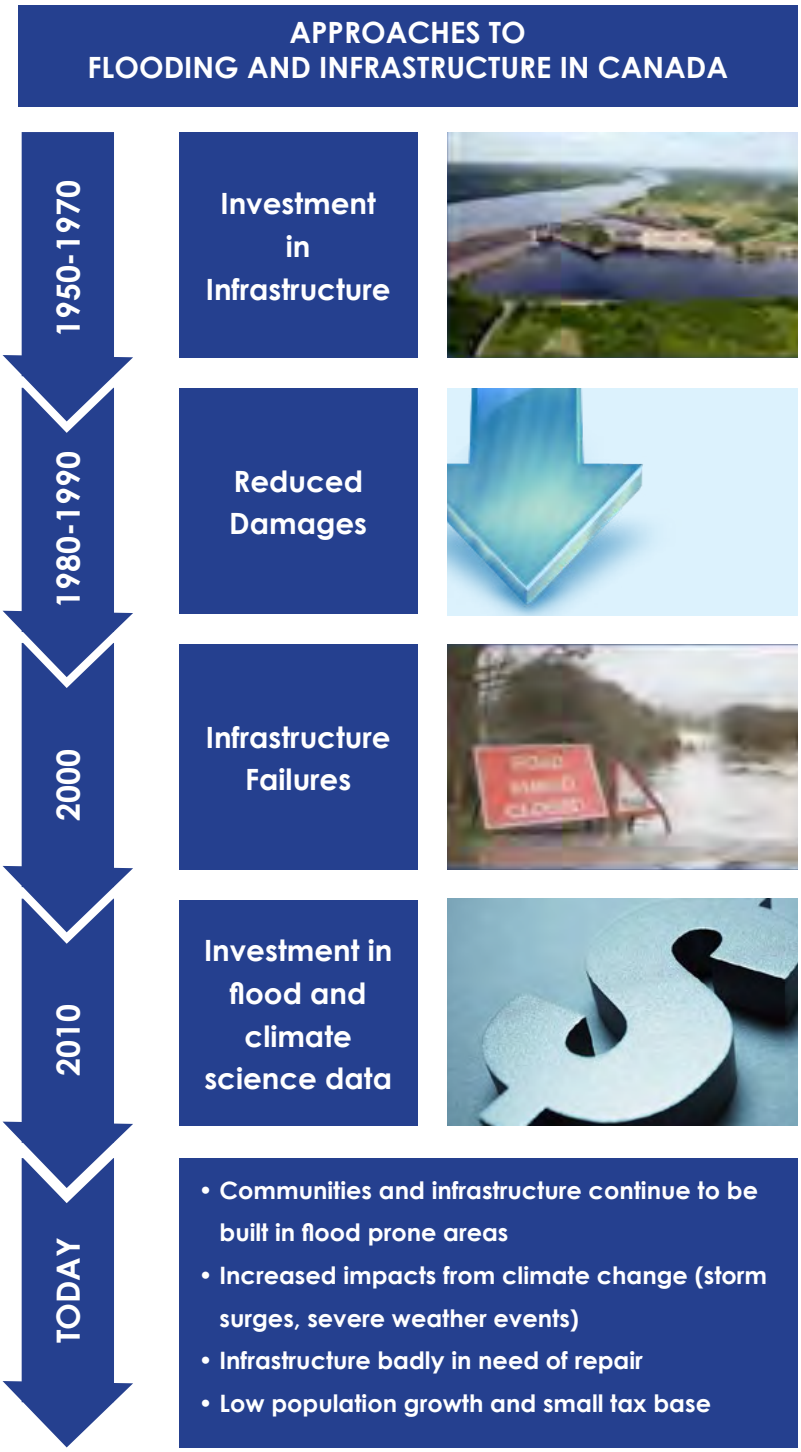


PHOTO CREDITS: (1) ÉNERGIE NB POWER (2) THE CANADIAN PRESS

While the conservation of areas that provide ecosystem services is one important strategy, the use of natural asset frameworks in land use planning is ultimately about permitting development in ways that also allow for healthy ecosystem function. For example, development that takes into account and respects wetlands services that reduce flood risk by slowing down runoff and reducing peak flows ultimately decreases a community's vulnerability to flood events. The high social and physical cost associated with flood damages makes investment in natural assets a cost effective alternative to those associated with improving and maintaining infrastructure to meet the needs of New Brunswick's population.

"The use of the ecosystem services concept has expanded rapidly in recent years. Ecosystem services are described as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life."
Source: Daily, 1997.

The Southeast Regional Service Commission has a unique opportunity to utilise the upcoming regional plan as a tool to address climate change planning on a regional scale as opposed to through individual municipal plans. There are a variety of emerging ecosystem service frameworks, and significant examples of how to best incorporate them into asset management and land-use planning practices.

> "When healthy and properly managed, ecosystems can play a crucial role in mitigating and adapting to the effects of climate change that our regions will face in the future."
> *Source*: Shrubsole, 2000

Section 1.2 of the report provides a review the evolution of the ecosystem service concept. Following an overview of the history of ecosystem services, a description of the study area is provided. In Section 2, case studies are introduced that exemplify the current state of ecosystem service frameworks as they relate to policy and valuation in land-use planning and freshwater flood-risk management. In Part 3, sample policies are proposed to show how the concepts introduced in the report might be introduced into a regional plan.

The intent of this report is to serve as a 'road map' for the Southeast Regional Service Commission to integrate natural assets, especially pertaining to freshwater

management and climate change adaptation, into planning and decision making processes in southeastern New Brunswick. This type of comprehensive approach is critical to sustaining the long-term resilience of the regions communities.

1.2 HOW HAS THE ECOSYSTEM SERVICES CONCEPT EVOLVED?

Ecosystem services are the benefits people obtain from ecosystems.[18] Every day, ecosystems supply services that support the well-being of human populations and communities. These "ecosystem services" (also termed ecological or natural assets, eco-assets, green infrastructure, and natural capital) provide us with food, clean drinking water and clean air, the disposal and decomposition of waste, control of nutrient cycles, pollination, protection against floods, waves, high winds, and other natural hazards, and much more.

Provided 'for free' ecosystem services are not generally included in most markets or economic structures and over the years ecosystem services in most regions have been considerably degraded as a result. Ironically, intensifying human impacts on ecosystems worldwide and growing realization of the supply of services they provide is driving the movement to understand and value nature's capital.[19]

The introduction of the ecosystem services concept to mainstream literature is generally attributed to the ground-breaking article authored by Costanza et al. (1997) in the journal of Nature. Since then, the United Nations Environmental Program's Millennium Ecosystem Assessment (MA) was launched in 2005 and delivered a published report which made clear and profound connections between human welfare and ecosystem function. The MA was the first international examination of the world's natural ecosystems and concluded that approximately 60% (15 of 24) ecosystem services on earth are being degraded or used unsustainably, and that this degradation has contributed to an important rise in the frequency of natural hazards (including flooding) on all continents.[20]

[18] Millennium Assessment, 2005

[19] Daily, 1997; de Groot et al., 2002; Gomez-Baggathun, 2009

[20] Millennium Assessment, 2005

The MA presented a powerful vision of the future; a world where people and institutions view natural systems as vital assets. It recognized the central roles these assets play in supporting human well being, and routinely incorporate their material and intangible values into decision making.[21] The MA contributed greatly to integrating ecosystem services into policy agendas, and since its release, literature relating to ecosystem services has grown considerably.[22]

Despite the increased focus on ecosystem service research in recent years, tools to support decision-making processes are still limited.[23] There are examples where local governments have addressed ecosystem services in official community plans, however, the intent to protect and/or utilize ecosystem services are often addressed as policy, there are few examples where integration efforts are included as enforceable by laws.[24] In planning contexts a policy is a document that outlines the objective or intent of the municipal government. A bylaw, on the other hand, is a system of rules passed by the government intended to aid in realizing the municipal policy statements. For this reason by law is often regarded as the 'teeth' of policy statements, though both are equally critical to municipal operations.

ECOSYSTEM SERVICES INCLUDE:

- **Purification of air and water**
- **Mitigation of droughts and floods**
- **Generation and preservation of soils and renewal of their fertility**
- **Detoxification and decomposition of wastes**
- **Pollination of crops an natural vegetation**
- **Dispersal of seeds**
- **Cycling and movement of nutrients**
- **Control of the vast majority of potential agricultural pests**
- **Maintenance of biodiversity**
- **Protection of coastal shores from erosion by waves**
- **Protection from harmful ultraviolet radiation**
- **Partial stabilization of climate**
- **Moderation of weather extremes and their impact**
- **Provision of aesthetic beauty and intellectual stimulation that lifts the human spirit**

[21] Daily and Matson, 2008.

[22] Gomez-Baggathun, 2009. Fisher et al., 2009.

[23] Geneletti, 2012.

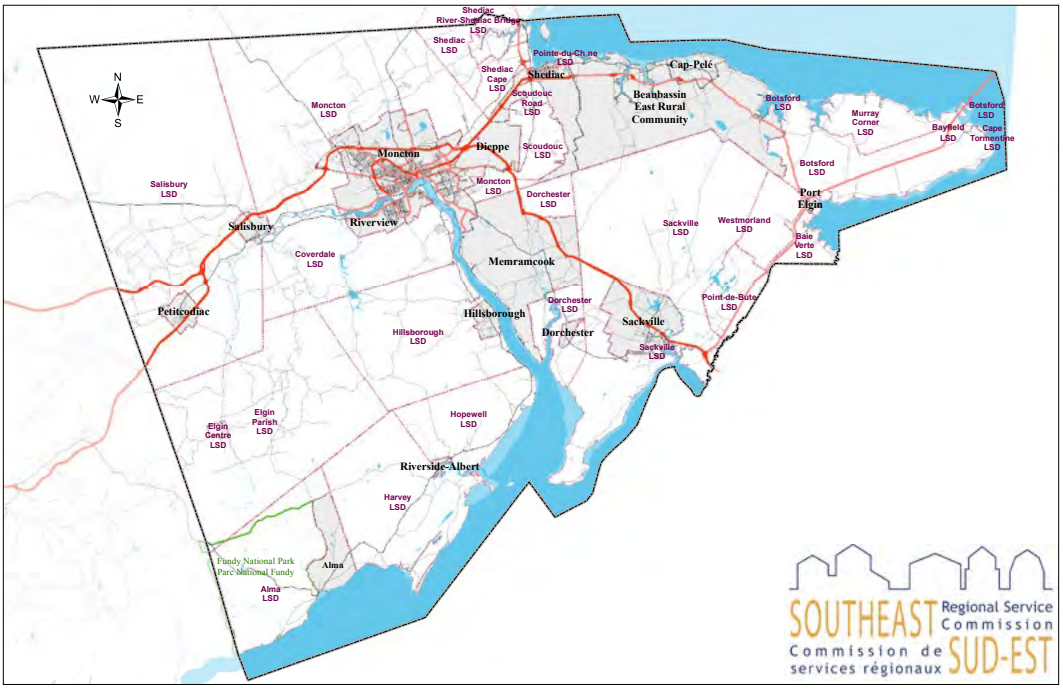
[24] Jack et al., 2008. Geneletti, 2012.

The application of ecosystem services beyond policy documents entails the valuation of services of interest so their state can be monitered on an ongoing basis, and supported if need be. Regulations like bylaws benefit from having quantitative values to uphold. Integrating ecosystem services into regulation requires relating science, spatial mapping, and policy objectives with appropriate regulatory mechanisms.[25]

1.3 OVERVIEW OF THE STUDY AREA

The Southeast Regional Service Commission (SERSC) provides planning services to the southeast corner of New Brunswick. The latest report from the Intergovernmental Panel on Climate Change (IPCC) cautions that an increase in the intensity and variability of precipitation is projected to intensify the risks of flooding to this area and globally. In addition, sea level rise for regions along the Northeast Atlantic is projected to be greater than the global average.[26] Much of the Southeast region

FIGURE 2 : MAP OF STUDY AREA



[25] Daily and Matson, 2008.

[26] NOAA, 2017.

has populations concentrated along the coasts and rivers. Changing weather patterns associated with climate change are expected to lend to increased wind intensity, water levels, and storm surge as storms increase in frequency and intensity. These considerations, in combination with some of the world's largest tidal cycles in the Bay of Fundy are likely to make the territories and populations the SERSC serves some of the most impacted by climate change in Canada.

The region is one of the fastest growing in Atlantic Canada, with increasing commercial, industrial and residential development in and around the urban centres of Moncton, Dieppe, Riverview and Shediac – creating further infrastructure susceptible to flooding. In the map of the region (Figure 2) grey shading represents the incorporated areas in Southeast New Brunswick, and the white areas represent the rural Local Service Districts (LSDs).

"Evidence indicates that the better approaches to climate change are to integrate, share information between all facets of government, the scientific community, and private sector; they engage the public to educate, allow consideration of communal values, and encourage acceptance of climate change regulations; and they are holistic, incorporating sustainable measures and adopting a `big picture` view of societal values, existing land uses and activities, environmental constraints, as well as valuable scientific forecasts. "

Source: Michelle Doherty, Cost Benefit Analysis – Climate Change Adaptation, 2012.

1.4 WHAT REGULATIONS ADDRESS FLOOD-RISK IN THE STUDY AREA?

The southeast region of New Brunswick was among the first regions in Canada to address sea-level rise through official community plans and by-laws. Beginning with Beaubassin-Est, the SERSC has adopted or are in the process of adopting by-laws generally requiring new construction in sea-level-rise 'flood zones' to be suited for a 1 in 100 year flood event over the life-span of the structure.

The Sea Level Rise (SLR) By-Law is a good example of a local government proactively incorporating climate change adaptation into planning regulation and it has been designed in such a way so that could be easily adapted to other areas.[27]

While the province has an existing strategy in place to address in land and coastal flood risk, current mechanisms are insufficient in regulating new development in flood risk zones and are in need of updating. For instance, the province's *Clean Water Act* sets a thirty metre buffer against development from watercourses and wetlands[28] but offers a *Watercourse and Wetland Alteration (WAWA) Permit* which allows for variances on this distance. Applications for WAWAs are rarely turned down at this time. In addition, these buffers are inadequate for watercourse protection or flood mitigation where floodplains extend beyond thirty metres horizontally.

In 2011, the NB Department of Environment and Local Government proposed a modification to the wetlands conservation policy and related mapping. The proposed mapping designated 18% of the province's territory as wetland, up from 4%. In Moncton, 40% of the city-owned land would have been considered wetland or potential wetland.[29] During public consultation, the new mapping was deemed too restrictive as well as inaccurate and the proposed changes were overturned.

Wetlands provide an abundance of services, including storm water storage and filtration. The overturning of the changes proposed in 2011 represented a lost opportunity to benefit from these services by protecting a greater portion of the provinces wetlands. On the other hand, this incident is one that can be learned from. Development does not have to be pitted against conservation efforts. In fact, development can work best and be less costly in the long-term, when it incorporates the natural landscape through processes such as conservation design.

[27] Doherty, 2012.

[28] Clean Water Act, SNB 1989.

[29] CBC News, 2012

It is evident that there is a need to establish a strategic direction whereby it refocuses the ad hoc style of development and more effectively manages freshwater resources in relation to the built environment. This, as previously suggested, requires a comprehensive regional approach which leverages local data and resources to permit development and manage against flood events while simultaneously protecting the region's valuable ecosystem services a level higher than a local government is otherwise able to achieve. Figure 4 illustrates to how natural infrastructure can serve in the place of traditional engineered infrastructure. Figure 4 (a) shows natural functions of a healthy water cycle at a watershed scale, while Figure 4 (b) shows the service provided by the associated function.

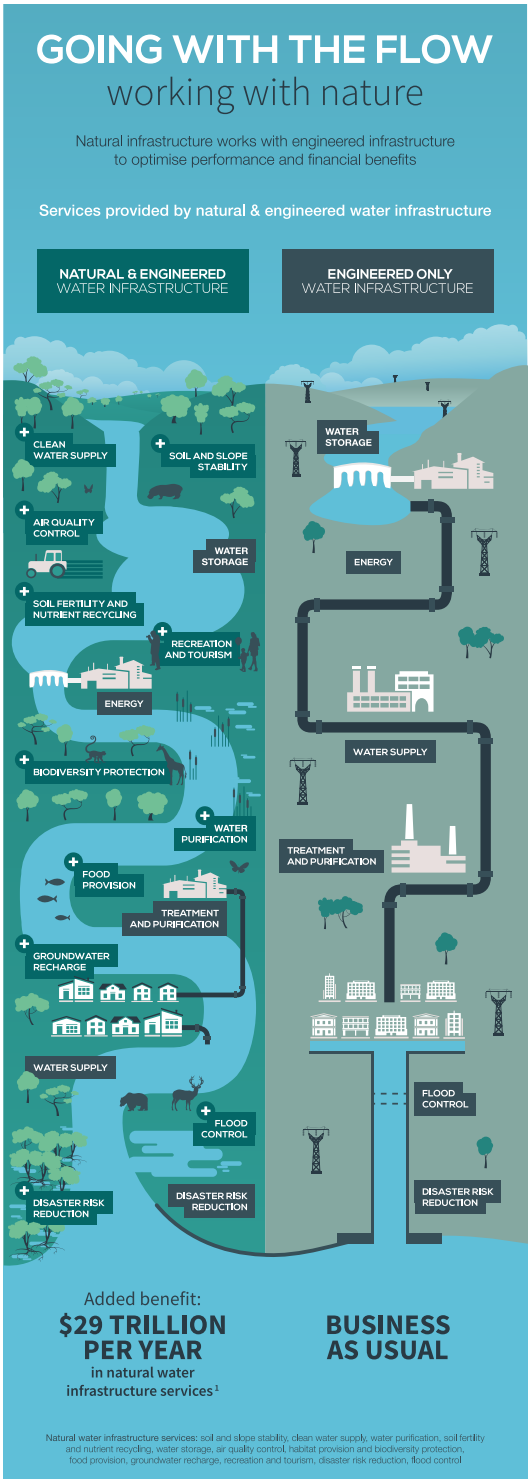
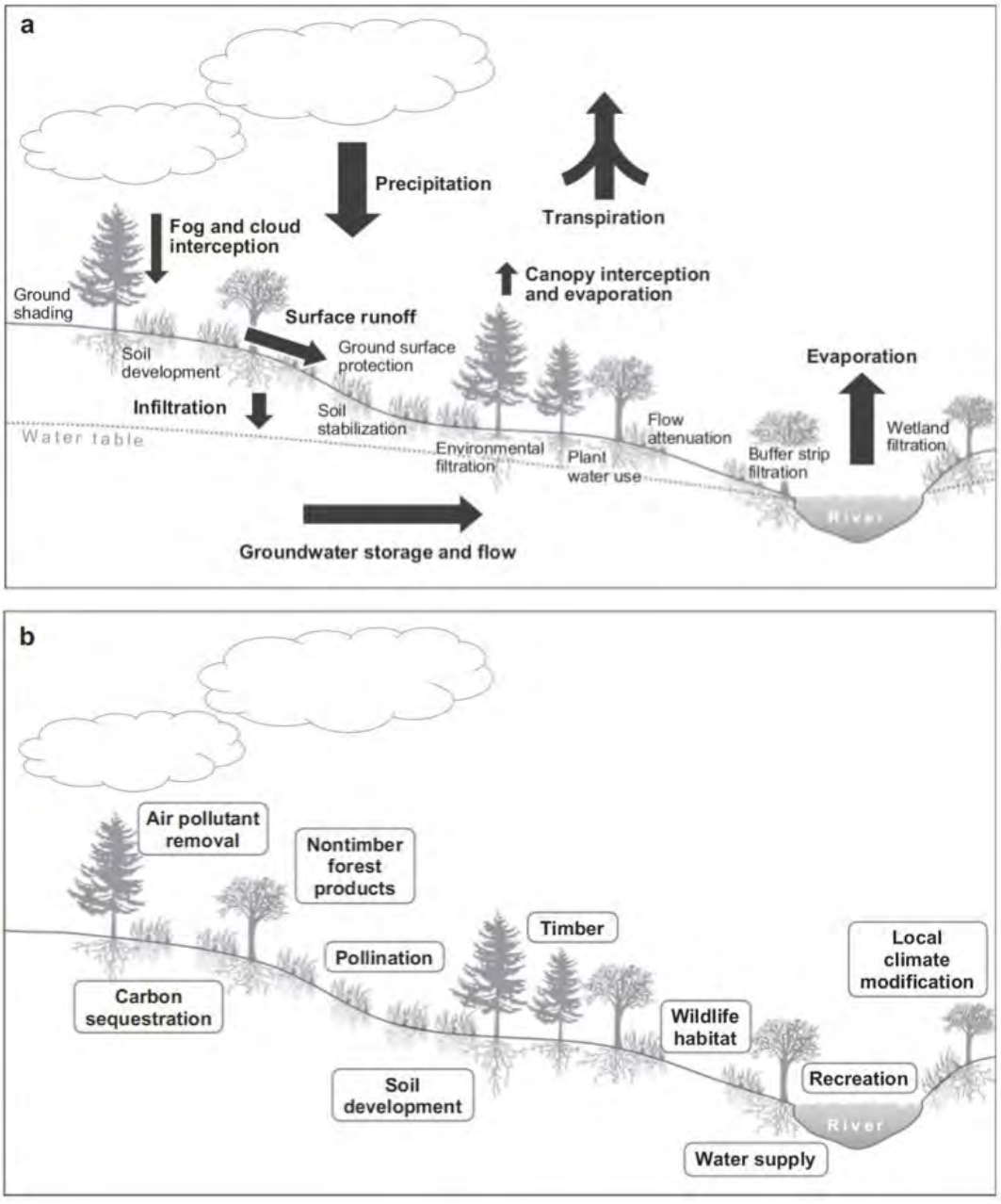


FIGURE 3 : GOING WITH THE FLOW WORKING WITH NATURE

Source: IUCN Water Programme

FIGURE 4 : WATER CYCLE-ECOSYSTEM INTERACTION ILLUSTRATION



(a) At the watershed scale, ecosystems affect water through local climate interactions, water use by vegetation, ground surface modification, and water quality modification. The hydrologic cycle is driven by energy from the sun.

Water vapor evaporated from oceans or surface water bodies' forms clouds and falls as rain, fog, or snow onto Earth's land and oceans. On land, water infiltrates into groundwater or flows over the surface. Both ground and surface water is eventually either discharged into the ocean, is transpired by plants, or evaporates back into the atmosphere where the cycle starts anew.

(b) In addition to hydrologic services, a watershed produces a variety of other services; examples of these are shown in the figure.

Source: Brauman, 2007

1.5 OVERVIEW OF THE PROJECT

The purpose of the report is to provide the Southeast Regional Service Commission of New Brunswick with the knowledge base necessary to move forward with the integration of hydrologic ecosystem services into regional planning and decision making. It is within the best interest of the region to adopt a regional climate change adaptation strategy that will encourage development away from flood hazard areas and establish methods to value ecosystem services that mitigate flood effects.

> "Place-based solutions, local authorities have a pivotal role in advancing comprehensive climate change adaptation."
>
> *Source*: Christine Wamsler et al., 2016

Around the world, there has been an increase in policy related to the field of ecosystem science. In October of 2015, the United States Executive Office of the President issued a memorandum for executive departments and directing agencies to begin developing and institutionalizing policies to promote consideration of ecosystem services.[30] In Europe, Sweden is a forerunner and pioneer in both environmental and climate-change planning.[31] Ecosystem-based approaches have been promoted by the Swedish government since 2007. In the UK, the City

[30] Dickinson, Male, & Zaidi, 2015.

[31] Wamsler et al., 2016.

of Birmingham City Council recently adopted a Green Living Spaces Plan, which is the mechanism through which the City can adopt a comprehensive approach to natural capital in all aspects of future development.[32] Vietnam, Brazil, Costa Rica, Columbia and Peru are creating payment for ecosystem services (PES) programmes at municipal and state levels.[33] In China, central and local governments have rapidly expanded their range of policy and program innovations, many under the broad heading of "eco-compensation," which have laid the groundwork for the development of ecosystem services markets.[34] Canada is becoming an emerging leader in natural capital with the recent establishment of a national cohort of economists, accountants, statisticians, ecologists, NGOs, government and business leaders collaborating on pilot projects to establish natural capital accounting in the country.[35] The list goes on.

"In each successful attempt to build robust investment in natural infrastructure, an essential component has been collaboration among a variety of stakeholders and experts and the emergence of champions within stakeholder groups to push the program forward".

Source: Natural Infrastructure Report Investing in Forested Landscapes for Source Water Protection in the United States, 2013

With aging infrastructure and increasing climate change risk, especially related to flooding, now is a critical moment for the region. This report will look to the best practises in ecosystem based adaptation approaches to see how we effect land-use changes in order to address increasing regional challenges. This report comprises part of a three-year joint initiative between the Southeast Regional Service Commission, Université de Moncton, Nature NB, and other environmental NGOs.

[32] Birmingham City Council, 2013.

[33] Waage & Kester 2014, Wong et al., 2014.

[34] Bennett, 2013.

[35] Natural Capital Lab, 2016.

The overall objectives for the overall joint-project include:

(1) Incorporate freshwater flooding and related ecosystem services into land-use planning;
(2) Identify key ecosystem services: assessing their quality or value through modeling;
(3) Gather and validate necessary data;
(4) Identify existing policies and practices that enable/incorporate ecosystem services into local and regional plans;
(5) Develop methodology/toolkit for planners to use in decision making;
(6) Propose new policies and bylaws that enable/incorporate ecosystem services into local municipal and regional plans; and
(7) Educate/outreach/communicate.

The intended outcomes of the overall joint-project include:

(1) Decreasing the current service failures in local communities due to flood hazards;
(2) Protecting future development from climate change events;
(3) Decreasing the burden on current insufficiently built infrastructures;
(4) Decreasing the financial burden on tax-payers and all tiers of government; and
(5) Providing intact ecosystems to aid with flood drainage and provide other beneficial services.

This endeavour is currently being realized with the help of Université de Moncton's Engineering Department. Pilot sites at select watersheds have been established to measure flood hazards and risks and create standards and methods for inland flood mapping for the region. Through LiDAR mapping of the hydrological landscape of the province flood patterns for a 1 in 100 year return period in 2100 are being determined. In addition, SERSC is working closely with researchers, community partners and NGOs, including Nature NB to ensure the creation of informed policies and by-laws that guide development patterns in accordance with important ecosystem services for flood control.

PART 2 CONCEPTS AND APPROACHES

2.1 INTRODUCTION

Adapting to climate change and the associated flood risks requires comprehensive and integrated planning approaches. Significant time, money, and resources are being dedicated to understanding how communities globally might withstand and rapidly recover from flood-related disasters. Accurate tools, models, mapping methods and land use approaches/conventions that can alter flood risk are now available in order to guide the creation of stronger, safer, and more resilient communities. This updated information allows planning professionals to create policy and regulation based on up to date flood extent predictions rather than those derived from the outdated mappings that may have be available from the 1970s and 1980s.[36]

Canada in the 1950s through to the 1970s spent heavily in engineered infrastructure. These investments coincided with the prevalent attitude of the time which sought to 'control' nature rather than work within or alongside it.[37] Planners and ally disciplines are developing approaches which consider how proposed developments may impact the landscapes natural capacity to mitigate floods and other emergency events.[38] Reducing flooding extents by minimizing or prohibiting development within floodplains is one example of a foreword thinking approach to planning that will reduce long term costs and enhance the region's climactic resilience.

[36] Schwab, 2016.

[37] Schrubsole, 2000.

[38] Schwab, 2016.

It is the role of land use planning to balance private and public land use interests, and to avoid conflict between types of use. Modern land use planning aims to utilize land sustainably so that its value can be passed on to future generations. Sustainable land use increasingly includes protecting the environmental and ecologic integrity of the landscape; it can also mean preserving the more social, cultural, or economic interests associated with a site. Land use decision making is frequently more sustainable when drivers are evaluated in conjunction with one and other, rather than in isolation.[39]

The goal of this report is to evaluate how to best incorporate the natural assets that relate to climate change adaptation, specifically around flood-risk, into the regional planning processes in Southeastern Brunswick. This chapter will assess current approaches which utilize ecosystem services at local, regional and national scales. The first subsection (2.1) will introduce two landmark case studies: one taken from New York City, and the other from a small coastal community along British Columbia's Sunshine Coast. In subsection 2.2, case studies are featured that deal with watershed management approaches, storm water management, asset management approaches, conservation subdivision design, ecosystem based adaption and natural capital valuation in order to exemplify how other jurisdictions have integrated natural capital and ecosystem services into planning contexts.

2.2 WHAT MOTIVATES COMMUNITIES TO TAKE ADAPTIVE ACTION?

Numerous studies suggest that through proper management, the preservation of ecosystems in place of engineered infrastructure provides a low-cost alternative to costly construction and maintenance as well as providing the environmental, social, and economic benefits associated with natural landscapes. One landmark case demonstrating a forward thinking approach to sustainable water resource management is the New York State Catskill/Delaware Watershed. The Catskill/Delaware Watershed is located 120 miles North of New York City, and supplies nearly 90 percent of the City's potable water needs, requiring little to no treatment

[39] Manuel, 2016.

while doing so. In the 1980s concerns about microbial contamination led the United States Environmental Protection Agency (EPA) to establish legislation requiring that all water suppliers serving over 100,000 consumers had to filter their drinking water. Instead of building a water treatment plant, the City of New York tried implementing watershed based best management practices. These management practices provided the desired result, clean drinking water, and at a fraction of the cost of an engineered solution.[40]

Stakeholders in the Catskill/Delaware watershed chose to protect land around the headwaters and compensate landowners to implement best management practices that protect water quality and protect the city's drink water supply.[41] The program provides financial incentives to forestland owners to keep forest intact and to farmers to fence off livestock, and includes incentives for septic tanks and stormwater protection measures that reduce water pollution[42]. Approximately $660 million has been invested in the protection and restoration of natural capital in the Catskill/Delaware Watershed - a fraction of what would have been spent on a treatment plant.[43]

The premise of this highly cited example, and the "natural infrastructure" approach in general, is that healthy ecosystems can provide essential services to water utilities, governments, and businesses; from flood mitigation to water quality and temperature regulation.[44] The New York State Catskill/Delaware Watershed employed watershed management practices that addressed an infrastructure challenge, and the approach resulted in a robust policy that saved the city money, and provided supplemental benefits to New York's environment and community.

Twenty years subsequent to the example set by New York State, other cases of municipalities integrating forward thinking approaches into their planning and regulatory systems have begun to emerge. In 2014, the Town of Gibsons, a small

[40] Brooke and Amos, 2016.

[41] Levitt, 2005. McBryde, 2015.

[42] Kenny, 2006.

[43] McBryde 2015. Hoffman, 2005.

[44] Gartner & Mulligan, 2016.

coastal community of roughly 4,400 people on the Strait of Georgia in British Columbia, completed an asset management strategy that included an assessment of the quality of the community's natural assets. Through this work, it was determined that investing $28,000 annually into their natural aquifer/watersheds avoided the need to construct and maintain an expensive water treatment plant.[45]

The town recognized that natural capital could be managed using concepts that are routinely applied to managing (municipal) engineered infrastructure. The rationale is that the natural services provided by these systems, in terms of stormwater management, flood control and water purification, add value to the community and are as, or more effective than engineered infrastructure. Valuing these natural assets in the same asset management system as engineered infrastructure recognizes the value they provide to the community and integrates them into existing municipal framework for operating budgets, maintenance and regular support.[46]

Intensifying floods and other climatic implications associated with climate change are increasingly making their way into the agendas of water resource managers, stakeholders, and beneficiaries internationally. These challenges provide a unique opportunity to integrate natural infrastructure into stormwater management efforts to reduce costs, enhance resilience to climate change, and provide a suite of co benefits for the air we breathe, the places we play, the wildlife we share our landscapes with, and the climate we live in.

Recognizing that an integrated approach to mitigating inland and coastal flood risk, as well as other watershed services are a cost-effective and common sense solution, jurisdictions globally are looking to incorporate natural assets as part of a solution to the aforementioned growing challenges.[47] In the previous sections, we examined what ecosystem services are, how they relate to land-use planning, the evolution of the concept generally, and then provided an overview of the study area. Following are some inspirational cases where ecosystem services for flood-reduction were incorporated into the regulatory framework.

[45]Town of Gibsons, 2015.

[46]Town of Gibsons, 2015.

[47]Gartner et al., 2013.

2.3 WHAT ARE COMMUNITIES DOING?

NO.	CASE STUDY	LOCATION	APPROACH	BRIEF CASE STUDY DESCRIPTION	PG. NO.
1	Role of Planning and Asset Management in British Columbia	British Columbia	Asset Management, Natural Capital Valuation	A framework that utilizes the whole life-cycle of municipal assets, enabling long-term financial planning that includes the town's natural assets.	22
2	Municipal Natural Assets Initiative in Canada	Gibsons, BC & Nanaimo, BC	Natural Asset Management, Natural Capital Valuation	MNAI is seeking to develop a reproducible framework to evaluate natural assets at the municipal level. One pilot community is in Nanaimo, BC where water modelling is being done to better understand the role local hydrological ecosystems have on stormwater management.	25
3	Watershed Management in Canada	Lake Simcoe Watershed, ON	Watershed Management, Integrated Watershed Management, Sub watershed Management, Climate Change Adaptation Strategy	Ontario has in place regional based land use plans that provide watershed management for select areas in the in the province. The Lake Simcoe Protection Plan uses an integrated watershed management approach to maintain the health of the ecosystem features and functions in region.	27
4	Floodplain and Wetland Management in the US	Middlebury, VT	Floodplain Management, Wetland Management, Wetland Valuation, Flood Mitigation Ecosystem service	Quantifying the economic value of wetlands of flood mitigation, researchers at the University of Vermont's Gund Institute estimated how much the local flood plain saved the town in damages during Hurricane Sandy.	31
5	Subdivision Design and Flood Hazard Areas in the US	Charlotte Mecklenburg County, NC	Floodplain management, Conservation Subdivision Design, Subdivision Design and Flood Hazard Areas, No adverse Impact	A coalition of environmentalists, citizens, developers, and local officials created a stream buffer plan which defines buffer widths based on the acreage drained by each creek to assist with flood mitigation. This approach has been incorporated into local development policy.	34
6	Stormwater Management in the Urban US	Seattle, WA	Stormwater Management and habitat restoration in urban US	Seattle Public Utilities assessed the ecosystem service benefits and was able to factor that cost to persuade local officials to build a levee to benefit the natural salmon species, habitat and provide flood protection for the city of Seattle.	37
7	Climate Change Adaptation in the US	Boston, MA	Climate Change Adaptation, Climate Change Preparedness and Resiliency Checklist, Green Building Design	The local planning authority requires the development community to complete the Climate Change Preparedness and Resiliency Checklist—this checklist is changing practice and providing information so that future development is less vulnerable to flood risk in the future.	39
8	Ecosystem Services Approach in UK	Birmingham, UK	National Ecosystem Assessment, Ecosystem Services Approach	The city of Birmingham is has created a set of maps for the city, which looks at green infrastructure, air quality, flood risk, aesthetics, etc. These series of maps were overlaid to produce a single multiple challenge map for the city to allow the planning authority to determine future development.	42
9	Ecosystem-based Adaptation in Sweden	Malmö, SW	Ecosystem-based adaptation, nature based adaptation planning approach	The Swedish Government has set a goal of ensuring that by 2018 ecosystem services are to be integrated into economic positions, political considerations and other [planning] decisions in country. Malmö municipality uses a range of projects to integrate ecosystem-based adaptation into its municipal structure.	44
10	Natural Capital Valuation in Ontario's Greenbelt	Greenbelt, ON	Ecosystem service assessment, natural capital valuation	Using the National Ecosystem Services Classification System (NESCS) as a framework, a tool was created to quantify the value of natural assets to the wellbeing of a region of the Greenbelt in southern Ontario. Overall, it was determined that the Greenbelt accounts were valued at $3.2 B per year. It was identified that the average wetland within the Greenbelt provides over $1 M per year in protection to human property.	47

FIGURE 5: TABLE OF CASE STUDIES & SUMMARIES

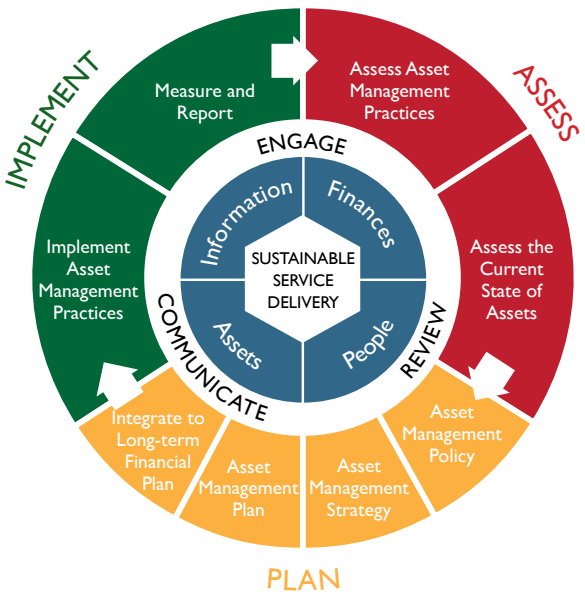
2.3.1 CASE STUDY LAND-USE PLANNING AND ASSET MANAGEMENT IN BC

APPROACH: Asset Management, Natural Capital Valuation

CONTEXT: Municipalities are typically silhoed into various departments; finance, engineering, recreation public works and so on. This arrangement generally does not lend itself to the collaboration required to design initiatives that are multi disciplinary.[48] New approaches to traditional asset management could change that.

Asset management is a process by which capital assets are assessed and planned for and where strategies are implemented to support sustainable service delivery. In 2009, the Public Sector Accounting Board created guidance standards by which municipalities can account for their capital assets in their financial reporting. Asset management considers both the current and future infrastructure needs of a municipality then identifies opportunities to support informed decisionmaking related to the best use of community resources. Asset management strategies cover the whole 'life cycle' of capital assets enabling long term financial planning for maintenance, operations, renewal and replacement of infrastructure.[49] Municipalities also need to demonstrate progress on asset management business processes to receive federal Gas Tax funding for municipal infrastructure.[50] Most municipalities are in the very early stages of developing asset management plans.

FIGURE 6: ASSET MANAGEMENT FOR SUSTAINABLE SERVICE DELIVERY A BC FRAMEWORK



Source : Asset Management BC, 2014.

[48]Machado, 2016.

[49]Atlantic Infrastructure Network, 2016.

[50]Machado, 2016.

PROJECT: In December of 2014, the province of British Columbia released its own asset management framework. This framework goes beyond the requirements set by the Public Sector Accounting Board. British Columbia's framework is progressive in that the importance of land use planning in efficient service delivery and the 'design with nature' philosophy are both inherent in the document. The framework is used to guide municipal decision-making toward a service delivery model that minimizes long term ('life-cycle') asset costs and in doing so considers alternative infrastructures that are more natural, reliable as well as energy and cost efficient.

Facing a $200 billion dollar challenge for the renewal of deteriorating infrastructure in BC, *Asset Management for Sustainable Service Delivery: A BC Framework*, provides a financially responsible rationale through which local governments can integrate watershed management and climate change adaptation into asset management.[51] Asset management typically entails inventorying existing assets, implementing new practices, as well as processes of engagement, communication and review (Figure 6). Asset management in municipal contexts should no longer apply only to hard engineered infrastructure and should include natural assets.

Traditionally engineered infrastructure was constructed, maintained and decommissioned without long-term planning. The asset management approach requires life-cycle planning of an asset *prior* to the asset being built. Cost avoidance is a driver in this new approach. This paradigm-shift starts with land use and watershed based planning to determine what services are affordable, both now and in the future.[52]

The four core elements to support the process and ensure sustainable service delivery in BC's asset management framework are: people, information, assets and finances.

> ASSETS are the government's natural and built physical infrastructures that enable service delivery. In order to ensure the sustainability of service delivery asset management must consider all costs associated with existing, new and future assets.

[51]Stephens, 2016.

[52]Asset Management BC, 2014.

INFORMATION informs decisions that are cost-effective, manage risks and support long-term service delivery. Local governments that maintain an updated asset inventory are better able to make informed decisions and provide the reporting requirements set by the Public Sector Accounting Board. Information concerning the asset may include its location and description/ type, depreciated value, condition, remaining life-cycle, service and asset risks, current and targeted level of service, requirements for repair/upgrade/ replacement, costs, and an asset retirement/replacement schedule.

PEOPLE from a diversity of disciplines are critical to sustainable asset management because of the continuous, interdisciplinary and pioneering nature of the framework.

FINANCES also play a crucial role in asset management as the long-term, life cycle costs of infrastructure are one of the driving forces behind the decision making process.

OUTCOME AND TAKEAWAYS: The BC Framework is what many in the field consider to be a frontier approach to sustainable service delivery. Asset Management is an integrated process, unifying skills, expertise, objectives, data, and finances so that informed decisions can be made supporting sustainable asset management.[53]

In the case of Gibsons, BC, the policy change occurred with the adoption of the Town's 2013/14 Strategic Plan. This document combined Gibsons' sustainability framework with a more traditional strategic plan. Gibsons recognized both informally and in practice that nature, and the services provided are an integral part of the town's infrastructure system; it is one of the first communities in North America to do so.[54]

[53]Asset Management BC, 2014.

[54]Machado, 2014.

2.3.2 CASE STUDY MUNICIPAL NATURAL ASSETS INITIATIVE IN CANADA

APPROACH: Natural Asset Management, Natural Capital Valuation

PROJECT: The Town of Gibsons, BC launched an initiative to manage its climate related risks, finances and ecosystems under one management mechanism. It is the one of the first communities to incorporate ecosystem services into official community planning processes. Interest in the natural asset management approach is spreading, and other municipalities in British Columbia and Ontario are piloting similar projects.[55] For this reason, Gibsons, in cooperation with the David Suzuki Foundation, Sustainable Prosperity, and Brooke & Associates Consulting, have created the the Municipal Natural Assets Initiative (MNAI).

MNAI's goals include:

(a) Developing a quantifiable financial and operational understanding of the core municipal services (e.g. stormwater management, water purification, disaster risk reduction) provided by natural capital (e.g. forests, foreshores, wetlands, riparian areas); and,

(b) Integrating this tangible economic information into core municipal asset management and financial planning processes. This approach in effect values the services provided by nature and brings the information into the heart of mainstream decision-making, which in turn can result in better management of natural assets and reduced municipal costs and risks.[56]

Before launching the program in 2015, the MNAI collaborated with the Province of BC, the Federation of Canadian Municipalities, the Planning Institute, various local municipalities, academia, non-profit groups, etc. for input and feedback.[57] The MNAI is now seeking to integrate the approach pioneered by Gibsons into the frameworks used by three local governments: one in British Columbia and two in Ontario.

[55] Machado, 2016.

[56] Machado, 2016.

[57] Machado, 2016.

One of the pilot municipalities is the City of Nanaimo, BC. Nanaimo has a variety of objectives but few as important as the city's desire to maximize the municipal services derived from the preservation of the Buttertubs Marsh Conservation Area; a 55 hectare wetland/floodplain in center of the city. The marsh, which is adjacent to the Millstone River, has a long history of flooding. The city is interested in understanding, quantifying and maximizing the municipal services gained from the marsh. The marsh was selected because of its stormwater retention and flood mitigation properties and its importance as a local natural landscape.

One of the principal goals of Nanaimo's MNAI pilot site is to quantify the economic value provided by natural assets (principally the marshland), by understanding their function in relation to the landscape's hydrologic processes. These processes can be simulated using a computer models where sets of equations determine, for example, how water infiltrates in a given land use, or how the shape of a stream channel impacts the flow rate. There are a variety of stormwater models, each taking a slightly different approach. This study utilizes the U.S. Environmental Protection Agency's (EPA) Stormwater Management Model (SWMM), version 5.1.010.[58]

OUTCOME AND TAKEAWAYS: The importance of understanding local hydrologic processes and how to properly manage watersheds is becoming increasingly important within municipal agendas. Hydrologic and hydraulic modelling provides mechanisms used to develop an understanding of how water dynamics might impact community planning practice and policy. Quantifying hydrologic services provided by ecosystems, then valuating any associated maintenance costs provides a point of comparison to engineered alternatives, which would be required to replace natural assets. In these respects, the MNAI initiative and Nanaimo pilot site are initiatives to keep an eye on.

[58] MNAI, 2016.

2.3.3 CASE STUDY WATERSHED MANAGEMENT IN CANADA

APPROACH: Watershed Management, Environmental Planning, Valuation, Climate Change Adaptation Strategy

CONTEXT: Canadians have a longstanding relationship with hydrologic resources. Early in Canadian history waterways were viewed as abundant resources that could advance the Canadian economy and society. Little thought was given to human imposed stresses on Canadian water systems.[59] Despite the historic lack of understanding, wetlands and other hydrologic features have always provided important ecological services such as enhancing water quality, increasing groundwater recharge, and more recently, mitigating the impacts of climate change and providing opportunities for tourism and recreation.

In the early 20th century legislators began to regulate and manage water resources including permitting withdrawal volumes. These efforts resulted in the Fisheries Act (1868), 1909 Boundary Waters Treaty between Canada and the United States, and the Grand River Conservation Commission (GRCC) in Ontario (1932). Some of this legislation (e.g., Boundary Waters Treaty and the GRCC) stated that waters were to be managed at the watershed scale; this acted as the introduction of watershed management in Canada.

Later, in the 1970s, the impact of land use change on erosion and stormwater patterns started to be recognized. Today, most Canadian jurisdictions have yet to establish clear mandates or departments to undertake Integrated Watershed Management (IWM), though many have informal IWM planning approaches and are working to continuously improve their approaches.[60]

The purpose of an IWM plan is primarily to protect aquatic resources and ecosystems. Therefore such plans generally consider a wider geographic extent

[59] Canadian Council of the Ministers of the Environment, 2016.

[60] Canadian Council of the Ministers of the Environment, 2016.

than those outlined in most floodplain management plans. The policies in most watershed management plans apply to the entire basin, and not just areas subject to frequent flooding. These plans can be fairly complex and are often taken on by watershed management groups, with consultation from experts, as opposed to being a municipal planning exercise.[61] Though watershed management plans do not focus solely on land use planning, it has been recognized that there is a strong relationship between upstream land use and downstream flood-risk and have the potential to be integrated in official community plans.[62]

In Ontario, wetlands make up about one-third of the province's land base, and are found primarily within the watersheds of northern Ontario. Land-use alterations and settlement have led to huge wetland losses in southern Ontario, with about 72 per cent of the wetlands present prior to European settlement having since been converted, and some areas having lost historic wetlands near entirety.[63] Within the Great Lakes Basin, an estimated 65 per cent of coastal wetlands have been converted to other land covers.[64]

The Ontario Provincial Policy Statement (PPS), which is the key component of the province's land use planning system, asserts that wetlands should be protected.[65] However like in most jurisdictions in Canada, drainage for agriculture, development and road construction often take precedence. The province has in place regional landuse plans such as the Greenbelt Plan, the Niagara Escarpment Plan, the Lake Simcoe Protection Plan, and the the Oak Ridges Moraine Conservation Plan which, in instances of conflicting policy or objectives, take precedence over the PPS. These plans establish protective policy for select areas within the province, but do not provide broader safeguards such as those under the provincial PPS. It would be more effective for the environment to be treated as an integrated system and, at a minimum, given equitable consideration to other planning and land use elements

[61] Doherty, 2012.

[62] Pattison and Lane, 2011.

[63] Environmental Commissioner of Ontario, 2011.

[64] Environmental Commissioner of Ontario, 2007.

[65] Environmental Commissioner of Ontario, 2005

at a scale larger than regionalized efforts.[66] Regardless, protection plans like the Lake Simcoe Protection plan provide essential watershed management outcomes and are outlined in the following case study.

PROJECT: The Lake Simcoe Watershed is located about an hour north of Toronto, and is home to approximately 350,000 permanent residents and an additional 50,000 seasonal residents. The watershed crosses 23 municipal boundaries, including those that make up York and Durham Regions. It also contains portion of the Oak Ridges Moraine, and the provincially designated Greenbelt, regulated under their respective acts.[67] The Lake Simcoe watershed contains significant natural, urban, infrastructure and agricultural systems, with components and sub areas of the watershed regulated by a variety of stakeholders. The Lake Simcoe Watershed area is particularly valuable to the Ontario economy, with recreational activities contributing approximately $200 million per year to the province's economy, and agricultural lands, which makes up nearly half of the watershed, generating another $300 million annually.[68]

During the 1970s, as a result of extensive development pressure, the health of Lake Simcoe began to deteriorate, impairing the ability for lake trout and other cold water fish species to reproduce naturally.[69] In response, the Ontario government passed the Lake Simcoe Protection Act (LSPA) in 2008, aimed to protect and restore the Lake Simcoe watershed's ecologic integrity. The LSPA allowed for the creation of the Lake Simcoe Protection Plan which consists of targets, indicators, and policies organized into categories. These categories include: aquatic life, water quality, water quantity, shoreline health, natural heritage, as well as other threats and activities.[70]

[66] Environmental Commissioner of Ontario. 2009.

[67] Environmental Commissioner of Ontario, 2009.

[68] Ontario Ministry of the Environment, 2009.

[69] Environmental Commissioner of Ontario, 2010.

[70] Environmental Commissioner of Ontario, 2010.

OUTCOME AND TAKEAWAYS: The Lake Simcoe Protection Plan is an example of a watershed based approach where integrated watershed management was intended to address environmental concerns. Over the past decade, the Ontario government has enacted numerous such plans to enhance the provinces valuable natural environments, but often is the case these plans are put into effect following significant degradation of the locality being protected; as was the case with the LSPA. These regulations are often geographically and temporally disjointed, suggesting that there might be room for Ontario's government to consider better integrating the efforts of the different levels of government and non governmental organizations, while at the same time working to consistently take a proactive approach with environmental protection – rather than the retrospective alternative.

Rather than implementing measures to retrospectively restore environmental degradation, as was the initial driver behind the LSPA, Ontario's government should focus on conserving and protecting wildlife, wetlands, forests, lakes and rivers prior to adverse impacts. Integrated watershed management, currently practiced by most conservation authorities, is an excellent example of how natural landscape features might be preserved through the mechanism of Ontario's PPS.[71]

[71] Environmental Commissioner of Ontario, 2010.

2.3.4 CASE STUDY FLOODPLAIN AND WETLAND MANAGEMENT IN THE US

APPROACH: Floodplain Management, Wetland Management, Wetland Valuation, Flood Mitigation Ecosystem service

CONTEXT: Major hurricanes like Hurricane Katrina in 2005 and Sandy in 2012 have been costly for coastal communities along the Eastern seaboard. As a consequence of these natural disasters, there has been an increase in research related to stormwater management and how green infrastructure might play a role. The Environmental Protection Agency (EPA), in cooperation with other agencies and groups, lead in the effort to better understand, evaluate and regulate around wetlands and the role they play in water storage capacity and flood reduction. The Federal Emergency Management Agency (FEMA) has also worked to make flood maps available to communities across the United States. FEMA works closely with the National Flood Insurance Program (NFIP) to deliver accurate flood hazard maps intended to better regulate where buildings can be erected.[72]

Degradation of wetlands and floodplains, a result of past planning practises, are increasingly targeted by contemporary restoration efforts with green infrastructure goals. Conversely, conservation efforts are often applied where degradation has yet to adversely impact the waterway in question. In 2015, the Obama Administration issued a memorandum directing Federal agencies to factor the value of ecosystem services into Federal planning and decision-making. The memorandum directed agencies to develop and institutionalize policies that promote consideration of ecosystem service where appropriate and practical.[73]

Quantifying the economic value of flood mitigation services to influence regional-scale planning decisions is plausible, in terms of real and avoided flood damages, but not simple. The following study, undertaken in Middlebury, Vermont, clearly demonstrates the relationship between upsteam land use and downstream vulnerability. Such research provides practical examples of a science that was previously inaccessible.

[72] FEMA, 2017.

[73] Dickinson, Male, & Zaidi, 2015.

PROJECT: A 2016 study completed by the University of Vermont's Gund Institute and the Rubenstein School of Environment and Natural Resources found that during the 2011 Tropical Storm Irene floodplains and wetlands diminished damages near Middlebury, VT, from 84 to 95 percent, saving as much as $1.8 million in flood damages. The study is the first of its kind to calculate the economic benefits that river wetlands and floodplains provided during a major storm event.

Researchers went on to evaluate 10 flood events in effort to estimate the value of the Otter Creek floodplain near Middlebury. They found that the natural barrier saves the town an average of $126,000 to $450,000 per year, or up to 78 percent of otherwise occurring flood-related damages. Researchers used data from the U.S. Geological Survey, which monitors water levels in Middlebury and Rutland, two municipalities set on either side of the Otter Creek floodplain. This helped Kerri Watson, the lead researcher, identify how much more water – and damage – would have struck Middlebury had vegetation in the floodplain not slowed peak flows.[74]

Watson was able to estimate the value of damages to private and public property had the Otter Creek floodplain not been preserved and as a result, did not provide a mitigating effect to flood events. The study did not assess town infrastructure: roads, bridges and utilities. Considering those assets would increase wetland benefits even further.[75]

OUTCOME AND TAKEAWAYS: Land use change has concentrated development and agriculture in Vermont's floodplains in recent years. The studies undertaken at the Middlebury complex establish a powerful narrative—presenting flood mitigation as an ecosystem service of interest.[76]

Researchers at the Gund Institute quantified the economic value of flood mitigation services provided to Middlebury by Otter Creek's floodplain and wetland network. Quantification was assessed in terms of avoided damages to human beneficiaries.

[74] Waugh, 2016.

[75] Waugh, 2016.

[76] Gund Institute, 2014.

Through this process two principal questions were addressed:

1) What was the value of the Otter Creek wetlands and floodplains in reducing flood damage during Tropical Storm Irene in 2011?

2) Beyond this single event, what is the expected annual value of the wetlands and floodplains in mitigating flood damages?

These valuations allowed researchers to quantify the damages of specific high-profile storm events and bring attention to the role of wetlands and floodplains in bolstering a municipality's climate resilience, and to estimate the damages avoided in an average year. The principal objective of the project was to create a straightforward approach to valuing the wetlands that could be easily replicated. The approach leveraged by the Gund Institute was built upon strong ecologic, hydrologic, and economic principles.[77]

[77] Watson et al., 2016.

2.3.5 CASE STUDY SUBDIVISION DESIGN AND FLOOD HAZARD AREAS IN THE US

APPROACH: Floodplain management, Conservation Subdivision Design, Subdivision Design and Flood Hazard Areas, No Adverse Impact

CONTEXT: Since 1968 the United States National Flood Insurance Program (NFIP) has enabled property owners in participating communities to purchase insurance as a protection against flood losses. In exchange, participating communities must adopt and enforce floodplain management regulations aimed to reduce future flood damages to homes and businesses. Participation in the NFIP is a community decision and based on agreements between communities and the Federal Emergency Agency (FEMA).[78]

Development brings with it impervious surfaces, which are associated with increased localised runoff volumes. These effects are exacerbated in floodplains, where runoff volumes and water level is routinely elevated during storm events. Runoff speed is expedited over impervious surfaces amplifying the intensity of floodwaters and causes watercourse degradation through a process known as the urban stream syndrome.[79] The absence of vegetation, and the filtration services it provides, can also mean that runoff carries more sediment and other pollutants. This has influence on aquatic chemistry and sediment volumes in streams, and can have detrimental effect on the health of the waterway. Streams and rivers need space to 'spill over' or adjust to their capacity during flood events. Peak flows of water need room to spread and slow, this is done naturally through floodplains which rivers have shaped over time. The more heavily channelized, engineered, or impervious a floodplain becomes, the more human influence has interfered with natural systems.[80]

Locating subdivisions away from flood hazard areas has become an increasingly important practice due to the high social and physical costs associated with flood damages. When a new development like a subdivision is built near or within a

[78] Schwab, 2016.

[79] Walsh et al., 2005.

[80] Schwab, 2016.

floodplain it can raise the projected FEMA 500-year and 100-year flood level. This is due largely to erosion, unnatural drainage patterns that increase surface runoff, and other factors associated with the landscape modifications made during development. That is why it is the responsibility of the local government to consider the effect development has on the surrounding environment.

The No Adverse Impact (NAI) floodplain management approach was developed by the Association of State Floodplain Managers (ASFPM) to help communities identify the potential impacts of development and implement actions to mitigate those impacts before they occur. In essence, NAI floodplain management is an approach that ensures the action of any landowner does not adversely affect the properties and rights of another landowner. This is ensured by verifying that localised peak flood level, flood stage, flood velocity, erosion, and sedimentation post development are not higher than those pre development. If a community values a particular natural function of a floodplain more than others, it can be prioritized for protection over other services via the community's NAI approach.[81]

PROJECT: Charlotte-Mecklenburg County, North Carolina is one example of an area in the US that has installed measures to limit new development within the floodplain. In response to the damages caused by Hurricanes Bertha and Fran, the North Carolina Department of Public Safety's emergency management division launched the Hazard Mitigation Planning Initiative (HMPI) in 1996. The ultimate goal of the HMPI was to reduce community vulnerability to natural hazards through mitigation policy and projects.[82]

One such policy sought to reduce community vulnerability through a Surface Water Improvement and Management (SWIM) Program. Although SWIM was initially created to improve water quality in streams and creeks, over time it developed into a program to protect water quality through flood hazard mitigation. Using an integrated approach, a coalition of environmentalists, citizens, developers, and local officials developed a plan that established stream buffer widths based on the

[81] Schwab, 2016.

[82] Schwab, 2016.

acreage drained by each creek or stream. Basically, the larger the drainage area, the larger the buffer required. If the buffer area exceeded the mapped FEMA 100-year floodplain, no new development was allowed within the buffer, even though it was outside the FEMA floodplain. By preserving stream floodplains, riparian vegetation has been able to filter pollutants and the protected floodplains can provide more water storage capacity to mitigate flooding during intense storm events.[83]

In addition to the SWIM program, in 1999, Charlotte-Mecklenburg Stormwater Services began to update its outdated 1975-era flood maps. The result was new floodways based on ultimate buildout, and a 0.1 foot allowable rise (versus the one foot allowable under National Flood Insurance Program minimum standards). These new floodways had an average 454 foot width versus those averaging 290 feet wide in the dated 1975 mapping. This additional land allowed for infiltration that was found to decrease flood heights by 0.5 feet.[84]

OUTCOME AND TAKEAWAYS: In the Charlotte-Mecklenburg example the local government passed regulations, supported by the development community, which would guide development in and around the jurisdiction's floodplain. The result is based on ultimate development in the watershed plus one foot of freeboard and a 0.1-foot allowable floodway rise. Based on economic studies of the new nationwide floodplain maps and associated regulations, it is estimated that in excess $330 million in flood related damages have potentially, and continue to be avoided with the new approach.[85]

[83] Schwab, 2016.

[84] Schwab, 2016.

[85] Schwab, 2016.

2.3.6 CASE STUDY STORMWATER MANAGEMENT IN THE US

APPROACH: Stormwater Management, green infrastructure, economic benefit/ valuation

CONTEXT: In the United States, federal and state law can be used to leverage local government into enacting certain measures. For instance, maintaining wetland or open space buffers at a local scale is a required condition to meet the federal Clean Water Act Standards in land use planning and development.[86]

Regulations such as the Clean Water Act and Safe Drinking Water Act attempt to uphold the United States' water quality objectives. Municipal jurisdictions often rely on large-scale infrastructure to capture, convey, and treat water resources that extend beyond their boundaries. There is growing recognition, however, that harnessing natural processes may offer a preferred set of benefits.[87] For example, green and natural infrastructure can reduce the volume of stormwater runoff entering storm sewers and/or nearby waterways, resulting in two major water-related economic benefits: (1) avoided costs associated with reduced stormwater runoff, and (2) reduced flooding.[88]

PROJECT: In 2005, Seattle Public Utilities (SPU) in Seattle, Washington was in the planning stages for the Tolt River Levee Restoration and Habitat Preservation Project. The project represented a $5 million investment to benefit threatened Chinook Salmon habitat while simultaneously providing flood protection services to the city. Given the Tolt River Watershed is the source of approximately 30 percent of Seattle's drinking water supply, the SPU was interested in the full suite of ecosystem service benefits the project might achieve and contracted Earth Economics to identify and valuate the services provided by the site in current conditions (the river was disconnected from the floodplain), compared to those associated with the restoration scenario. The ecosystem service benefits were estimated to range from

[86] Schwab, 2016.

[87] Buckley, Souhlas, and Hollingshead, 2011.

[88] Buckley, Souhlas, and Hollingshead, 2011.

$134,000 to $484,000 annually, resulting in a net present value of $4.0 million to $14.3 million. This valuation justified the project based on the public benefit and value provided by the Tolt River's ecosystem services.[89] Given this additional information, Seattle Public Utilities' senior management committee approved the Tolt project unanimously, and construction is now complete.

OUTCOME AND TAKEAWAYS: By putting a dollar figure on essential services provided by nature, and assessing the full suite of ecosystem services provided by the Tolt watershed, Seattle Public Utilities were successful in presenting their case to the City. The Tolt River Levee setback was approved, and works to protect local fish species and habitat primarily, but also provides needed flood protection for the city of Seattle.

[89] Vogel et al. 2016.

2.3.7 CASE STUDY CLIMATE CHANGE ADAPTATION IN THE US

APPROACH: Climate Change Adaptation, Climate Change Preparedness and Resiliency Checklist, Green Building Design

CONTEXT: Over the past 10-15 years, many champions of climate adaptation have shifted their focus from hazard mitigation and recovery to more comprehensive adaptation efforts in order to build holistic resilience to the climate variability, extreme weather events, and climatic changes expected in the decades to come.[90] This shift began around the time of Hurricane Katrina in 2005, the costliest natural disaster in recent U.S. history, and has since been fuelled by events such as Superstorm Sandy and the California drought.[91]

Communities in the U.S. are pursuing a diversity of climate adaptation actions that are making them more resilient to climate impacts. These actions serve as models and lessons that can help other communities better protect themselves from climate risks like flooding, heat waves, wildfires, and severe storms.[92]

PROJECT: The City of Boston, Massachusetts has historically been shielded from severe impacts associated with extreme weather events as a result of its 34 harbour islands which have dampened and dissipated storm surges. Like many coastal cities, much of Boston's development has occurred at low elevations near to the shoreline. Approximately 30 percent of the City is built on filled tidelands, which lie within 8 feet of today's high tide. Without intervention the City will be at risk of chronic saltwater flooding by 2100.[93] The possibility of this breech, as well as more inland flooding, is growing due to climate change.[94]

To deal with these issues, now former Boston Mayor Thomas M. Menino, started a series of initiatives to "green" the built environment. Initially, efforts focused

[90] Vogel et al. 2016.

[91] Vogel et al., 2016.

[92] Melillo et al., 2014.

[93] City of Boston, 2015c.

[94] Vogel et al., 2016.

on reducing the city's contribution to climate change by mitigating city and community-wide greenhouse gas emissions. Over time however, this work evolved to include efforts to prepare for the risks and impacts related to the changing climate.[95]

In 2007, Mayor Menino issued an executive order directing all city offices to incorporate climate change into municipal and community planning, permitting, and review processes[96]. This lead to the Boston Redevelopment Authority (BRA) Board being founded in 2013, a body whose mandate is to ensure that climate change be considered as part of the review process involved with large new developments and renovation projects. This mandate revised Article 80 of the Boston Zoning Code to require that proposed structures over 20,000 square feet, or significant renovations over 100,000 square feet identify changes in the climate and environment and then design for those changes with regard to the survivability, integrity, and safety of the structure and its inhabitants[97].

The mandate is implemented by requiring developers to complete a Climate Change Preparedness and Resiliency Checklist. The purpose of the checklist is to assess how climate change and extreme weather conditions might affect a building over its design life.[98] The completed Checklist is submitted to the BRA as part of a project's Article 80 Review and is factored into the approval decision. To date, a number of projects have been redesigned to accommodate climatic changes, and nearly all projects now locate systems above flood levels.

While the BRA and the Boston Environment Department can and do provide developers with flexibility, they still require changes be made during the permitting process if the solution proposed by the developer is deemed insufficient. For example, a building proposed for development near the coast or in a Federal Emergency Management Agency (FEMA) floodplain is required to adhere to design practices which ensure the building is capable of withstanding expected

[95] Vogel et al., 2016.

[96] City of Boston, 2013.

[97] BRA, 2013.

[98] Vogel et al., 2016.

flood events. If the city feels that the proposed design is insufficient, it can require the developer to consider alternative options. Similarly, if developers fail to address climate change in their applications, and project reviewers believe the proposal is to likely be vulnerable, the city can require that applicants redo their checklists. If a project still fails to address climatic change sufficiently, the reviewers can refuse the project, thereby removing it from development consideration. This type of intervention has been rare to date. More commonly, the checklist provides a foundation for meaningful discussions, brainstorming, and collaboration with project developers about how the facilities will be maintained throughout the full lifecycle of the building" [99].

OUTCOME AND TAKEAWAYS: With an already successful history of integrating "green" building practises into the development planning, the BRA chose to explore how environmental change was being considered in development and redevelopment applications. Deciding there needed to be emphasis on sea level rise and coastal flooding, the Boston Redevelopment Authority mandated that associated climate change considerations be addressed as part of the review process.

Article 80, and the requirement to complete the Climate Change Preparedness and Resiliency Checklist is both reimaging common practice and providing information so that future development is less vulnerable to floodrisk.[100] Ultimately, the Climate Change Preparedness and Resiliency Checklist is an effort by city authorities to seamlessly integrate climate change and flood mitigation practices into development discussions and permitting processes in the city of Boston.[101]

[99] Vogel et al., 2016.

[100] Vogel et al., 2016.

[101] Vogel et al., 2016.

2.3.8 CASE STUDY ECOSYSTEM SERVICES APPROACH IN THE UK

APPROACH: National Ecosystem Assessment, Ecosystem Services Approach

CONTEXT: In 2011, the UK National Ecosystem Assessment (NEA) was published. The NEA came as a response to support global and regional obligations, such as the Convention on Biological Diversity which calls on participating countries to conduct such assessments, or the European Union Water Framework Directive, which encourages member countries to explore more responsible management of aquatic ecosystem services.[102]

The NEA provides a comprehensive overview of the state of the natural environment in the UK, as well as new methods to estimate the nation's wealth.[103] The report suggested that if the UK's ecosystems were properly protected and enhanced they could improve the UK economy by an additional £30 billion. Alternatively, neglect and loss of ecosystem services could cost the UK as much as £20 billion annually.[104]

Both scientists and economists were involved in the NEA assessment, which was funded by the governments of England, Scotland, Northern Ireland and Wales, by the Natural Environment Research Council and the Economic and Social Science Research council. Today, although few initiatives use the term 'ecosystem approach' in their work, there are many examples throughout the UK of how the approach has been applied.[105]

PROJECT: Birmingham is a city with a population of roughly 1.1 million people[106], and its surround metropolitan area is UKs largest and most populous outside of London. By applying the same scientific valuation approach as the National Ecosystem Assessment, Birmingham has become the first city in the UK to inventory

[102] UK National Ecosystem Assessment, 2012.

[103] UK National Ecosystem Assessment, 2011.

[104] British Ecological Society, 2011.

[105] Ecosystems Knowledge Network, 2017.

[106] Grayson, 2014.

what services nature can supply locally and then go on to identify where the demand for those services are at their greatest considering the social, economic and environmental demands of the centre.[107]

As part of the City's Local Development Framework it was identified that Birmingham would need a Green Infrastructure Strategy. Birmingham's Green infrastructure Strategy leveraged the findings of the NEA to create an ecosystem service approach which would identify the city's network of natural infrastructure.

The Green Living Spaces Plan is an approved City wide planning policy and introduces a new approach for urban centres to identify and inventory natural capital within the centre. As part of the Green Commission's vision for Birmingham, the Green Living Spaces Plan has become the vessel through which the City is able facilitate a comprehensive approach to natural capital, and is deeply embedded in all municipal operations, inclusive of financial, planning, civil and environmental obligations.[108]

No other UK city has undertaken a comprehensive combined evaluation and mapping exercise to the scale of Birmingham's Green Living Spaces Plan. This effort has produced a totally new map series of the city that shows the population's current relationship with the natural environment. It is embedded in the Birmingham Development Plan, which is the statutory planning framework that guides decisions on development and regeneration in Birmingham (and will continue to do so until 2031). The Green Living Spaces Plan works in conjunction with the city's Climate Change Adaption Action Plan, designed to ensure the City is prepared for future climate impacts and extreme weather events.

OUTCOME AND TAKEAWAYS: The city of Birmingham has effectively become the "most mapped city" in the world according to Birmingham City Council's Climate Change and Sustainability Manager, Nick Grayson. The new set of maps for the city look at green infrastructure, air quality, flood-risk, aesthetics, etc. These series of maps were overlaid to produce a single 'challenge' map for the city. The concept is that future development will reference the map series and other innovative resources as decision making mechanisms for future development.

[107] Birmingham City Council, 2013.

[108] Birmingham City Council, 2013.

2.3.9 CASE STUDY ECOSYSTEM-BASED ADAPTATION IN SWEDEN

APPROACH: Ecosystem-based Adaptation, nature-based adaptation planning approach

CONTEXT: With increased climate change impact globally, and a lack of a coordinated response internationally, governments have an important role to play in fostering a transition toward a globally sustainable future. In this sense, ecosystem-based adaptation is increasingly being recognized as one multi benefit approach that applies a jurisdiction's inventoried ecosystem services.[109]

Ecosystem-based adaptation can be defined as the use of ecosystem services as part of an adaptation strategy designed to aid a jurisdiction in building resilience to the adverse effects of climate change in coming years.[110] An adaptation plan may include sustainable management practices or policies, conservation plans, or the restoration of ecosystems, all of which contribute to an overall strategy which addresses the multiple social, economic and cultural co benefits for communities. Adaptation can be facilitated both through specific ecosystem management measures and through increasing ecosystem resilience to climate change.

In Sweden, substantial climate change impacts are expected, and the importance of ecosystems to climate change adaptation strategies has been acknowledged at the national level since 2007. Given the Swedish governments promotion of the ecosystem concept, it has become a key driver for nature based adaptation planning approaches at the municipal level.[111]

In 2013, the Swedish Government produced a report called *Making the value of ecosystem services visible*, which set the goal of ensuring that by 2018, "the importance of biodiversity and the value of ecosystem services are to be generally known and integrated into economic positions, political considerations and other decisions in society".[112] Swedish officials have been very successful in attracting international funding for ecosystem based adaptation.[113]

[109] Wamsler, 2014.

[110] CBD, 2009.

[111] Wasler, 2014.

[112] Ministry of the Environment, 2013.

[113] Wamlser, 2016.

Sweden has taken on two regional cooperation and research circles: "Planning under Increased Uncertainty" and "Ecosystem Services Planning". Under these circles two major research projects have taken form: "Ecosystem Services as a Tool for Climate Change Adaptations in Coastal Municipalities", and "Sustainable Urban Transformation for Climate Change Adaptation". These projects were developed in hopes of pushing ecosystem services further into public agendas. Sweden's southern region of Scania County has made particular progress, especially in the case of Malmö, Scania's most populous centre.

PROJECT: With a population of roughly 340,000 Malmö is the third largest city in Sweden and the 6th largest in the Nordic countries. Covering an area of 158.4 km², it is the economic and cultural centre of Southern Sweden.[114] In recent years, Malmö municipality has implemented a range of projects and coordinated activities that have fostered the integration of ecosystem-based adaptation into its municipal structure.[115] The primary initiatives include:

- The establishment of pilot projects on ecosystem-based adaptation through external funding.
- Increasing integration of the ecosystem service concept into the core work of the Environmental Department through the revision of various strategic planning documents.
- Active collaboration between departments, developers, consultants and researchers to stimulate the mainstreaming of ecosystem-based concepts at different levels.
- The adoption of a planning tool to leverage the loss of green space in new development projects.
- Increasing support from politicians for activities related to ecosystem service integration.[116]

Malmö's Department of Environment has been the highly successful in securing thirdparty funding. This reality has led to the implementation of the city's own ecosystem-based adaptation project (''Green tools for urban climate adaptation'', 2009–13).

[114] Statistics Sweden, n.d.

[115] Wamsler, 2014.

[116] Wamsler, 2014.

The integration of the ecosystem service concept into the core work of the Department of Environment has been fostered by the inclusion of ecosystem service terminology into the department's objectives and strategic planning documents. Cooperation and working groups have been established to develop planning guidelines and policy documents (e.g. GreenClimeAdapt, 2014; Malmö Stad, 2012, 2013, 2014).[117] The City Council also passed the decision to fund a two-year project "Living Malmö", which launched in 2014. The project builds on the Comprehensive Plan (Malmö Stad, 2014) and was meant to generate knowledge on how reach the city's vision of a dense, green and socially cohesive urban centre. Finally political support has garnered Malmö's participation in the "Making Cities Resilient" campaign run by the United Nations Office for Disaster Risk Reduction (UNISDR). The program will assess Malmö's hazard risk profile and identify how risk reduction and adaptation could be better coordinated.

OUTCOME AND TAKEAWAYS: In terms of integrating the ecosystem service concept in to municipal planning frameworks and comprehensive plans, Sweden is a pioneer. Malmö is a leader in terms of having local champions leveraging ecosystem-based adaptation. There are other major Swedish centres seeking to integrate ecosystem services into municipal operations, for example the cities of Lomma and Kristainstad, who, as a result of past flooding, have both increased support for the use of green infrastructure in adaptation efforts.

Almost half of the municipalities of in Sweden have assessed more then 50% of their land area for biological value.[118] In Sweden, ecosystem based adaptation measures and the use of ecosystem services are not necessarily labeled as such at the municipal or city level, and implementation in the country is somewhat fragemented as a result of jursidictional powers. It takes time for these terms to be explicitly adopted, although they are already implicitly reflected in practise.[119]Researchers suggest that there is a need to integrate governance structures that coordinate well-established conservation efforts between established decision making bodies in different regions and between hierarchal levels.[120]

[117] Wamsler, 2014.

[118] Palo, 2016.

[119] Sitas, 2014.

[120] Wamsler, 2014.

2.3.10 CASE STUDY NATURAL CAPITAL VALUATION IN ONTARIO GREENBELT

APPROACH: Ecosystem service assessment, natural capital valuation

CONTEXT: There are a number of valuation tools to quantify the flows of "services" provided by nature to humans. Developed by the U.S. Environmental Protection Agency, the National Ecosystem Services Classification System (NESCS) is one such tool. A framework in this case, the NESCS is designed to assess what implications policy induced changes to ecosystems have on human welfare.[121]

NESCS focuses on Flows of Final Ecosystem Services (FFES), which it defines as the direct contributions made by nature to human production processes or to human well-being.[122] By final goods and services it refers to ecosystem services which occur at the point of hand-off between natural systems (ecosystems) and human systems (producers and households). While intermediate ecosystem services are inputs to the natural processes that ultimately produce final ecosystem services. For example water purification is important for sustaining fish populations, but fish contribute directly to commercial fishing. The value of the fish itself is embedded within the value of final ecosystem services. Distinguishing between final and intermediate ecosystem services avoids double counting their values.[123] To better understand this concept, refer to Figure 7. The NESCS is not a tool for quantification or valuation, the goal is to support identification of pathways or flows between ecological and human systems, which can then be used as a basis or starting point for quantification or valuation. An example describing how Green Analytics was able to draw on the NESCS to assess a series of ecosystem service accounts for Ontario's Greenbelt, is outlined in the project below.[124]

Source: United States Environmental Protection Agency, 2015.

[121] United States Environmental Protection Agency, 2015.

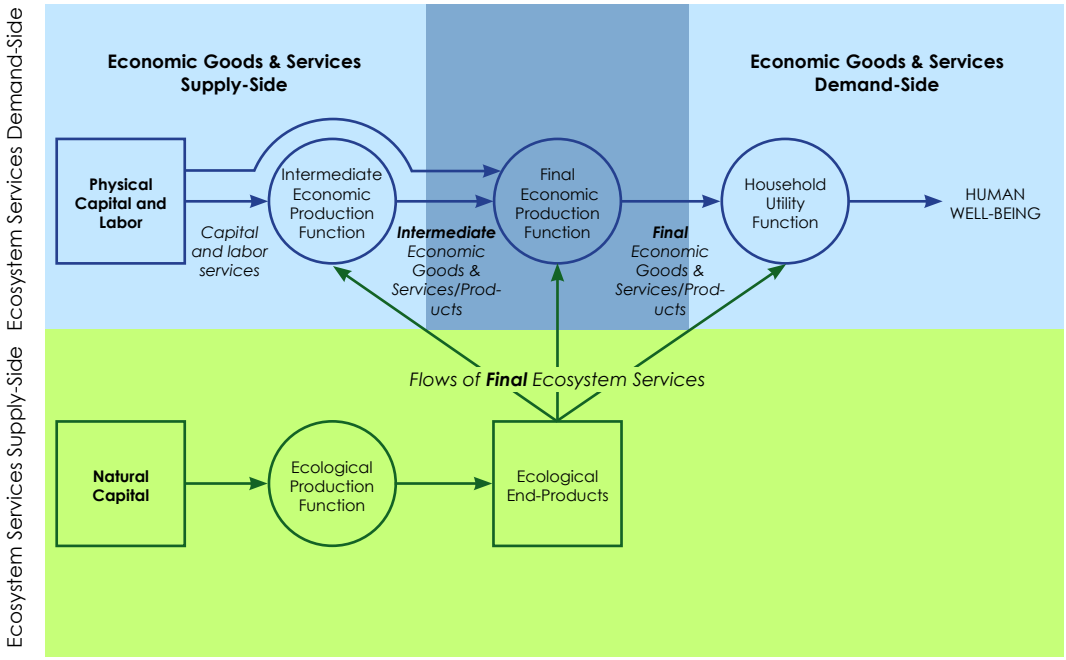
[122] United States Environmental Protection Agency, 2015.

[123] United States Environmental Protection Agency, 2015.

[124] Green Analytics, 2016.

PROJECT: Ontario's Greenbelt is 2 million acres of protected land. It extends as far north as Tobermory and stretches 325 kilometres from Rice Lake in Northumberland County to the Niagara River. The Greenbelt also wraps around the Greater Golden Horseshoe — the area that surrounds the western end of Lake Ontario. It is one the fastest growing regions in North America.[125]

FIGURE 7: CONCEPTUAL FRAMEWORK INCLUDING FLOWS OF FINAL ECOSYSTEM SERVICES (FFES) AS INPUTS TO HUMAN SYSTEMS



Source : EPA

The Greenbelt Plan was established in 2005 to protect prime farmland and environmentally sensitive areas from urban development and sprawl.[126] A recent study conducted by Green Analytics modified the NESCS framework and the FFES concept (illustrated in the diagram above) so that it could be used to calculate the value of the Greenbelt's natural capital. This natural capital valuation tracked, valued, and measured the contribution of natural assets to the wellbeing of the Greenbelt. The valuation is based on a systematic approach that focuses on the final (or end)

[125] Friends of the Greenbelt Foundation, n.d.

[126] Green Analytics, 2016.

benefits to the human populations residing in or visiting the Greenbelt. Overall, it was determined that the Greenbelt accounts were valued at $3.2 billion per year.[127]

One of the Greenbelt's most important natural assets are its wetlands, which protect property through an inherent capacity to mitigate flood intensities and volumes. Using the results of a custom meta analysis, the value of property protection was estimated to be $224 M per year. The estimate included a valuation for over 15,000 provincially significant wetlands throughout the Greenbelt, whose individual wetland values ranged from $3,000 to over $5.5 M annually. The average wetland within the Greenbelt provides over $1 M per year in protection to human property.[128]

In addition to wetlands, the study identified a total of 100 accounts and found data to value 65 of them. The assessment drew on cutting edge analytical approaches and data to provide refined estimates of the value of services provided by the natural capital of Ontario's Greenbelt.

OUTCOME AND TAKEAWAYS: The framework and results identified by Green Analytics report *Ontario's Good Fortune: Appreciating the Greenbelt's Natural Capital* is one application of the U.S. Environmental Protection Agency's National Ecosystem Services Classification System (NESCS). The NESCS framework is one approach stakeholders can leverage in an effort to inventory a region's natural capital assets. Through regular monitoring of the quantity, quality, and value (based on human usage) of natural capital, municipalities can better protect and manage it.[129]

[127] Green Analytics, 2016.

[128] Green Analytics, 2016.

[129] Green Analytics, 2016.

PART 3 POLICY

The purpose of this section is to present how adaption to inland flooding can be incorporated into the forthcoming regional plan for the southeast region of New Brunswick. This section will highlight guiding principles as well as sample policies. It will also identify linkages that inland flood-risk adaptation has to other land uses, development protocols and infrastructure issues addressed elsewhere in the regional plan.

One of the responsibilities of the Regional Service Commissions is the development of regional plans. A regional plan provides "strategies that foster sustainable development practices, encourage coordinated development between communities, influence and guide the location of significant infrastructure and enhance coordination of commercial/industrial development".[130] Regional plans will also serve as an important tool in better managing, protecting and connecting urban and rural landscapes and resources.

This section consists of three parts. Part one is an introduction, which places the first part of the report it in context of the regional plan. Part two are the aforementioned guiding principles. Part three are sample policies that would guide the codification of the principles in municipal by-laws. The sample policy provisions included in this section make use an environmental management perspective that can be adapted into a planning framework.*

***Disclaimer:** It is important to note that the policies included in this section are sample policies recommended to the Southeast Regional Service Commission, but do not necessarily reflect the views of the SERSC.

[130] Government of New Brunswick, 2017.

3.1 INTRODUCTION

The Southeast Regional Service Commission (SERSC) is one of twelve RSCs (Regional Service Commissions) in New Brunswick, established in January of 2013. The SERSC exists as the combination of three former planning commissions, each of which provided planning services within what is now the SERSC's territory. The SERSC is in line to create one of the first regional plans in the province. The SERSC recognizes that the inland flood-risk component is a key element of the regional plan and aims to make communities sustainable through adaption measures, similar to those that have already been implemented by coastal communities in the region.

Increasingly, there is a need to invest in infrastructure that has the ability to withstand or mitigate climate change impacts, including intensified flooding, storm surge and precipitation events. Adaptation measures that leverage a region's natural assets, such as the flood mitigation services provided by wetland areas, inherently reduce a community's vulnerability to a climate-related hazard.

For the Southeast New Brunswick region, there is a unique opportunity to integrate a vast array of natural assets i.e. wetlands, riparian zones, saltmarshes and forested areas into the regional plan, utilizing significant capital that was previously not valued.

Local governments can use the regional planning policy to increase community climate resilience by:

- More effectively integrating natural capital frameworks into policy through increased collaboration between municipal centres;
- Locate development away from hazardous areas or reduce risks to developments already located in hazardous areas;
- Promote climate-resilient buildings and infrastructure that can withstand a variety of environmental stresses;
- Build additional capacity into infrastructure systems that serve multiple purposes, such as natural areas that can serve both as flood control mechanisms and recreational spaces;

- Preserve and enhance the natural environment, which helps moderate the impacts of extreme weather events and a changing climate;

- Seek to build the capacity of staff and residents to better understand climate trends, projections, impacts and opportunities to increase resilience; and

- Address social sustainability and economic development factors associated with climate resilience.[131]

A comprehensive and integrated regional plan can manage growth through coordinated land management efforts between communities within the same watershed. Regional plans are useful in establishing more cohesive watershed and floodplain management plans that frequently extend beyond the territory of a single community or subdivision. While policies addressing climate change can exist in municipal planning strategies, implementing them through a regional plan allows for the coordination of resources between communities and by pooling municipal knowledge and objectives the region has the opportunity to create highly refined policy.

3.2 GUIDING PRINCIPLES

There is a growing understanding of the impact climate change has is likely to have on infrastructure, community operation, and planning efforts. Moving forward, there is a growing need to prepare for deteriorating climatic conditions, and ensure that the regional planning strategy is one that results in more resilient communities. The guiding principles of the regional plan outline the community's vision and are the basis on which regulation is formed.[132] Suggested guiding principles for the SERSC and the forthcoming regional plan are listed on the following page.

[131] Columbia Basin Trust, 2015.

[132] Columbia Basin Trust, 2015.

SAMPLE GUIDING PRINCIPLES

1. SUSTAINABILITY - Making decisions that consider the environment, economy, and community, and strive for a balance between these three pillars of sustainability by:
    - Economic: Utilize a fiscally responsible approach in relation to flood-risk that reduces flood damages at low costs to local governments, which will allow for greater financial security to invest in community wellbeing;
    - Social: Ensure health and safety during flood events and ensuring no one is disproportionately affected by flooding;
    - Environment: Ensure protection of natural assets and utilize the multiple benefits that the environment provides to reap improved social and economic rewards.

2. INTEGRATED PLANNING - Consider climate change, impacts and strategies to increase climate resilience in all long-term decision-making, specifically related to reviewing land use development patterns, infrastructure standards and flood management policies. Ensure policies nurture the unique cultural heritage and natural assets while supporting opportunities for the local economy.

3. PARTNERSHIPS - Enhance partnerships with senior staff and local governments, neighbouring RSCs, public agencies, community organizations, businesses and individuals for the efficient and effective coordination of regional planning, policies and initiatives, including risk and vulnerability assessment of local climate impacts, specifically around freshwater flood-risk.

3.3 SAMPLE POLICY

3.3.1 SAMPLE POLICY DEVELOPMENT SITING

Historically, communities in Atlantic Canada have been settled adjacent to major hydrographic features. The location of communities in relation to waterways makes them especially susceptible to extreme weather as well as inland and coastal flooding. Anticipated increases in winter precipitation as well as the frequency of extreme rainfall events year round is likely to contribute to increased flood frequency and intensity. Developments in flood hazard or other high risk areas should consider the resilience of the proposed property to extreme weather events. Adopting policies that either direct development away from hazardous areas or ensure that development occurring near or within is capable of accommodating intensifying storm events, ensure the ongoing safety of residing populations.

GROWTH MANAGEMENT

It shall be the policy of council:

3.3.1.1 to direct new development and focus infrastructure investment within the region's growth centres.

DEVELOPMENT CONSTRAINT STANDARDS

It shall be the policy of council:

3.3.1.2 to identify and designate in the Constraints Overlay environmental risk areas inclusive of, but not limited to, the floodway and flood fringe, where development will be restricted or prohibited.

3.3.1.3 to work in cooperation with the province, local governments, conservation groups, and other stakeholders to monitor and map the location of the region's wetland network.

3.3.1.4 to consider participating in any flood monitoring initiatives designed to record flood event characteristics and pursuing partnerships with

local governments in the region, the Province of New Brunswick, the Government of Canada and any other interest group that has a stake in flood related issues.

3.3.1.5 to maintain current flood hazard mappings for the region from which flood regulations and policy is based.

FLOOD RISK AREAS

It shall be the policy of council:

3.3.1.6 to limit the types of land use permitted and require appropriate floodproofing measures be detailed as part of any development application taking place within those flood fringe areas delineated in the development constraints overlay.

3.3.1.7 to prohibit development with those floodway areas delineated in the development constraints overlay.

3.3.1.8 to recognize the existence of the regions wetland network provides a level of inherent flood protection to the jurisdiction's communities.

3.3.1.9 to encourage the preservation and protection of the southeastern regions wetlands, waterbodies, and riparian environments in order to maintain them as important visual, accessible, natural community resources, as well as flood mitigating infrastructure.

3.3.1.10 to consider what impact prospective development will have on overland flow direction, flow volume, sediment volumes, water quality and chemistry, as well as localised erosion.

3.3.1.10.1 to ensure changes to these conditions will not impact environmental condition or cause damage to adjacent properties.

3.3.1.11 to establish the minimum watercourse setbacks as follows:

3.3.1.11.1 development limits as established by the provincially regulated wetlands and watercourses;

3.3.1.11.2 development limits as established by the geotechnical limit of the hazard lands;

3.3.1.11.3 development limits as established by a minimum elevation above the high water mark of a watercourse (i.e. vertical buffer);

3.3.1.11.4 development limits as established by a minimum elevation above the existing top of bank, where there is a defined bank.

3.3.1.12 to require the completion of the following studies where construction is proposed within or proximate to a mapped or regulated hazard area:

3.3.1.12.1 geotechnical report;

3.3.1.12.2 erosion and sediment control plan;

3.3.1.12.3 stormwater plan;

3.3.1.12.4 other studies as required by the By-Law.

3.3.2 SAMPLE POLICY INFRASTRUCTURE AND UTILITIES

Climate change is likely to result in the deterioration and damage of aging infrastructure due to increased peak stormwater flows, flooding and increased freeze/thaw stresses. Like many regions across Canada, the southeast region of New Brunswick is struggling to balance the community's desire to maintain and improve infrastructure and amenities with the desire to keep taxation at a reasonable level. This necessitates careful attention to asset management.

Regional transportation infrastructure is likely to be adversely affected by extreme events. Increased closures and maintenance requirements are anticipated to increase with the intensity and frequency of storms. Transportation policies that address climate adaptation should generally focus on a) planning for transportation systems that are resilient and adaptable to extreme weather conditions, and b) retrofitting transportation infrastructure that is vulnerable to extreme weather.

Other engineered infrastructure, including water and power servicing may need to be designed to accommodate the anticipated realities of the changing climate.

GENERAL INFRASTRUCTURE

It shall be the policy of council:

3.3.2.1 to investigate what climate change adaptation strategies are required to prevent damage to the region's infrastructure and property due to flooding from storm surge, sea level rise, precipitation or other extreme weather events.

3.3.2.2 to consider life cycle costs prior to the construction of any proposed infrastructure.

3.3.2.3 to consider natural infrastructure to compliment engineered infrastructure where possible.

3.3.2.4 to promote and explore the viability of adaptive and multi functional infrastructure solutions (green infrastructure).

3.3.2.5 to require, at minimum, that engineered infrastructure be designed to accommodate the local 1:100 year flood level over the duration of the infrastructure's life.

3.3.2.6 to leverage existing infrastructure with development where possible.

3.3.2.7 to limit the provision of new (public) engineered infrastructure in support of proposed development.

POTABLE WATER SUPPLY

It shall be the policy of council:

3.3.2.8 to continue to protect and manage the quality and supply of potable water within the watersheds of the community.

3.3.2.9 to work with regional stakeholders to identify and implement watershed management guidelines for development, and enforce buffer zones in riparian areas, particularly those rivers and streams that feed into the regional aquifers.

STORMWATER MANAGEMENT

It shall be the policy of council:

3.3.2.10 to encourage development that either maintains or enhances the pre-development hydrologic character of the site through innovative site design and engineering techniques.

3.3.2.11 to enforce 'net zero' runoff standards for proposed development where possible.

3.3.2.12 to encourage the use of existing natural drainage and retention systems where possible.

3.3.2.13 to adopt performance standards limiting the percentage impervious surface on a site based on the associated land use zone. Development may be permitted to exceed the maximum coverage where innovative mechanisms are included in the proposal (e.g. bio swales, green roofs, permeable pavement, etc.).

3.3.2.14 to work with local governments to assess, prioritize system upgrades and repairs, then monitor the condition of storm sewers.

SEWER SYSTEMS

It shall be the policy of council:

3.3.2.15 to require that development in 'high-risk areas' prone to sanitary sewer backup and surface flooding shall be subject to special requirements.

POWER SERVICING

It shall be the policy of council:

3.3.2.16 to require that development within the regulatory flood fringe be serviced with above grade power lines.

ROAD INFRASTRUCTURE

It shall be the policy of council:

3.3.2.17 to require that new roads utilize contemporary stormwater management techniques including, but not limited to, culvert sizing, permeable surfaces, swales to reduce water runoff.

3.3.3 SAMPLE POLICY NATURAL ENVIRONMENT

Natural infrastructure can provide a valuable service to communities by mitigating some of the impact of extreme weather events. Regulatory mechanisms such as riparian setbacks can conserve wildlife, habitat, water quality and chemistry near freshwater bodies, and serve to keep property away from flood and erosion hazards. This increases community resilience and reduces building and infrastructure costs. Other contemporary principles such as new urbanism or conservation design offer modern perspectives which place inherent emphasis on the *inclusion* of natural infrastructure in planning.

Wetlands and riparian areas play a variety of roles in our natural environment and if integrated into the region's design, will not only contribute to the overall health of our watersheds, but offer the opportunity to serve as places for recreation throughout the region. In addition, these natural systems can contribute to the SERSC's infrastructure needs, especially those related to water supply and stormwater management. The region's wetlands, riparian areas, and forested areas are unsung heroes. These assets play an important role in stormwater management and climate adaptation, and can significantly reduce the cost of infrastructure investment just through their preservation.

NATURAL ENVIRONMENT

It shall be the policy of council:

3.3.3.1 to apply ecosystem-based management and integrated watershed planning approaches for the comprehensive management of land, surface water and groundwater resources.

3.3.3.2 to promote healthy terrestrial and aquatic ecosystems, maintenance of hydrological functions and resilience to climate change.

3.3.3.3 to work within provincial regulations (e.g. the Clean Water Act, and EIA) and bolster where necessary.

3.3.3.4 to ensure development within or proximate to environmentally sensitive areas does not have adverse impact to the environmental integrity of the area.

3.3.3.5 to require appropriate setbacks and other measures for new development along rivers, streams, and wetlands.

3.3.3.6 to develop the environmental asset inventory by making explicit reference to natural infrastructure and related terminology in municipal documents.

3.3.3.7 to ensure that deleterious substances (including sewage and other toxic materials) are not deposited into aquatic environments without meeting treatment standards.

3.3.3.8 to evaluate, improve and streamline measures to conserve certain forest stands that serve as water retention assets on both public and private property before they are developed.

3.3.4 SAMPLE POLICY PARKS, RECREATION AND TRAILS

As with other infrastructure, local governments are increasingly looking to parks, recreation areas and trails to serve as multi-functional assets. Recreational infrastructure can often serve additional purpose and help to protect biodiversity and ecosystem function.

PARKS, RECREATION AND TRAILS

It shall be the policy of council:

3.3.4.1 to include recreational parks as stormwater retention mechanisms and other forms of natural infrastructure where possible.

3.3.5 SAMPLE POLICY SOCIAL SUSTAINABILITY

Climate resilience policies often focus on social sustainability and can involve engaging the public and garnishing partnerships in the community being served. Engaging with the public and understanding public opinion can ease the acceptance of climate resilience measures in planning frameworks, where the regulations might otherwise be resisted. Local governments can also use public education to support climate adaptation efforts.

SOCIAL SUSTAINABILITY

It shall be the policy of council:

3.3.5.1 to inform and engage the community in local monitoring and implementation efforts related to climate change adaptation and mitigation.

3.3.5.2 to engage the community by raising awareness about climate change, especially pertaining to freshwater and coastal flood risk.

3.3.6 SAMPLE POLICY ECONOMIC DEVELOPMENT

Resilience to flood-risk is become an increasingly important factor in a community economic health in Southeastern New Brunswick. Projected changes in climate are likely to have significant impact on industries the region relies on, including forestry, tourism, and agriculture.

Communities that begin to address these potential changes now may find themselves in a better economic position in the future. There is ample economic justification for proactive adaptation actions rather than retrospective since they are typically more cost-effective.

ECONOMIC DEVELOPMENT

It shall be the policy of council:

3.3.6.1 to consider future climate projections and related impacts in economic development decision making. These topics include, but are not limited to tourism, resource extraction, areas of densification, commercial corridors, as well as parks and open spaces planning.

3.4 POLICY CONCLUSION

Progressive approaches to climate change look to integrate planning as part of a collaborative effort between stakeholders. The sharing of information between all facets of government, the scientific community, and the private sector is therefore imperative. Stakeholders should look to engage the public to educate, gather different perspectives, and encourage acceptance of climate change regulations. Progressive policy should be holistic, incorporating sustainable measures and adopting a "big picture" view of land uses and activities, environmental constraints, as well as valuable scientific forecasts.[133]

With the adoption of Bill 61, the Province of New Brunswick indicated the move towards regional planning frameworks, and over the coming years, work will be carried out to develop regional plans. This new level of planning offers an opportunity to establish an integrated approach to land use and growth management at a regional scale.

There is a need to encourage a new way to grow region-wide, that minimizes impacts on the natural environment, and encourages alternative, smarter infrastructure and design decisions, rather than assuming status quo standards[134]. The regional plan can play an important role in this sense, not only in shaping land use and development patterns that dictate future infrastructure costs, but also by raising these issues in the public discourse — managing growth patterns to achieve a balance of environmental, social and economic goals, and manage growth so as to employ land and infrastructure intelligently.[135]

[133] Doherty, 2012.

[134] Gibsons, 2015.

[135] Gibsons, 2015.

PART 4 CONCLUSION

It is becoming widely accepted that maintaining healthy ecosystems is cost-effective and critical to human health and well being. However, there remains a gap between policy and regulatory 'teeth' in the majority of current planning frameworks.

Efforts to further develop the benefits derived from ecosystem services in Southeast region of New Brunswick are underway, and this report presents additional opportunities where ecosystems might be incorporated into planning efforts. With the recent development of regionalized planning, the provincial government's commitment to approach flood mitigation through the lens of natural infrastructure (see *New Brunswickers' Response to Climate Change: Final Report of the Select Committee on Climate Change*), and requirements for local governments to account for all of their assets in financial accounting (see *Public Service Account Board regulation, PSAB 3150*), there exists ample opportunity to integrate natural assets into upcoming planning strategies.

New Brunswick will see both warmer temperatures and increased precipitation due to changing climatic conditions; higher water levels along New Brunswick coasts can also be expected as a result of these realities.[136] The frequency of major storm events is expected to insight flooding events of increased intensity, duration and frequency. Most of New Brunswick's local governments are located in floodplains, both inland and coastal. As a result of the combination of increased storm frequency and severity with the location of much of New Brunswick's population, much of

[136] Roy, P. and Huard D, 2016.

New Brunswick's ageing (engineered) infrastructure will be under increased stress in years to come. New Brunswick needs to acknowledge and plan for flooding in a way that improves the resilience of the province's engineered infrastructure and encourages the safety and wellbeing of communities and individuals.[137]

The research provided by this report suggests that adapting development to withstand potential inland flooding in high risk areas makes fiscal sense and further increases community resilience to climate change. Wetlands, as well as riparian areas and forested landscapes benefit communities in many ways beyond recreation or the provision of habitat: including the role they play in flood control, water filtration, erosion control, sediment retention and enhanced landscape resilience. Although wetlands and other hydrologic features are frequently highly interrelated, the current legal and policy framework associated with their management is fragmented, and measures in place are often not strong enough to protect these sensitive areas from the dangers presented by development.

Many jurisdictions, including those mentioned in the report case studies, have acknowledged the co benefits of integrating natural assets into asset management, whether it be for stormwater and flood risk reduction purposes or otherwise. When considered together, these case studies provide and approach to flood adaptation that can span multiple disciplines.

Conventional land use regulations and planning practices, especially zoning bylaws, have contributed to ad hoc development, increasing the per capita costs of infrastructure maintenance and renewal.[138] The financial and social benefit reaped by the Province of New Brunswick in taking advantage of ecosystem services would be considerable. Using the services provided by nature to address growing infrastructure costs, makes creating *climate resilient communities possible*.

Future research recommendations include: (1) further valuation of hydrologic assets region-wide; (2) additional consideration of hydrologic assets in the permitting of

[137] Queensland Reconstruction Authority, n.d.

[138] Adin, 2016.

new development within the region's watersheds and firmer regulations related to; and (3) an assessment of total costs (i.e., market and non market) of flooding events in relation to flood risk reduction. If implemented, these recommendations would help create more sustainable communities. The valuation of natural assets can play a major role in regional decision-making, and the case studies outlined in this report are demonstrative of this.

It is hoped that this report will provide a basis for further discussion about how ecosystem services, specifically related to inland flood risk in Southeast New Brunswick are to be integrated into regional land planning processes. Decision-makers are encouraged to use this report to assist in informing discussion on how best to establish a strategic direction whereby regional planning refocuses the business-as-usual style of development and begins to properly manage hydrologic resources within the built environment.

KEY DEFINITIONS

Asset: The physical infrastructure natural or built owned by local governments to enable service delivery (e.g. water and wastewater systems, drainage and flood protection systems, transportation systems, civic facilities, parks).[139]

Asset management: A coordinated activity of an organization to realize value from assets. Realization of value will normally involve a balancing of costs, risks, opportunities and performance benefits.[140]

Climate change: Changes in climate variables and patterns of weather over time because of a warming of the Earth's atmosphere.

Climate change adaptation: The adjustment of systems (natural or human) in response to actual or expected climatic stimuli, or their effects, to moderate harm or exploit beneficial opportunities.[141]

Climate impact: The effect experienced by a human or natural system as a result of climate variability, extreme events, or climate change, such as droughts, flooding, or sea level rise.

Ecosystem-based adaptation: The use of biodiversity and ecosystem services as part of an adaptation strategy against the adverse effects of climate change.[142]

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[139] AMBC, 2014.

[140] AMBC, 2014.

[141] Wamsler, et al., 2016.

[142] Wamsler & Pauleit, 2016.

Ecosystem Services: The processes within ecosystems that yield a benefit to society[143]. These are typically clustered into four types of services:

- Provisioning: provides goods that are typically visible and directly useful for human consumption before or after some transformation. Provisioning services typically already have a market price (e.g. food, fresh water, wood and fibre, fuel).[144]
- Regulating: often the 'invisible' services in an ecosystem, but are nonetheless directly beneficial for humans. These services are crucial to maintaining a hospitable and healthy living environment (e.g. climate regulation, flood regulation, disease regulation, and water purification).[145]
- Cultural: services that indirectly benefit human by increasing quality of life (e.g. aesthetic, spiritual, educational, and recreational).[146]
- Supporting: may be 'invisible' services. Supporting services are crucial to the healthy functioning of ecosystems and are necessary for the production of other services, but typically do not yield a direct benefit to humans (e.g. nutrient cycling, soil formation, and primary production).[147]

Ecosystem Services Valuation: These valuation of ecosystems and their services, typically in monetary terms.

Floodplain: Low lying area adjacent to water that is subject to frequent or occasional inundation.[148]

Flood-Risk Area: Land subject to flooding with a 1 in 100-year return period (1% chance of being inundated in any given year). Any location may be designated as a flood-risk area if it has been inundated in the past by a major flood event with heights greater than the 1 in 100-year flood.[149]

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[143] Town of Gibsons

[144] TEEB in Local Policy, 2010.

[145] TEEB in Local Policy, 2010.

[146] TEEB in Local Policy, 2010.

[147] TEEB in Local Policy, 2010.

[148] Doherty, 2012.

[149] Doherty, 2012.

Green Infrastructure: A cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray stormwater infrastructure— conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.[150]

Infrastructure: A means for ensuring the delivery of goods and services that contribute to the quality of life of citizens.[151]

Infrastructure Gap: The gap between spending needed to maintain infrastructure assets and what can be afforded.[152]

Multifunction: The ability for ecosystems to produce multiple ecosystem services simultaneously.[153]

Natural Capital: An economic metaphor for the limited stocks of physical and biological resources found on earth,[154] as opposed to human capital (labour) or produced capital (market, infrastructure, etc.). It comprises the resources that we can easily recognize and measure (e.g. minerals and energy, forest timber, agricultural land, fisheries and water) and ecosystems services that are often 'invisible' (e.g. air and water filtration, flood protection, carbon storage, pollination, and habitat).[155]

Natural Assets: Assets of the natural environment that provide equal or superior civil municipal goods and services as its engineered equivalent (e.g. aquifers, creeks and foreshores).[156]

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[150] Schwab, 2016.

[151] OECD, 2008.

[152] Smart Plan: Gibsons Official Community Plan, 2015.

[153] Swedish Government Official Report, 2013

[154] Town of Gibsons.

[155] TEEB in Local Policy, 2010.

[156] Town of Gibsons.

Natural Infrastructure: see natural assets.

No Adverse Impact: An approach that ensures the action of any community or property owner, public or private, does not adversely impact the property and rights of others. An adverse impact can be measured by an increase in flood stages, flood velocity, flows, the potential for erosion and sedimentation, degradation of water quality, or increased cost of public services.[157]

Resilience: The ability to maintain the same structure, function, and capacity to adapt to stress after being impacted by climate change.

Sustainable Development: Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.[158]

Vulnerability: The degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.[159]

Wetland: Land that has the water table at, near, or above the land's surface, or which is saturated, for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activities adapted to the wet environment.[160]

[157] Schwab, 2016.

[158] WCED, 1987.

[159] IPCC, 2007.

[160] Natural Resources and Energy, Environment and Local Government, 2002.

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PLANNING THE BLUE ZONE: A ROAD MAP FOR IMPLEMENTING A REGIONAL CLIMATE CHANGE ADAPTATION STRATEGY FOR FRESHWATER FLOOD MANAGEMENT IN SOUTHEAST NEW BRUNSWICK

2017