September 2017

Recommendations Report - DRAFT

Climate Lab
University of Prince Edward Island
550 University Avenue
Charlottetown, Prince Edward Island
Canada C1A 4P3
Dear Islanders,

The UPEI Climate Lab is developing the *Prince Edward Island Climate Change Adaptation Recommendations Report* for the Government of Prince Edward Island. We are seeking public input to help us develop relevant, practical, and innovative recommendations for climate change adaptation. Climate change adaptation refers to the ways in which we can take advantage of the opportunities arising from climate change, as well as reduce the negative impacts from climate change.

The recommendations included in this draft report were developed in four stages. First, the public and sector stakeholders were consulted on their concerns regarding climate change and adaptation. Second, adaptation approaches used in other jurisdictions regionally, nationally and internationally were reviewed to prepare a discussion document for each sector. Third, roundtable discussions with stakeholders for each sector were held to review the relevance and practicality of the approaches in the discussion document for the Island and to suggest additional recommendations. Last, the sectors’ input was incorporated in the discussion documents, which form the sector chapters of this draft report.

We are hosting a final round of public consultations next month. They are open to everyone – individuals, businesses, organizations, etc. You can provide feedback online until Friday October 20, 2017 and in person at one of the following public engagement sessions:

- **Charlottetown**: Tuesday, October 17, 5 to 6 pm at UPEI, Andrew Hall building, Room 142 (please use parking lot A or B)
- **Summerside**: Wednesday, October 18, 7 to 8 pm at the Summerside Community Church
- **Montague**: Thursday, October 19, 7 to 8 pm, Riverhouse Inn

Refreshments will be provided. Please register by emailing us at climate@upei.ca with the session you would like to attend. If you are unable to attend the sessions and would like to provide feedback in person, please let us know by email.

We look forward to receiving your input and recommendations. The feedback collected from all public and sector consultations will be reviewed and incorporated in the final report, which will be submitted to the Provincial Government by October 31, 2017.

Thank you,

Dr. Adam Fenech
Director, UPEI Climate Lab
upei.ca/climate
ACKNOWLEDGEMENTS

This work was supported by the Government of Prince Edward Island Department of Communities, Land and Environment.

This Report was developed by Stephanie Arnold of the UPEI Climate Lab with the input of many individuals and organizations. We would like to thank them for their expertise and time. Please note that their participation does not imply their endorsement of this Report and the information presented does not necessarily reflect the views of the participants or the organizations they represent.

Dr. Bishnyu Acharya  
Peter Boswell  
Jessica Brown  
Matthew Carville  
Darren Chaisson  
John Cuninffe  
Rosemary Curley  
Andrew Daggett  
Alex Dalziel  
John Dewey  
Greg Donald  
Brian Dunn  
Darrell Evans  
Dr. Aitazaz Farooque  
Kelly Farrar  
Mary Finch  
Alex Forbes  
Bill Glen  
Melanie Griffin  
Dr. Daryl Guignon  
Dr. Helen Gurney-Smith  
Dr. Matthew Hall  
Janice Harper  
Scott Harper  
Amber Jadis  
Jim Jenkins  
Dr. Yefang Jiang  
Bill Kendrick  
Pooja Kumar  
Evan MacDonald  
James MacDonald  
Rosanne MacFarlane  
Bob MacGregor  
Heather MacLeod  
Shaun MacNeill  
John MacQuarrie  
Ken Mayhew  
Dan McAskill  
Kim McBurney  
Dr. Lyndsay Moffat  
Tanya Mullaly  
Samantha Murphy  
Tom O'Handley  
Angus Orford  
Dr. Heather Pringle  
Mike Proud  
Betty Pryor  
Aaron Ramsay  
Matt Ramsay  
Bruce Raymond  
Brad Romanik  
John Rowe  
Corrine Rowswell  
Peter Rukavina  
Dr. Marina Silva-Opps  
Brenda Simmons  
Ritchie Simpson  
Shirley Smedley Jay  
Ira Smith  
Kyra Stiles  
Dr. Andrew Swingler  
Barry Thompson  
Brian Thompson  
Julie Vasseur  
Ron Waite  
Peter Warris
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>5</td>
</tr>
<tr>
<td>Introduction</td>
<td>17</td>
</tr>
<tr>
<td>Climate Change Impacts</td>
<td>20</td>
</tr>
<tr>
<td>Agriculture Sector</td>
<td>26</td>
</tr>
<tr>
<td>Education and Outreach Sector</td>
<td>39</td>
</tr>
<tr>
<td>Energy Sector</td>
<td>50</td>
</tr>
<tr>
<td>Fish and Aquaculture Sector</td>
<td>65</td>
</tr>
<tr>
<td>Forestry and Biodiversity Sector</td>
<td>82</td>
</tr>
<tr>
<td>Insurance Sector</td>
<td>94</td>
</tr>
<tr>
<td>Properties and Infrastructure Sector</td>
<td>102</td>
</tr>
<tr>
<td>Public Health and Safety Sector</td>
<td>114</td>
</tr>
<tr>
<td>Tourism Sector</td>
<td>126</td>
</tr>
<tr>
<td>Water Sector</td>
<td>133</td>
</tr>
<tr>
<td>Conclusion</td>
<td>145</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

INTRODUCTION

Global climate change is seen as one of the greatest threats posed to the future of humankind and the world. Changes in our climate are often so small as to take decades, centuries, or millennia to be observable. These small changes in climate, however, can have significant impacts on the environment, society, and economy of Prince Edward Island. While climate mitigation strategies are necessary to reduce greenhouse gas emissions from anthropogenic sources, those alone are unlikely to be sufficient to eliminate the negative impacts of climate change. The impacts of climate change from emissions of greenhouse gases over the past 150 years will have to be confronted by all jurisdictions now. Therefore, pursuing a complementary strategy of enabling jurisdictions to adapt to climate change and negate many of the expected adverse impacts is equally, if not more, urgent. This report focuses solely on climate change adaptation.

Effective adaptation requires coordinated efforts of the public, private sector, non-governmental organizations, and all levels of government. The approach must be based on the best evidence available and a spirit of openness and partnership. Joint action also has the added benefit of combining resources, experiences, perspectives, and expertise from different groups to tackle a shared problem. Therefore, the recommended adaptation actions proposed in this document are the responsibilities of different groups, with many of them requiring a collaborative effort from two or more groups.

CLIMATE CHANGE IMPACTS

TEMPERATURE

Climate change is projected to warm most regions of Canada. Over the past fifty years, annual mean temperatures rose in Atlantic Canada (e.g., 0.5°C in Charlottetown, PE) (Fenech, 2015). This trend is expected to continue; using a statistically-downscaled global climate model average, Fenech (2015) forecasts a rise in annual mean temperatures by 0.7°C on average by the 2020s, 1.6°C on average by the 2050s and 2.4°C on average by the 2080s. These may seem small increases in annual average temperatures; however, these small increases have dramatic effects on our environment, society, and economy.
PRECIPITATION

Over the past fifty years, annual total precipitation (rain, snow, sleet) decreased (e.g., -5% in Charlottetown, PE) (Fenech, 2015). This trend is expected to continue. While precipitation is expected to generally increase for Atlantic Canada, Prince Edward Island is forecasted to experience a decrease from today’s normal (1981-2010) by 6% on average by the 2020s, making it drier and more susceptible to drought conditions. Over time, our models show precipitation returning to today’s normal by the 2080s (2071-2100).

EXTREME WEATHER EVENTS

Precipitation events are expected to decrease in frequency and increase in severity under a changing climate. That means there will be fewer events but they will be much more intense such as the December 2014 rainstorm, where over 180-mm fell causing $9 million in damages as a result of run-off, inland flooding, road washouts, etc.

SEA LEVEL RISE

According to the most recent assessment by the U.S. National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, U.S. Geological Survey, Rutgers University, and the U.S. Department of Commerce, global mean sea-level could rise in the range of 2.0 to 2.7 metres by 2100 (Sweet et al., 2017). Rising sea-levels will lead to an increase in the reach and severity of coastal flooding and coastal erosion.

WIND

Fenech and Su (2014) applied statistical downscaling techniques to global climate model output to predict similar average wind velocities as over the past thirty years for Prince Edward Island, Canada. Trends in wind velocity and direction, however, are difficult to determine conclusively, in part because datasets are not as complete as for air temperature (NRCAN, 2016).

SEA ICE

Ocean temperatures in the Magdalen Shallows ocean region where Prince Edward Island sits have increased over the past thirty years. However, by how much sea-ice cover will be reduced with climate change is unclear (Benoît et al., 2012). While climate change can be expected to bring many ice-free
winters, interannual variability will likely ensure that ice will be present during at least some of the winters in the coming decades (Benoît et al., 2012).

**AIR QUALITY**

Ground-level ozone (O₃) is a human toxin and a plant toxin. It is created when two other air pollutants – nitrogen oxides (NOₓ) and volatile organic compounds (VOCs) – react in sunlight and air. Almost all of Prince Edward Islands NOₓ comes from on-island burning of diesel and gasoline for transportation and heavy fuel oil at industrial facilities (Government of Prince Edward Island, 2016). Projections modeled by Kelly et al. (2012) forecast an increase of O₃ concentrations for the Island by the middle of the century as a result of climate change only, with anthropogenic air pollution emissions held constant. However, with an upward trend in air pollution, combined with increasing formation of O₃ with rising temperature (Myers et al., 2017), future levels of O₃ could exceed the maximum threshold.

**RECOMMENDED ADAPTATION ACTIONS**

A total of 86 climate change adaptation actions were recommended for each of the ten sectors studied and consulted: Agriculture, Education and Outreach, Energy, Fish and Aquaculture, Forestry and Biodiversity, Insurance, Properties and Infrastructure, Public Health and Safety, Tourism, and Water.

*Table 1. List of all adaptation actions recommended for ten sectors within Prince Edward Island.*

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agriculture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Commission a comprehensive study of crop opportunities and challenges under warming conditions over the next thirty years.</td>
<td>Leads: Sector, Provincial Government Collaborators: Experts</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td>2. Build an understanding of irrigation requirements and anticipated drought conditions and common methods used to address them.</td>
<td>Leads: Sector, Provincial Government Collaborators: Experts, other sectors</td>
<td>Fill knowledge gaps; Reduce non-climatic factors</td>
</tr>
<tr>
<td>3. Conduct on-farm demonstrations of best practices in adaptation.</td>
<td>Lead: Sector Collaborators: Farmers</td>
<td>Fill knowledge gaps; Engage in outreach</td>
</tr>
<tr>
<td>4. Add 100 climate stations across the Island to improve the collection of climate data, including soil temperature, to develop a baseline for the analysis of climate trends at</td>
<td>Lead: Sector</td>
<td>Fill knowledge gaps; Increase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>higher resolutions.</td>
<td>Collaborators: Farmers, Experts</td>
<td>collaboration</td>
</tr>
<tr>
<td>5. Integrate climate change considerations in the agricultural insurance framework (e.g., offer insurance for new crop varieties expected to thrive and adjust the framework for exiting crops anticipated to struggle under a changing climate).</td>
<td>Lead: Agriculture Insurance Corporation Collaborators: Experts</td>
<td>Fill knowledge gaps; Mainstreaming climate change</td>
</tr>
<tr>
<td>6. Commission a comprehensive study of pests and pathogens that could be introduced to the Island, the types of livestock at risk, and the common methods used in their management.</td>
<td>Lead: Sector, Provincial Government Collaborators: Experts</td>
<td>Fill knowledge gaps; Reduce non-climatic factors</td>
</tr>
<tr>
<td><strong>Education and Outreach</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Integrate climate change in the curriculum for lower grades where interdisciplinary and inquiry-based learning is already taking place (e.g., identify resources and activities).</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Address knowledge gaps; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>8. Integrate climate change in the curriculum for higher grades, focusing on increasing the skills, competencies, and knowledge of students across all subject areas.</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Address knowledge gaps; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>9. Support teachers by implementing small-scale initiatives to introduce climate change to the students in the near-term (e.g., host full-day workshop during PD days, provide inquiry-based activities to teachers).</td>
<td>Lead: Provincial Government Collaborators: Experts, Informal education providers</td>
<td>Address knowledge gaps; Promote climate change mainstreaming; Increase collaboration</td>
</tr>
<tr>
<td>10. Identify ways to increase experiential learning without leaving the school grounds (e.g. design and build a rain garden to manage stormwater on-site).</td>
<td>Lead: Provincial Government, Public Schools Branch, French Language School Board; Private Schools Collaborators: Experts, Home and School Federation</td>
<td>Address knowledge gaps; Engage in outreach</td>
</tr>
<tr>
<td>11. Increase exposure to climate change, interdisciplinary-learning, and inquiry-based learning at the post-secondary level.</td>
<td>Lead: Post-secondary institutions Collaborators: Experts</td>
<td>Address knowledge gaps</td>
</tr>
<tr>
<td>12. Increase awareness of opportunities to learn outside of the classroom.</td>
<td>Leads: Informal education providers, Provincial Government Collaborators: Parents and</td>
<td>Engage in Outreach; Increase collaboration</td>
</tr>
<tr>
<td>Recommendation</td>
<td>Guardians</td>
<td>Leads</td>
</tr>
<tr>
<td>----------------</td>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>13. Develop new informal education programming to expand the students’ knowledge.</td>
<td>guardians</td>
<td>Leads: Informal education providers</td>
</tr>
<tr>
<td>14. Place more emphasis on inspiring action and less on improving understanding of scientific knowledge when engaging the public.</td>
<td></td>
<td>Leads: Municipal and Provincial Governments, all sectors</td>
</tr>
<tr>
<td>15. Encourage knowledgeable provincial staff to communicate with colleagues and citizens about their areas of expertise.</td>
<td></td>
<td>Leads: Provincial Government</td>
</tr>
<tr>
<td>16. Identify different segments of the population (e.g., ‘unconcerned and dismissive’ versus ‘most concerned and motivated’) and generate public outreach approaches accordingly.</td>
<td></td>
<td>Leads and collaborators: All levels of government, All sectors</td>
</tr>
<tr>
<td>17. Leverage best practices in outreach from other sectors and jurisdictions (e.g., EMO is effective in educating the public of risks).</td>
<td></td>
<td>Leads and collaborators: All levels of government, All sectors</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Relocate, retrofit, and/or protect critical energy infrastructure and equipment vulnerable to climate change impacts (e.g., move infrastructure located in areas vulnerable to erosion, add guying to utility poles to avoid cascades of falling poles).</td>
<td></td>
<td>Leads: Utilities</td>
</tr>
<tr>
<td>19. Lower energy demand as a complementary approach to addressing peak capacity (e.g., develop an alert system with suggested actions to reduce consumption when system is near peak capacity to avoid rolling brownouts).</td>
<td></td>
<td>Leads: Utilities, Provincial Government</td>
</tr>
<tr>
<td>20. Decentralize, diversify, and develop redundancy in the sector to increase its capacity to cope with hazardous events and avoid large-scale system failures (e.g., solar panels, energy storage equipment, district energy systems).</td>
<td></td>
<td>Leads: Utilities, Provincial Government</td>
</tr>
<tr>
<td>21. Implement policies and regulations to foster climate change adaptation in the areas such as design and safety standards and permitting, siting and zoning.</td>
<td></td>
<td>Leads: Provincial Government</td>
</tr>
<tr>
<td>Recommendation</td>
<td>Leads</td>
<td>Promote/Increase</td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>-----------------</td>
</tr>
<tr>
<td>22. Integrate climate change impacts into day-to-day operations as well as planning, risk assessment and management, and decision-making processes (e.g., load and demand forecasting, training, investment planning).</td>
<td>Utilities</td>
<td>Climate change mainstreaming</td>
</tr>
<tr>
<td>23. Plan new developments with climate change in mind (e.g., make buildings “solar ready”, site new developments in areas with low vulnerability to coastal erosion and flooding).</td>
<td>Utilities, Businesses, Individuals</td>
<td>Resilience; Climate change mainstreaming</td>
</tr>
<tr>
<td>24. Conduct a cost-benefit analysis of climate change adaptation options. There is growing evidence that the cost of adaptation far outweighs the cost of inaction.</td>
<td>Utilities</td>
<td>Address financial concerns</td>
</tr>
<tr>
<td>25. Increase collaboration and communications among sector stakeholders (e.g., share climate forecasts, coordinate planned shutdowns to minimize impacts on other parties).</td>
<td>Utilities</td>
<td>Increase collaboration</td>
</tr>
<tr>
<td><strong>Fish and Aquaculture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Conduct research and collect data to form a foundation for evidence-based adaptation planning (e.g., create an inventory and map habitats of significant marine species and environmental variables, study effective responses against invasive species).</td>
<td>Sector, Provincial Government</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td></td>
<td>Collaborators: Experts, Environmental groups</td>
<td></td>
</tr>
<tr>
<td>27. Reduce non-climatic stressors to increase the ability of marine life to cope with climate change impacts (e.g., reduce runoff, restore coastal habitats).</td>
<td>Sector, Provincial Government, Federal Government</td>
<td>Increase resilience; Reduce non-climatic factors; Engage in outreach</td>
</tr>
<tr>
<td></td>
<td>Collaborator: Fishers, Experts, Public</td>
<td></td>
</tr>
<tr>
<td>28. Manage risks and adapt to increased variability in the sector via diversification (e.g., diversity livelihoods, decentralize and spread out locations of facilities).</td>
<td>Fishers, Sector</td>
<td>Increase resilience</td>
</tr>
<tr>
<td></td>
<td>Collaborators: Experts</td>
<td></td>
</tr>
<tr>
<td>29. Invite other jurisdictions to share best practices (e.g., seek ways to cope with green crab, share local methods of transferring mussel seed from an infested area to a new area).</td>
<td>Fishers, Sector</td>
<td>Increase collaboration</td>
</tr>
<tr>
<td></td>
<td>Collaborators: Experts</td>
<td></td>
</tr>
<tr>
<td>30. Relocate, retrofit, and/or protect existing properties and infrastructure and redesign new properties and infrastructure to reduce flooding and erosion vulnerabilities.</td>
<td>Infrastructure owners</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>31. Utilize regulatory measures to harmonize adaptation objectives and approaches among different stakeholders that are reliant on the same resource (e.g., prioritize sustainability of the industry and the environment over short-term profit and yield).</td>
<td>Provincial Government, Federal Government</td>
<td>Leverage regulation; Increase collaboration</td>
</tr>
<tr>
<td></td>
<td>Collaborators: Fishers, Sectors, Other sectors</td>
<td></td>
</tr>
<tr>
<td>Recommendation</td>
<td>Lead</td>
<td>Collaborators</td>
</tr>
<tr>
<td>----------------</td>
<td>------</td>
<td>---------------</td>
</tr>
<tr>
<td>32. Employ financial mechanisms such as insurance and other innovative instruments to help limit business losses caused by climatic events (e.g., create a co-operative that offers insurance against production losses).</td>
<td>Leads: Sector, Provincial Government</td>
<td>Collaborators: Fishers, Experts</td>
</tr>
<tr>
<td>33. Recognize opportunities (e.g., improvements in technology and farming practices such as selective breeding).</td>
<td>Leads: Sector</td>
<td>Collaborators: Fishers</td>
</tr>
</tbody>
</table>

**Forestry and Biodiversity**

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Lead</th>
<th>Collaborators</th>
<th>Focus Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Reduce non-climatic stressors to keep forests healthy and productive and maintain biodiversity (e.g., reduce pollution, promote development of ground cover).</td>
<td>Leads: Sector, Provincial Government, Woodlot owners</td>
<td>Collaborators: Environment Groups, Municipal Governments</td>
<td>Reduce non-climatic stressors; Increase resilience</td>
</tr>
<tr>
<td>35. Support research and data collection in climate change impacts and adaptation to create a foundation for evidence-based adaptation (e.g., establish current state of biodiversity).</td>
<td>Leads: Sector, Provincial Government; Collaborators: Environmental Groups, Experts</td>
<td></td>
<td>Full knowledge gaps; Increase collaboration</td>
</tr>
<tr>
<td>36. Increase natural connectivity among natural areas (e.g., preserve core habitat areas, increase hedgerows).</td>
<td>Leads: Provincial Government Collaborators: Sectors, Municipal Governments, Public, Environmental Groups</td>
<td></td>
<td>Increase resilience</td>
</tr>
<tr>
<td>37. Increase natural areas (e.g., restore abandoned agricultural fields, sell tree saplings as school fundraisers).</td>
<td>Leads: Provincial Government, Environmental Groups Collaborators: Public</td>
<td></td>
<td>Increase resilience</td>
</tr>
<tr>
<td>38. Leverage regulation to promote needed adaptation where existing incentive is lacking (e.g., expand the buffer zone).</td>
<td>Lead: Provincial Government Collaborators: Sectors</td>
<td></td>
<td>Leverage regulation; Reduce non-climatic factors</td>
</tr>
<tr>
<td>39. Assign an economic value to the ecosystem services that forests provide (e.g., pollination and carbon storage services).</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td></td>
<td>Address financial concerns</td>
</tr>
<tr>
<td>40. Engage in outreach to generate additional support for adaptation actions (e.g., frame the benefits of forests and biodiversity in ways that resonate with the public).</td>
<td>Lead: Provincial Government Collaborators: Sector, Environmental Groups, Experts</td>
<td></td>
<td>Engage in outreach; Increase collaboration; Fill knowledge gaps</td>
</tr>
<tr>
<td>41. Connect with other environmental groups, community groups, and sectors to raise support for adaptation activities (e.g., coordinated habitat restoration for Fish and Aquaculture and Forestry and Biodiversity sectors).</td>
<td>Leads: Environmental Groups, Sectors Collaborators: Provincial Government, Experts</td>
<td></td>
<td>Increase collaboration</td>
</tr>
<tr>
<td>42. Collaborate with local Indigenous groups to incorporate Traditional Ecological Knowledge.</td>
<td>Lead: Sector Collaborators: Indigenous groups, Provincial Government, Environmental groups</td>
<td></td>
<td>Increase collaboration; Fill knowledge gap</td>
</tr>
<tr>
<td>43. Increase capacity within the government (e.g., dedicate more staff to outreach)</td>
<td>Lead: Provincial Government</td>
<td></td>
<td>Fill knowledge gap; Engage in outreach</td>
</tr>
<tr>
<td>44. Develop a coordinated approach to implement the</td>
<td>Leads: Provincial Government,</td>
<td></td>
<td>Increase</td>
</tr>
<tr>
<td>Suggested Adaptation Actions for the sector (e.g., stakeholder meetings, on-site demonstrations).</td>
<td>Sector Collaborators: Woodlot owners, Environmental groups, Outreach groups</td>
<td>collaboration; Engage in outreach; Fill knowledge gaps</td>
<td></td>
</tr>
</tbody>
</table>

### Insurance

| 45. Gather required data to address concerns of risk exposure (e.g., create and update flood risk maps). | Lead: Sector, Insurers Collaborators: Experts, Federal Government | Fill knowledge gaps; Increase Collaboration |
| 46. Raise public awareness on the different types of flooding and the different types of insurance coverage. | Lead: Sector Insurers | Engage in outreach |
| 47. Look for opportunities to develop new insurance products (e.g., insure against coastal flooding). | Lead: Sector Collaborators: Insurers, Experts | Fill knowledge gaps; Increase Collaboration |
| 48. Promote adaptation actions, especially where insurance coverage is limited or unavailable (e.g., use visualization techniques to inspire adaptation, encourage relocation from areas of high flood risk). | Lead: Sector, All levels of government Collaborators: Other sectors, Experts | Engage in outreach |

### Properties and Infrastructure

| 49. Address budgetary constraints through financial planning (e.g., create an inventory of roads and bridges in coastal zone and perform a cost-benefit analysis to prioritize adaptation). | Leads: Property and infrastructure owners (e.g., individuals, businesses, governments) | Address financial concerns; Promote climate change mainstreaming |
| 50. Make erosion and coastal and inland flood risk maps available to all asset owners. | Lead: Provincial government Collaborators: Experts | Fill knowledge gaps |
| 51. Set a future climate scenario to establish design standards (e.g., should roads be built to withstand 1-in-50 year or 1-in-100 year rain events and are the events taking place in 2020, 2050 or 2100?). | Lead: Provincial Government Collaborators: Experts | Promote climate change mainstreaming |
| 52. Incorporate future climate considerations into land use and building regulations (e.g., increase horizontal and vertical setbacks, require additional information during the development permit process). | Lead: Provincial and Municipal Governments Collaborators: Other sectors, Experts | Leverage regulation; Promote climate change mainstreaming |
| 53. Explore the issue of liability surrounding developments and real estate transactions within flooding and erosion risk zones. | Leads: Provincial Government Collaborators: Experts | Fill the knowledge gaps |
| 54. Utilize complementary green infrastructure when upgrading or designing stormwater management systems (e.g., rain gardens). | Leads: Stormwater management system managers and owners, Homeowners Collaborators: Experts, Other sectors | Increase resilience |
| 55. Encourage a bottom-up approach by making property and infrastructure owners and managers aware of projected climate change impacts, adaptation actions available to them, and how those actions should be implemented. | Lead: Provincial Government Collaborators: Educators, Other sectors | Engage in outreach; Fill knowledge gaps |
| 56. Provide a forum for asset and infrastructure owners and managers to learn and share best practices. | Lead: Provincial Government Collaborators: Municipal Governments, Sector, Public | Fill knowledge gap; Engage in outreach; Increase collaboration |

### Public Health and Safety
<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Lead</th>
<th>Collaborators</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>57. Invite other jurisdictions to share best practices and innovative approaches (e.g., WHO developed a tool to estimate costs and benefits of adaptation decisions).</td>
<td>Provincial Government</td>
<td>Experts</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td>58. Integrate climate change impacts in all existing vulnerability assessments, management activities, policies, programs, etc. (e.g., adjust the operating budget to allow for increased demand for services).</td>
<td>Provincial Government</td>
<td>Experts</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>59. Develop a public outreach strategy for the general public to help them adapt to climate change. The information should be practical and relevant on a personal level and does not have to discuss climate change.</td>
<td>Provincial Government</td>
<td>Educators</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>60. Evaluate the knowledge gaps in the existing system and identify data, skills, or expertise required to address climate change impacts; develop multidisciplinary partnerships; and, support interdisciplinary research.</td>
<td>Provincial Government</td>
<td>Educators, Other sectors</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>61. Monitor and map environmental factors and other events related to public health to identify high-risk areas (e.g., algae bloom outbreaks, fish kills, water temperature, air quality).</td>
<td>Provincial Government</td>
<td>Experts</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>62. Reduce non-climatic factors (e.g., prevent chronic disease so Islanders will become more resilient and able to cope with climate change impacts).</td>
<td>Provincial Government</td>
<td>Educators</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>63. Create a mechanism at the community-scale to identify and assist vulnerable groups when emergencies arise so first responders can focus on those with the greatest needs.</td>
<td>Municipal government, EMO</td>
<td>Public</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>64. Conduct training exercises involving emergency services and local responders to respond to severe, wide area flooding and improve response time.</td>
<td>EMO</td>
<td></td>
<td>Fill knowledge gap</td>
</tr>
<tr>
<td>65. Ensure dual access to properties when possible to assist in the emergency management response should one access route be impassable (e.g., flooded, washed out, surrounded by forest fire).</td>
<td>Property owners</td>
<td>EMO</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>66. Create lists of safe spaces within communities and establish a mechanism to communicate the choice before/during/after the event.</td>
<td>Municipal governments, EMO</td>
<td></td>
<td>Increase resilience; Increase collaboration</td>
</tr>
</tbody>
</table>

**Tourism**

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Lead</th>
<th>Collaborators</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>67. Forecast future climate variables that impact tourism (e.g., number of “comfort days” for golf, soft adventure).</td>
<td>Sector, Provincial Government</td>
<td>Experts</td>
<td>Address financial concerns</td>
</tr>
<tr>
<td>68. Develop more offerings for the shoulder seasons (e.g., festivals, events, experiential products).</td>
<td>Sector</td>
<td>Tourism operators</td>
<td>Promote climate change mainstreaming</td>
</tr>
<tr>
<td>69. Promote Prince Edward Island as an escape from urban heat.</td>
<td>Provincial Government</td>
<td>Sector</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>70. Protect assets and infrastructure that are vulnerable to the effects of flooding and erosion (e.g., relocate at-risk tourist accommodations, protect scenic routes, site new attractions away from flood and erosion risk zones).</td>
<td>Provincial Government, Asset and infrastructure owners</td>
<td>Sector, Tourism operators</td>
<td>Leverage regulation; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>71. Golf course operators may need to consider new</td>
<td>Golf course operators</td>
<td></td>
<td>Increase resilience</td>
</tr>
<tr>
<td>PEI Climate Change Adaptation Recommendations Report – DRAFT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>irrigation methods and select different turfgrass that</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>would be suitable under a changing climate.</strong></td>
<td>Collaborators: Experts</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>72. Diversify product offering (e.g., eco-tourism, cultural</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>heritage, and culinary experiences) to include more all-</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>weather products.</strong></td>
<td>Lead: Tourism operators</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborator: Sector</strong></td>
<td>Increase resilience</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>73. Determine the viability of storm-watching as an</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>attraction on the North Shore.</strong></td>
<td>Lead: Parks Canada, Tourism operators</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborator: Sector</strong></td>
<td>Engage in outreach;</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fill knowledge gap</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>74. Integrate climate change considerations in financial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>planning. Water infrastructure owners and managers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>need to consider the costs and timing of adaptation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>actions in relation to the costs associated with the</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>increase in liability, increase in maintenance, shorter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>lifespan, etc.</strong></td>
<td>Leads: Property owners, Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborator: Sector</strong></td>
<td>Fill knowledge gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>75. Set a future climate scenario to establish design</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>standards and analyze the resilience of existing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>infrastructure (e.g., should stormwater management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>systems be built to withstand 1-in-50 year or 1-in-100</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>year rain events and are the events taking place in 2020,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2050 or 2100?)</strong></td>
<td>Leads: Provincial Government, Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Experts</strong></td>
<td>Fill knowledge gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>76. Put back-up systems in place to limit disruptions to</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>service during extreme weather events (e.g., spare flood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>pumps, back up electricity source).</strong></td>
<td>Leads: Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborator: Sector</strong></td>
<td>Engage in outreach</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>77. Utilize land use planning policies and regulations to</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>prompt the development of climate-resilient water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>infrastructure (e.g., include septic tanks in building</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>setback).</strong></td>
<td>Leads: Provincial Government, Collaborators: Experts</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Sector</strong></td>
<td>Address financial constraint</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>78. Reducing demand on water infrastructure (e.g.,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>sensitize public to the challenges facing groundwater,</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>provide practical recommendations on how to reduce</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>demand).</strong></td>
<td>Lead: Provincial Government, Collaborators: Educators, Public</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Experts</strong></td>
<td>Increase collaboration</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>79. Consider complementary green infrastructure when</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>upgrading stormwater management systems (e.g. green</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>roofs, rain gardens).</strong></td>
<td>Lead: Property owners, Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Provincial and Municipal Governments, Experts</strong></td>
<td>Increase resilience</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>80. Create a pilot project to demonstrate bioretention</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>techniques (see Adaptation Action #79).</strong></td>
<td>Lead: Provincial Government, Collaborators: Educators</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Sector</strong></td>
<td>Engage in outreach; Fill knowledge gap</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>81. Supply flood risk maps to municipalities with water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>infrastructure.</strong></td>
<td>Lead: Provincial Government, Collaborators: Municipal governments</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Sector</strong></td>
<td>Fill knowledge gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>82. Identify needs for data, training, knowledge and tools</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(e.g., install weather stations, improve understanding of</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>groundwater recharge and discharge rates, provide</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>training on watershed monitoring and restoration).</strong></td>
<td>Lead: Provincial Government, Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Experts</strong></td>
<td>Fill knowledge gaps</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>83. Engage in public outreach. Provide guidance on how</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>to minimize the risk of flooding and improve water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>security.</strong></td>
<td>Lead: Provincial government, Collaborators: Municipal governments, Educators</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Sector</strong></td>
<td>Engage in outreach</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>84. Provide financial incentive to property owners to</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>manage stormwater on site (e.g., ditches, permeable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>surfaces).</strong></td>
<td>Leads: Provincial Government, Municipal governments, Water infrastructure owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaborators: Sector</strong></td>
<td>Address financial constraint</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Despite the unique characteristics of each sector, common themes emerged from the recommended adaptation actions: fill knowledge gaps, increase resilience, reduce non-climatic factors, promote climate change mainstreaming, increase collaboration, engage in public outreach, leverage regulation (e.g., land use planning), and address financial concerns.

MOVING FORWARD

Throughout the sector consultation sessions, the consensus on climate change and the need to adapt was clear. There were high levels of awareness and adaptive capacity observed at the consultation sessions. However, there exist barriers to adaptation across all groups and sectors that are preventing efficient adaptation from taking place. The common barriers and the associated potential solutions include: uncertainty, lack of funding, insufficient incentive, lack of guidance, requirement for high levels of coordination, and gradual nature of climate change.

To move forward, it must be recognized that climate change is a shared problem that requires shared responsibility from everyone – individuals, businesses, non-governmental organizations, sectors, different levels of government, etc. Joint action is required in instances where different groups and sectors are impacted. The provincial government could play a critical role in leading the development of a medium- and long-term strategy in adapting to climate change. They have expertise across all sectors, the authority to compel action, and ability to coordinate and implement large-scale initiatives.

Climate change adaptation needs to be mainstreamed, that is to say climate change considerations should be integrated into all existing decision-making processes (e.g., financial planning, risk estimation and evaluation). Similar to safety, climate change adaptation is not a “priority” – it must be considered a normal way of life. It is time to shift from coping to adapting. Planned adaptation takes time. Fortunately, the gradual nature of climate change affords us that time, but the work must begin immediately.

References


1 INTRODUCTION

1.1 CLIMATE CHANGE

Global climate change is seen as one of the greatest threats posed to the future of humankind and the world. Climate is not weather. Weather is short-term changes (hours, days) in temperature, cloud cover, precipitation (rain, snow, sleet), humidity or wind at the local or regional scale. Climate, on the other hand, is long-term changes (months, seasons, years, decades) in these variables at the global, regional or local scale. Changes in our climate are often so small as to take decades, centuries, or millennia to be observable. These small changes in climate, however, can have significant impacts on the environment, society, and economy of Prince Edward Island.

There are two main responses to addressing climate change: mitigation and adaptation (see Figure 1.1). Mitigation looks to combat climate change by reducing greenhouse gas emissions, the root cause of climate change. Adaptation addresses the symptoms of climate change by adjusting decisions, activities, behaviours, and mentalities to take advantage of the opportunities arising from climate change and to reduce the negative consequences of climate change.

While climate mitigation strategies are necessary to reduce greenhouse gas emissions from anthropogenic sources, those alone are unlikely to be sufficient to eliminate the negative impacts of climate change. The impacts of climate change from emissions of greenhouse gases over the past 150 years will have to be confronted by all jurisdictions now. Therefore, pursuing a complementary strategy of enabling jurisdictions to adapt to climate change and negate many of the expected adverse impacts is equally, if not more, urgent. This report focuses solely on climate change adaptation.
1.2 CLIMATE CHANGE ADAPTATION

Climate change adaptation is necessary to survive and thrive under a changing climate. Unlike coping, which is primarily reacting to immediate damages associated with climate impacts, adaptation requires developing an informed, forward-looking, comprehensive strategy that supports broader goals such as resiliency and sustainability of the environment, society, and economy. Adaptation can take many forms: technological, operational, financial, sociological, or regulatory/administrative (Johnson, 2012).

Effective adaptation requires coordinated efforts of the public, private sector, non-governmental organizations, and all levels of government. The approach must be based on the best evidence available and a spirit of openness and partnership. Private adaptation actions are essential given the highly localized nature of climate change impacts and their effects on different parts of society and economy. Government adaptation actions are critical in addressing barriers to timely and effective adaptation. Joint action also has the added benefit of combining resources, experiences, perspectives, and expertise from different groups to tackle a shared problem. Therefore, the recommended adaptation actions proposed in this document are the responsibilities of different groups, with many of them requiring a collaborative effort from two or more groups.

1.3 REPORT FORMAT

This report – Prince Edward Island Climate Change Adaptation Recommendations Report (DRAFT) – contains thirteen chapters and an Executive Summary. This introduction (Chapter 1) is followed by an overview of Climate Change Impacts (Chapter 2), which provides observed and projected changes in climate (e.g., temperature, precipitation, extreme weather events, sea level rise) specific to Prince Edward Island. Chapter 3 to 12 constitute the main body of this report, with one chapter dedicated to each of the ten sectors studied and consulted: Agriculture, Education and Outreach, Energy, Fish and Aquaculture, Forestry and Biodiversity, Insurance, Properties and Infrastructure, Public Health and Safety, Tourism, and Water. These chapters address the sectors’ sensitivities to climate, the risks and opportunities presented by climate change, and recommended adaptation actions to address them. These adaptation recommendations were developed in four stages. First, the public and sector stakeholders were consulted on their concerns regarding climate change and adaptation. Second, adaptation approaches used in other jurisdictions regionally, nationally and internationally were reviewed to prepare a discussion document for each sector. Third, roundtable discussions with stakeholders were held for each of the sectors to review the relevance and practicality of the approaches in the discussion document for Prince Edward Island and to suggest additional recommendations. Last, the sectors’ feedback was incorporated in the discussion documents, which form the sector chapters of this draft report. The conclusion (Chapter 13) of this report examines adaptation themes and barriers common to all sectors and the initiatives required to move forward collectively.
References

2 CLIMATE CHANGE IMPACTS

2.1 TEMPERATURE

Climate change is projected to warm most regions of Canada. Over the past fifty years, annual mean temperatures rose in Atlantic Canada (e.g., 0.5°C in Charlottetown, PE) (Fenech, 2015). This trend is expected to continue; using a statistically-downscaled global climate model average, Fenech (2015) forecasts a rise in annual mean temperatures by 0.7°C on average by the 2020s, 1.6°C on average by the 2050s and 2.4°C on average by the 2080s. These may seem small increases in annual average temperatures; however, these small increases have dramatic effects on our environment, society, and economy.

These seemingly minute increases in annual mean temperatures will influence the extremes of temperature significantly – the number of days exceeding extreme hot temperatures (>27.5°C) will likely increase from our current normal of 8 per year on average (1981-2010) to 16 per year on average in the 2020s (2011-2040), to 22 per year on average in the 2050s (2041-2070) and to 35 per year on average in the 2080s (2041-2100) (see Figure 2.1). The number of days exceeding extreme cold temperatures (<-20°C) will likely decrease from our current normal of 6 per year on average (1981-2010) to 5 per year on average in the 2020s, to 4 per year on average in the 2050s, to 3 per year on average in the 2080s (see Figure 2.2).

Figure 2.1. Projected number of days exceeding extreme hot temperatures (>27.5°C) for Charlottetown, PEI, Canada (Source: Preliminary results from statistically downscaled averages from Fenech and Jien (2015) using SDSM).
2.2 PRECIPITATION

Over the past fifty years, annual total precipitation (rain, snow, sleet) decreased (e.g., -5% in Charlottetown, PE) (Fenech, 2015). This trend is expected to continue. While precipitation is expected to generally increase for Atlantic Canada, Prince Edward Island is forecasted to experience a decrease from today’s normal (1981-2010) by 6% on average by the 2020s, making it drier and more susceptible to drought conditions (see Figure 3). Over time, the models show precipitation returning to today’s normal by the 2080s (2071-2100) (Fenech, 2016).
2.3 EXTREME WEATHER EVENTS

Precipitation events are expected to decrease in frequency and increase in severity under a changing climate. That means there will be fewer events but they will be much more intense such as the December 2014 rainstorm, where over 180-mm fell causing $9 million in damages as a result of run-off, inland flooding, road washouts, etc.

Figure 2.4. Extreme Precipitation Event on Prince Edward Island, Canada in December 2014.

2.4 SEA LEVEL RISE

Sea levels increased 33 cm per century from 1920-2011 (see Figure 2.5) at Charlottetown, Prince Edward Island (Daigle, 2012). Sea levels continue to rise, as do future projections made by scientists. According to the most recent assessment by the U.S. National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, U.S. Geological Survey, Rutgers University, and the U.S. Department of Commerce, global mean sea-level could rise in the range of 2.0 to 2.7 metres by 2100 (Sweet et al., 2017). Rising sea-levels will lead to an increase in the reach and severity of coastal flooding and coastal erosion.
2.5 WIND

Fenech and Su (2014) applied statistical downscaling techniques to global climate model output to predict similar average wind velocities as over the past thirty years for Prince Edward Island, Canada. Trends in wind velocity and direction, however, are difficult to determine conclusively, in part because datasets are not as complete as those for air temperature (Natural Resources Canada, 2016).

2.6 SEA ICE

Ocean temperatures in the Magdalen Shallows ocean region where Prince Edward Island sits (see Figure 2.6) have increased over the past thirty years (see Figure 2.7). However, by how much sea-ice cover will be reduced with climate change is unclear (Benoît et al., 2012). Senneville and Saucier (2007) estimated using numerical modelling that a 2°C increase in air temperature could translate to a decrease of up to 28% in ice cover and 55% in ice volume. While such winter temperature increases might seem far off into the future, the current interannual variability is already of this magnitude (Galbraith et al., 2011). While the much larger anomaly of 4.7°C observed in the winter of 2010 coincided with the almost complete absence of ice in the Gulf of St. Lawrence, the anomaly during the winter of 2011 was only 1.7°C and a similar very low ice cover occurred, much lower than foretold by such models. And while climate change can be expected to bring many ice-free winters, interannual variability will likely ensure that ice will be present during at least some of the winters in the coming decades (Benoît et al., 2012).
2.7 AIR QUALITY

Air quality in Canada is measured using the Air-Quality Health Index (AQHI), a three pollutant health metric designed by Health Canada in conjunction with Environment Canada, to convey the effects of air pollution on acute human health outcomes to the general public (Stieb et al., 2008). The AQHI is a function of three chemical species: ground-level ozone (O$_3$), particulate matter less than 2.5 microns (PM2.5) and nitrogen dioxide (NO$_2$). Projections of the AGHI by Kelly et al. (2012) do not show an increase in the overall average values under climate change, and only a slight increase in the extreme values.

Ground-level ozone (O$_3$) is a human toxin and a plant toxin. It is created when two other air pollutants – nitrogen oxides (NOx) and volatile organic compounds (VOCs) – react in sunlight and air. Almost all of Prince Edward Islands NOx comes from on-island burning of diesel and gasoline for transportation and heavy fuel oil at industrial facilities (Government of Prince Edward Island, 2016). VOCs are generated from many different sources; 36% of it originated from the burning of wood for home heating in 2014.
(Government of Prince Edward Island, 2016). The levels of O₃ in Prince Edward Island in 2011-2013 were between 54ppb (Southampton) and 55ppb (Charlottetown and Wellington), all below the maximum threshold of 63 ppb. However, projections modeled by Kelly et al. (2012) forecast an increase of O₃ concentrations for the Island by the middle of the century as a result of climate change only, with anthropogenic air pollution emissions held constant. However, with an upward trend in air pollution, combined with increasing formation of O₃ with rising temperature (Myers et al., 2017), future levels of O₃ could exceed the maximum threshold.

References


Daigle, R. (2012). Sea Level Rise and Storm Surge Projections for Prince Edward Island [Presentation at PEI’s Changing Climate: Results of the Atlantic Regional Adaptation Collaborative on Climate Change on April 17, 2012].


3 AGRICULTURE SECTOR

3.1 BACKGROUND

Agriculture has been an integral part of Prince Edward Island’s history, economy, and identity for generations. Out of the Island’s 1.4 million acres of land, approximately 0.6 million acres are cleared for agricultural use (see Figure 3.1). There were a total of 1,500 farms reported in the 2011 census; they range in size from a few acres to 3,000 acres (PEI Agriculture and Fisheries, 2015). In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the agriculture sector contributing $152 million or 3.2% (see Figure 3.2). In 2016, the agriculture and aquaculture industries employed approximately 3,100 people, out of 71,000 across all industries in the province (see Figure 3.3). The sector’s contribution to the provincial Gross Domestic Product or GDP (i.e., the total value of all goods and services produced in Prince Edward Island) increases to 10% (Campbell et al., 2014) and it becomes the largest provincial employer if food processing is included (see Figure 3.4).

![Figure 3.1. Agricultural land use in 2011](Source: PEI Agriculture and Fisheries, 2015)
Figure 3.2. Prince Edward Island GDP of crop and animal production in 2016 (in $million chained 2007 dollars). (Source: Statistics Canada, 2017b)

Figure 3.3. Employment in the agriculture sector compared to total employment as of January 2017 (Data source: Statistics Canada, 2017a). Note: Data for “agriculture” includes aquaculture.
3.1.1 CROP PRODUCTION

The 1,500 farms on Prince Edward Island are used primarily for growing crops and raising livestock. Out of all crops, potatoes generate the highest farm cash receipts\(^1\). In 2015, 89,500 acres were harvested (PEI Statistics Bureau, 2016), which generated farm cash receipts of approximately $223.8 million (see Figure 3.5). Potatoes are sold as table potatoes, seed potatoes and “fresh for processing” to other potato-producing regions, and potato products (e.g., french fries and other frozen potato products). Some are also stored as local seed for the next crop. PEI potatoes are sold in the Maritimes, across Canada, the United States and overseas (PEI Department of Agriculture and Fisheries [PEI AF], 2015). Grains (e.g., wheat, barley, oats) and oil seeds (e.g., soybeans) are primarily grown in rotation with potatoes. In 2015, 89,000 acres of grains and 58,000 acres of oilseeds were harvested (PEI AF, 2015), generating farm cash receipts of approximately $33.9 million (see Figure 3.5). The remaining crops are fruits ($10.7 million) such as blueberries, cranberries, strawberries, apples, grapes, etc. and “other” ($24.6 million), which include floriculture and nursery products.

\(^1\) Farm cash receipts are total monies paid to the farmer (e.g., revenues from sales, payments from insurance programs, payments from government agencies) before expenses (e.g. operating expenses, depreciation).
3.1.2 ANIMAL PRODUCTION

Out of all the livestock, dairy products generate the highest farm cash receipts. In 2015, approximately 180 dairy farms produced more than 100 million litres of milk (PEI AF, 2015) and generated farm cash receipts of $75.1 million (see Figure 3.5). Most of the milk is used to produce dairy products such as cheese, butter and ice cream; the remainder is used to supply the fresh market (PEI AF, 2015). Cattle and calves are second in farm cash receipts with approximately $39.3 million in 2015 (see Figure 3.5). Approximately 40% of farms on Prince Edward Island engage in beef production (PEI AF, 2015). This industry is tightly linked with the potato sector because they purchase cull potatoes and crops used in potato rotation as part of the beef feed ration. The remaining livestock and products categories are hogs ($12.4 million), eggs ($5.4 million) and “other” ($18.2 million).
3.2 IMPACTS OF CLIMATE CHANGE

Climate change will bring about warmer weather, changes in precipitation patterns, more intense storms, and rising sea levels in Prince Edward Island.

It is critical to note that opportunities and challenges resulting from climate change cannot be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the advantages in a longer growing season from warmer temperatures could be offset by the invasive pests and diseases that those temperatures bring.

3.2.1 TEMPERATURE

OPPORTUNITIES

Firstly, Fenech’s (2016) preliminary forecast shows 50 additional frost free days and 25 more days in the growing season (see Figures 3.6 and 3.7). This could potentially result in a double harvest for short season crops (e.g., soy beans followed by peas), increased yields for longer season crops, and better establishment of cover crops in the fall following row crop harvest.

![Figure 3.6. Historical observations and preliminary projections for the number of frost free days in Charlottetown, PE, Canada (Source: Fenech, 2016).](image-url)
Secondly, the rise in temperatures and will also increase the number of growing degree days (GDD) over 5°C by 500 by the 2050s (see Figure 3.8), which may be conducive to the planting of new and possibly more profitable crops that require more heat units (e.g., pulses such as lentils, dry peas, chickpeas, dry beans). In other areas of Canada, pulses are almost exclusively grown as a rotational crop with varieties such as wheat and canola (Bekkering, 2014).

Thirdly, the milder winter and spring seasons would be less harsh on pollinators. It would increase winter survival of honey bees and encourage build-up of colonies in the spring (Currie, n.d.).

Fourthly, shorter and milder winters will provide more opportunities for livestock to graze and be fattened outdoors, lower feed requirements, and increase survival rate of young (Agriculture and Agri-Food Canada [AAFC], n.d.).
CHALLENGES

Firstly, warmer temperatures will impact the range, frequency, and severity of pest and pathogen infestations that will, in turn, impact crops and livestock (AAFC, n.d.). The severity of outbreaks of existing pests and diseases will increase (Campbell et al., 2014), the winter survival rates of insect pests will increase and the range of new pests and diseases will shift northward (Myers et al., 2017). Crops are often unable to defend against non-native pests and pathogens (Myers et al., 2017). Animal health could be impacted by the presence of more ticks, mosquitoes, parasites, bacteria (Campbell et al., 2014).

Secondly, pollinators will face increased pest and disease activity, undermining their health. Their diet will also be disrupted by the change in timing of flowering due to warmer weather, the northward migration of plant communities, and the reduction in nutritional value of pollen due to increasing carbon dioxide concentrations (Myers et al., 2017). These changes limit the breadth and quality of their diet and could also lead to the poor pollinator health, in addition to a reduction in population, and possibly the eventual extinction of plants and pollinators (Myers et al., 2017).

Thirdly, the added heat will increase evaporation, causing water stress and lowering crop productivity (Campbell et al., 2014). Rain-fed crops will be especially vulnerable (Myers et al., 2017).

Fourthly, the milder winter and spring seasons could increase the likelihood of winter bud kill, especially for fruit trees and vines (Campbell et al., 2014). Plants that are normally dormant could begin to grow when unseasonably warm temperatures occur and begin to sprout leaves, flowers, and fruits. When temperatures suddenly return to freezing temperatures, the new growth could be damaged. It is possible that fruit and flower buds may not be able to bloom again later that year.

Fifthly, warmer summers could increase heat-wave deaths of livestock and decrease milk production, beef cattle weight gain, and reproduction in the dairy industry (AAFC, n.d.). Livestock feed may be impacted as the cropping sector adapts to the changing climate (Campbell et al., 2014).

Sixthly, warmer temperatures encourage the growth of weeds (Campbell et al., 2014).

Seventhly, warmer temperatures increase the survival rates of “volunteers” – potatoes that remain in the field after harvest. When winter frost does not penetrate the soil deeply, the volunteers can survive and regrow the next season, becoming a source of disease for neighbouring fields (B. Simmons, personal communication, September 15, 2017).
3.2.2 PRECIPITATION

CHALLENGES

Reduced precipitation combined with greater evapotranspiration from warmer temperatures could lead to higher reliance on irrigation management.

3.2.3 EXTREME WEATHER EVENTS

CHALLENGES

Firstly, these events greatly decrease crop yields by as much as 50% of the average yield during normal conditions (AAFC Canada). For example, PEI’s summer growing season of 2012 saw less than half the normal amount of rainfall, reducing low levels in streams and creeks and nearly caused a revocation in irrigation permits (Brennan, 2012). This could have impacted yield of some potato varieties by 25% (Fenech, 2012). In 2001, severe drought caused average potato yield reductions of 40% across the Island, with some farms experience greater losses (B. Simmons, personal communication, September 15, 2017).

Secondly, these events can compromise crop defences and allow pests and weeds to establish themselves (Myers et al., 2017)

Thirdly, heavy rain events and storm surge could also cause increased bank erosion and increased runoff, transporting sedimentation and chemicals such as pesticides and nutrients to water bodies, potentially causing eutrophication, fish kills, and other environmental damage.

Fourthly, extreme weather events such as droughts and floods can also decrease the availability of pasture and the amount of forage for herds.

3.2.4 SEA LEVEL RISE

CHALLENGES

Firstly, the likelihood of salt water intrusion in coastal aquifers would increase.

Secondly, bank erosion rates will increase.

Thirdly, low-lying areas will become permanently inundated. Erosion and flooding will decrease the availability of agricultural land.
3.2.5 CARBON DIOXIDE

Although the increasing concentrations of atmospheric carbon dioxide is the primary driver of climate change and is responsible for the impacts described above, the carbon dioxide itself also impacts the agriculture sector.

**OPPORTUNITIES**

The increase in concentration of carbon dioxide in the atmosphere can improve crop yield in three ways: accelerating the rate of photosynthesis, raising the efficiency of water use in plants, and strengthening plant defences against pests and pathogens (Myers *et al.*, 2017).

**CHALLENGES**

Firstly, increasing carbon dioxide concentrations in the atmosphere encourages the growth of weeds. Herbicides are not as effective in reducing this growth induced by elevated CO₂ concentrations (Myers *et al.*, 2017).

Secondly, carbon dioxide changes the nutritional composition of crops. Experiments have shown a 7-15% decrease in the protein content in edible portion of wheat, barley, and potatoes (Myers *et al.*, 2017).

3.2.6 GROUND-LEVEL OZONE

**CHALLENGES**

Ground-level ozone (O₃) is a human toxin as well as a plant toxin. It hampers crop photosynthesis and growth, and reduces grain weight and yields (Myers *et al.*, 2017). Experiments have shown that yields of wheat and soybean can decrease by 8-25% when O₃ levels are between 54 ppb and 75 ppb (Myers *et al.*, 2017).

3.2.7 UNKNOWNS

There are other indirect impacts of climate change that will affect the agriculture sector. For example, rising temperatures could open the Northwest Passage and impact trade routes. This could open new markets for export and/or raise competition. Food access and security will become increasingly valued with climate change. Model simulations have shown the global prices of staple grains such as wheat would increase 31-106% by 2050 (Myers *et al.*, 2017).
Efforts in climate change mitigation and adaptation in other sectors could have a significant impact on the agriculture sector as efforts to reduce energy use, water use, runoff, and greenhouse gas emissions gain momentum.

3.3 RECOMMENDED ADAPTATION ACTIONS

1. Commission a comprehensive study of crop opportunities and challenges under warming conditions over the next thirty years. The study should include:
   a. high resolution forecasts of temperature forecasts for different parts of the island so the agriculture sector can plan accordingly;
   b. a list of new and existing crop varieties, cover options, and rotation crop options that would best allow farmers to take advantage of the added heat from warmer temperatures, and the lengthening of the growing season;
   c. an analysis of existing crop varieties that would produce lower yields in higher temperatures. For example, the yield of Russet Burbank potatoes in the State of Washington decreased in areas experiencing higher temperatures (University of Nebraska-Lincoln, n.d.);
   d. a list of new pests and pathogens that could be introduced to the Island under the future climate, the types of crops that are at risk, and the common methods used in their management;
   e. a list of new technologies available to help crops adapt to the expected changes in climate (e.g., new crop protection products);
   f. an analysis of how the competitive landscape (e.g., markets, pricing) of the main crop varieties will change under the new future climate; and,
   g. a review of how other jurisdictions producing the main crop varieties are adapting to a changing climate.

2. Build an understanding of irrigation requirements by commissioning a study to investigate past, present and anticipated drought conditions and common methods used to address them. The study should include:
   a. correlation between past yield and precipitation, if any;
   b. crop-specific drought forecasting models for main crop varieties on PEI;
   c. high resolution forecasts of precipitation trends (e.g., length and severity of dry conditions, timing and severity of intense rain events) for different parts of the island so the sector can plan accordingly;
   d. anticipated irrigation requirements for the forecasted future climate;
   e. water management practices and structures suitable for future climate (e.g., use of mulching, contoured hedgerows and buffers, soil features, rainwater harvesting, manmade ponds, desalination, water efficiency and conservation strategies, conservation tillage); and,
f. a cost-benefit analysis of the water management practices and structures (see Recommended Adaptation Action #2e)

3. Conduct on-farm **demonstrations of best practices** developed in the studies suggested above (see Recommended Adaptation Actions #1 and #2) to showcase effective adaptation measures and provide producers with practical guidance.

4. **Add 100 climate stations** across the Island to improve the collection of climate data, including soil temperature, to develop a baseline for the analysis of climate trends at higher resolutions. The data and analysis should be made available in an easily accessible format (e.g., mobile device application).

5. **Integrate climate change considerations in the agricultural insurance framework.** The Agricultural Insurance Corporation should build a series of agriculture indicators to guide the timing of climate derivatives from year to year. The climate varies from one season to the next so the utilizing of derivatives based on climate rather than calendar dates would be more appropriate. The Agriculture Insurance Corporation should also use the suggested study of crop opportunities and challenges to begin building the framework to offer insurance for new crop varieties anticipated to thrive in warming conditions and adjust the framework for existing crops anticipated to struggle under changing climate conditions.

6. Commission a comprehensive **study of pests and pathogens** that could be introduced to the Island under the future climate, the types of livestock that are at risk, and the common methods used in their management (e.g., adjust stock density, change shearing and breeding patterns, supplement feeding).

The collaboration of farmers, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and the government will be critical in achieving effective adaptation. The table below summarizes the six recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

**Table 3.1: Summary of recommended adaptation actions for the agriculture sector.**

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Commission a comprehensive study of crop opportunities and challenges under warming conditions over the next thirty years.</td>
<td>Leads: Sector, Provincial Government Collaborators: Experts</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td>2. Build an understanding of irrigation requirements and anticipated drought conditions and common methods used to address them.</td>
<td>Leads: Sector, Provincial Government Collaborators: Experts, other sectors</td>
<td>Fill knowledge gaps; Reduce non-climatic factors</td>
</tr>
</tbody>
</table>
3. Conduct on-farm demonstrations of best practices in adaptation.

- Lead: Sector
- Collaborators: Farmers
- Fill knowledge gaps; Engage in outreach

4. Add 100 climate stations across the Island to improve the collection of climate data, including soil temperature, to develop a baseline for the analysis of climate trends at higher resolutions.

- Lead: Sector
- Collaborators: Farmers, Experts
- Fill knowledge gaps; Increase collaboration

5. Integrate climate change considerations in the agricultural insurance framework (e.g., offer insurance for new crop varieties expected to thrive and adjust the framework for exiting crops anticipated to struggle under a changing climate).

- Lead: Agriculture Insurance Corporation
- Collaborators: Experts
- Fill knowledge gaps; Mainstreaming climate change

6. Commission a comprehensive study of pests and pathogens that could be introduced to the Island, the types of livestock at risk, and the common methods used in their management.

- Lead: Sector, Provincial Government
- Collaborators: Experts
- Fill knowledge gaps; Reduce non-climatic factors

### 3.4 CONCLUSION

The importance of the agriculture sector in Prince Edward Island cannot be overstated. Aside from its role in the Island’s economy, its provision of healthy and affordable food is critical. Agriculture is inherently sensitive to climate and the lead times for adaptation are long. Therefore, the sector must be proactive in its adaptation strategy. Studies have shown that adaptation actions such as altering planting and harvest dates, changing crop varieties, and altering irrigation practices can lead to a 7-15% increase in yield (Myers et al., 2017). Building adaptive capacity as soon as possible will make the sector more resilient to manage with the known and unknown impacts that climate change will inevitably bring.

### References


Simmons, B. (2017, September 15). Email.


4  EDUCATION AND OUTREACH SECTOR

4.1  BACKGROUND

4.1.1  FORMAL EDUCATION

Education in Canada lies within the provincial or territorial jurisdiction. The Prince Edward Island Department of Education, Early Learning and Culture (PEI EELC) develops programs and curriculum for Islanders from birth to Grade 12 in English and French (PEI EELC, n.d.). In 2014, there were 19,133 students enrolled in 56 schools covering grades K to 12 within the English Language School Board; 825 students enrolled in 6 schools covering grades K to 12 within La Commission scolaire de langue française; and 226 students enrolled in 2 private schools (PEI EELC, 2015a). The department budget for fiscal year 2014-2015 was $232 million. As of February 2015, there were 76 licensed early learning and child care centres and 38 licensed family home and school age centres/programs across the province (PEI EELC, 2015b). There are 3 post secondary education institutions on the Island: UPEI, Holland College, and College Acadie I.P.E..

![PEI GDP - 2016 ($million)](image)

*Figure 4.1. Prince Edward Island GDP of various education subsectors in 2016 (in $million chained 2007 dollars). (Data source: Statistics Canada, 2017b).*

In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the education sector (e.g., elementary and secondary schools, universities, community colleges and other educational services) contributing approximately $345 million, or 7% (see Figure 4.1). Of the 58,455 people employed in Prince Edward Island, 5,007, or 8.6%, were employed by the educational services as of January 2017 (see Figure 4.2).
4.1.2 INFORMED EDUCATION AND PUBLIC OUTREACH

Learning happens at all ages and can be cultivated outside the formal structure described above. Individuals can learn at home, in community-based organizations, museums, libraries, etc. In addition, organizations often reach out to the public to raise awareness, engage them in decision-making, inspire action, etc.

4.2 CLIMATE CHANGE IMPACTS

All other sector chapters in this report outline the different ways a sector is affected by direct climate change impacts such as rising temperature, changing precipitation patterns, more intense and frequent storms, rising sea levels, etc. For the formal education subsector, these impacts will affect the operations of school. For example, storms can disrupt the energy supply or make travel conditions unsafe, forcing school closures. These types of impacts, and corresponding adaptation actions, are analyzed in the Energy sector, Properties & Infrastructure sector, and Water sector chapters\(^2\). Unique to the Education sector, however, is the nature of climate change. The remainder of this chapter will focus on the characteristics of climate change and how they impact the Education and Outreach sector.

Climate change will bring about opportunities and challenge to the sector. It is critical to note that none of them can be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the opportunity to explore complex issues using novel study methods may be offset by the lack of expertise to address the complexity of climate change.

---

\(^2\) Refer to these chapters for in-depth analyses of climate change impacts and recommended adaptation actions.
4.2.1 MULTIPLE FACETS

Climate change is a multifaceted topic, with studies ranging from its causes and effects to the corresponding mitigative and adaptive actions. These studies span across natural sciences (e.g., geology, chemistry), applied sciences (e.g., engineering, education) social sciences (e.g., economics, politics), and beyond. This presents a number of opportunities and challenges for the sector.

2.1.1 OPPORTUNITIES

Firstly, climate change education can serve as the conduit to impart the skills and experiences that society and employers demand. Students are increasingly expected to have a wide range of personal and social skills with interdisciplinary experience so they can be effective in the 21st century workforce (McCright, 2012). The sector has the opportunity to help students meet these demands by supporting the study of climate change across subject areas using multifaceted approaches.

Secondly, this is an opportunity for the sector to incorporate fields of knowledge that have not been widely used in the past. Tackling climate change is an endeavour that requires “all hands on deck”. For example, traditional ecological knowledge – built on generations of insights, experience, and knowledge – provides “an invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change” (United Nations University, 2011).

Thirdly, the study of climate change can ignite the interest of students in subjects they have not been drawn to in the past. For example, a student previously uninterested in language arts can become engaged by studying it through a lens that resonates with them:

my great great grandchildren
ask me in dreams
what did you do while the Planet was plundered?
what did you do when the Earth was unravelling?
surely you did something
when the seasons started failing?
as the mammals, reptiles, birds were all dying?....
what did you do
once
you
knew?
—Excerpt from Drew Dellinger’s ‘What Did You Do Once You Knew?’ (Alliance for Sustainable Communities Lehigh Valley, 2017)

Fourthly, the wide range of impacts climate change has on society has compelled leaders outside of the scientific community to speak up, adding new venues for public outreach and engagement. For example, Pope Francis, head of the Roman Catholic Church, addressed climate change in his encyclical on the environment, Laudato si’, in which he describes man’s destruction of climate as a sin and the role
of climate change in worsening the refugee crisis (McKenna, 2016). Studies have shown that political orientation, worldviews, and religious view influence the level of public engagement (Wibeck, 2014).

**CHALLENGES**

The delivery of climate change education using a cross-curricular approach will be challenging. Firstly, the current systems have been designed to effectively and efficiently promote learning by subject area. This is evident in how a school day is structured, a curriculum is developed, or the students are assessed. Supporting learning across subject areas in a holistic manner could be challenging.

Secondly, actors in public outreach and engagement will increasingly require a broad knowledge base and skill set to effectively promote action in climate change mitigation and adaptation.

**4.2.2 COMPLEXITY**

The study of climate change is viewed as a complex field; topics such as greenhouse gas interactions, global climate modeling, and ocean acidification may seem overwhelming. Many educators and public outreach and engagement actors feel unprepared to participate in climate change education due to their lack of deep scientific knowledge in physical sciences. Meanwhile, many students and members of general public lack the scientific literacy required to digest the technical concepts being disseminated. These gaps in knowledge provide both opportunities and challenges for the sector.

**OPPORTUNITIES**

In addressing the knowledge gap, there is an opportunity to apply well-studied approaches that currently exist within the education sector. To make climate change education less daunting for the teachers and the learners, inquiry-based learning and place-based learning could be utilized to engage both sides. For example, the teachers can become co-learners as they guide open discussions around students’ concerns and questions with an emphasis on real-life context over study within disciplines.

**CHALLENGES**

Firstly, climate change education is a relatively new field and teachers likely have limited exposure within their own schooling and professional training (Henderson et al., 2017). The lack of in-depth knowledge of the complex science concepts and effective ways to impart that knowledge in a digestible manner could cause hesitation in promoting climate change education in the classrooms (McNeal et al., 2017).

Secondly, many scientists lack the necessary communication skills to disseminate complex scientific information in plain language, making public engagement difficult. Despite the availability of the extensive knowledge on climate change, only a fraction of it is presented in a digestible manner or customized for use by specific groups (e.g., educators, governments).
Thirdly, low levels of scientific literacy in the general public have lead to doubt regarding climate science. Action on climate change has been limited by ideological polarisation on the subject (McNeal et al., 2017). Despite the fact that over 97% of climate scientists agree on the anthropogenic nature of recent climate change (McNeal et al., 2017), there is still public uncertainty on the true consensus of climate scientists, contributing to a misunderstanding of the causes of climate change and giving rise to the role of a “belief” system in discussions surrounding climate change.

Fourthly, to fill the gap between the communications failure from scientists and the low scientific literacy of the general public, mass media and the internet have played decisive roles in shaping the public’s understanding of climate change by acting as a bridge (Wibeck, 2014). The challenge is that the opinion of the general public and policy makers can be heavily influenced by how actors outside of climate science frame the issues. For example, while the news media in countries such as Sweden, France, and Germany provides a frame of certainty – “human-induced global warming is a direct cause of climate change, bringing with it dramatic consequences already at hand” (Wibeck, 2014) – this is not always the case. In the United States, the news media provides a frame of scientific uncertainty and uses the journalist practice of a balanced view by giving both sides equal weight in a debate (Wibeck, 2014). This further exacerbates public uncertainty and misunderstanding of the causes of climate change.

4.2.3 SPATIAL AND TEMPORAL SCALES

Research has shown that while climate change may be regarded as a serious risk, individuals perceive it as an issue that is distant in space (e.g., global warming) and time (e.g., sea level rise). This creates both opportunities and challenges for the sector.

OPPORTUNITIES

Public apathy is partly caused by the perception that climate change is not relevant to them or their communities (Hu and Chen, 2016). In Prince Edward Island, the impacts of climate change are visible; damage caused by coastal erosion, flooding, and extreme storm events can be observed first-hand. This provides an opportunity for educators and public outreach actors to engage students and the general public by exploring the spatial impact of climate change in a meaningful and experiential way.

CHALLENGES

Firstly, the public needs to balance day-to-day concerns with the medium- to long-term impacts of climate change. It is easy to think of climate change as a slow, gradual process with increases in loss occurring incrementally (Canadian Electricity Association, 2016), making the promotion of immediate climate change action difficult.
Secondly, the overwhelming scope of climate change creates “bigger-than-self problems” which reduce incentive for people to act (Wibeck, 2014). In these instances, the general public often feel overwhelmed, disengage, and look to the government to address their concerns.

Thirdly, the integration of a complex and wide-ranging issue such as climate change into school curriculum requires resources (e.g., time, money, expertise), above and beyond the day-to-day operations of the schools or maintenance of the status quo. It involves establishing guidelines, supporting new curriculum documents and specific instructional strategies, (re)training teachers, etc. Improving knowledge on climate change requires its integration in the curriculum review process, the timing of which is dictated by the Department of Education, Early Learning and Culture.

4.3 RECOMMENDED ADAPTATION ACTIONS

4.3.1 FORMAL EDUCATION

7. Integrate climate change in the curriculum for lower grades where interdisciplinary and inquiry-based learning is already taking place (e.g., Kindergarten to Grade 6). For example, identify resources and develop activities for teachers.

8. Integrate climate change in the curriculum for higher grades, focusing on increasing the skills, competencies, and knowledge of students across all subject areas. For example,
   a. incorporate teaching methods that promote multidisciplinary, interdisciplinary, and transdisciplinary learning;
   b. develop an interdisciplinary course for Grade 9 students;
   c. include subjects beyond natural sciences and social sciences (e.g., language arts), even those not historically taught within the school system (e.g., traditional ecological knowledge);
   d. focus on skills and competencies (e.g., problem solving, creative thinking, effective collaboration, critical thinking, scientific knowledge) as much as knowledge;
   e. leverage existing initiatives (e.g., use “Is it science?” to increase critical thinking and address any uncertainty surrounding climate change); and,
   f. excite and engage students by making climate change relevant (e.g., hands-on learning such as erosion monitoring and coastal restoration).

9. Support teachers by implementing small-scale initiatives to introduce climate change to the students in the near-term while the integration of climate change across the curriculum (see Recommended Adaptation Action #8) is taking place. For example:
   a. host a full-day workshop during professional development days. The agenda could include a question and answer period with a panel of experts in climate science, mitigation, adaptation, presentation of potential career paths for students, a field trip to
exemplify place-based learning (e.g., visit flood- and erosion-risk zones), and a roundtable discussion with teachers across all subject areas;

b. invite outside groups to the classrooms to share their expertise (e.g., workshops hosted by informal education provides and government staff – see Recommended Adaptation Action #15); and,

c. provide examples on how inquiry-based learning can be implemented. Sample sets of questions could demonstrate how to involve different subject areas. This could make coordination among subjects teachers easier if each teacher could build upon the topic. For example:

*Scenario: Joe’s property has been experiencing erosion for years. His shoreline is creeping closer and closer to his house.*

*Economics:* Perform a cost-benefit analysis by comparing the cost of putting armouring in place today against the cost of losing property and infrastructure over time.

*Physics:* Once the armouring is in place, how will this impact the wave energy of the water?

*Environmental science:* Armouring a coastline leads to the loss of sandy beach in front of the structure. How will this affect wildlife? Should there be a “cost” associated with this?

*Political science:* How can Joe’s predicament be shared with other coastal property and infrastructure owners to encourage support for government policy that increases setback limits for new developments?

Etc.

10. Identify ways to increase experiential learning without leaving the school grounds. For example, design and build a rain garden to help manage stormwater on-site.

11. Increase exposure to climate change, interdisciplinary-learning, and inquiry-based learning at the post-secondary level. For example, the University of Prince Edward Island has a School of
Climate Change and Adaptation. At a smaller scale, a course in interdisciplinary-learning could explore different topics (e.g., climate change) using subjects relevant to the students’ studies.

4.3.2 INFORMAL EDUCATION

12. Increase awareness of opportunities to learn outside of the classroom. Complete an inventory of existing programs offered by the Provincial Government and other groups. Work with other sectors to raise awareness of existing programs.

13. Develop new programming to expand the students’ knowledge of climate change outside of the formal education system and address gaps in existing programming (e.g., consideration of other subjects and perspectives such Traditional Ecological Knowledge and its respect for the carrying capacity of ecosystems). For example, an interdisciplinary one-week summer camp for grade nine and ten students using climate change as a topic and give students a chance to further develop core skills and competencies. The flexibility of a summer camp could address the limitations of the formal education structure (e.g., experiential learning in the field, operating drones to collect environmental data, focusing on areas of students’ interest).

4.3.3 PUBLIC OUTREACH

14. Place more emphasis on inspiring action and less on improving public understanding of scientific knowledge when engaging the public. For example:
   a. use place-based approaches and visualization techniques to demonstrate the impacts of climate change in a local and relevant context;
   b. demonstrate how climate change adaptation actions could benefit them and how inaction can cost them personally to encourage action. For example, the use of rain barrels and rain gardens by homeowners will reduce the risk of flooding during intense rain events; and,
   c. frame climate change in other contexts to strengthen the message and encourage action. For example, use a public health perspective to encourage reductions in emissions by promoting health benefits of cycling or walking over driving (e.g., improve cardiovascular health and air quality).

15. Encourage knowledge provincial staff to communicate with colleagues and citizens about their areas of expertise and what adaptation strategies and be initiated and provide opportunities to do so. For example:
   a. list the staff’s specific relevant expertise and experience on the online employee directory and make it queryable so individuals in need of help can quickly and easily connect with the relevant expert;
b. host internal and external “lunch and learns” by themes and invite staff with different expertise to present; and,
c. host workshops in schools (see Recommended Adaptation Action #9).

16. **Identify different segments of the population and generate public outreach approaches accordingly.** The communication strategy for the ‘unconcerned and dismissive’ segment should be drastically different than that for the ‘most concerned and motivated’ segment. For example, the focus for the ‘unconcerned and dismissive’ segment should be on the benefits of adaptation, rather than the cause and effect of climate change (see Recommended Adaptation Action #14). For example, the City of Charlottetown hosted a Fix It Fair, where Islanders saw saving money by learning to repair broken equipment rather than buying a replacement as the primary benefit and the diversion from landfills as a secondary benefit.

17. **Leverage best practices** from other sectors and jurisdictions. For example, emergency management organizations are effective in educating the general public of present and anticipated risks and hazards.

The collaboration of educators within the formal and informal education systems, experts (e.g., climate scientists), and the governments will be critical in achieving effective adaptation. The table below summarizes the eleven recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

*Table 4.1. Summary of recommended adaptation actions for the Education and Outreach sector.*

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Integrate climate change in the curriculum for lower grades where interdisciplinary and inquiry-based learning is already taking place (e.g., identify resources and activities).</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Address knowledge gaps; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>8. Integrate climate change in the curriculum for higher grades, focusing on increasing the skills, competencies, and knowledge of students across all subject areas.</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Address knowledge gaps; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>9. Support teachers by implementing small-scale initiatives to introduce climate change to the students in the near-term (e.g., host full-day workshop during PD days, provide inquiry-based activities to teachers).</td>
<td>Lead: Provincial Government Collaborators: Experts, Informal education providers</td>
<td>Address knowledge gaps; Promote climate change mainstreaming; Increase collaboration</td>
</tr>
<tr>
<td>10. Identify ways to increase experiential learning without leaving the school grounds (e.g. design and build a rain garden to manage stormwater on-site).</td>
<td>Lead: Provincial Government, Public Schools Branch, French Language School Board,</td>
<td>Address knowledge gaps; Engage in outreach</td>
</tr>
</tbody>
</table>
| 11. Increase exposure to climate change, interdisciplinary-learning, and inquiry-based learning at the post-secondary level. | Lead: Post-secondary institutions  
Collaborators: Experts | Address knowledge gaps |
|---|---|---|
| 12. Increase awareness of opportunities to learn outside of the classroom. | Leads: Informal education providers, Provincial Government  
Collaborators: Parents and guardians | Engage in Outreach; Increase collaboration |
| 13. Develop new informal education programming to expand the students’ knowledge. | Leads: Informal education providers  
Collaborators: Parents | Address knowledge gaps; Engage in outreach |
| 14. Place more emphasis on inspiring action and less on improving understanding of scientific knowledge when engaging the public. | Leads: Municipal and Provincial Governments, all sectors | Engage in outreach |
| 15. Encourage knowledgeable provincial staff to communicate with colleagues and citizens about their areas of expertise. | Leads: Provincial Governments | Address knowledge gaps; Engage in outreach |
| 16. Identify different segments of the population (e.g., ‘unconcerned and dismissive’ versus ‘most concerned and motivated’) and generate public outreach approaches accordingly. | Leads and collaborators: All levels of government, All sectors | Engage in outreach |
| 17. Leverage best practices in outreach from other sectors and jurisdictions (e.g., EMO is effective in educating the public of risks). | Leads and collaborators: All levels of government, All sectors | Engage in outreach; Increase collaboration |

### 4.4 CONCLUSION

The Education and Outreach sector plays an important role in the response to climate change. By developing effective approaches to raising awareness, and promoting knowledge and skill-development, the students, other sectors, and the general public will all benefit.

### References


5 ENERGY SECTOR

5.1 BACKGROUND

Energy is an essential part of our daily lives – public health and safety, access to clean drinking water, heating, lighting, transportation, economy, etc. depend on it. Currently, 7% of energy comes from biomass (e.g., wood), 21% of energy use comes from electricity (generated from coal, hydroelectricity, oil, diesel, wind power, and nuclear power) and the rest from fuel sources such as gasoline, light fuel oil, diesel, natural gas, and propane (see Figure 5.1).

In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the electric power generation, transmission and distribution subsector contributing $81 million or 1.7% and gas stations (retail) subsector contributing $18 million or 0.4%. Statistics Canada does not collect data specifically on the sale of home heating fuels but it is part of the “non-store retailers” of the retail sector, which contributed $26.7 million in 2016 (Statistics Canada, 2017a). GDP figures specific to biomass are unavailable.
There were 63,642 equivalent annual full time jobs in 2016 across all industries in Prince Edward Island (Statistics Canada, 2017a). Gasoline stations employed 666 of those jobs (Statistics Canada, 2017a). Data specific to the generation, transmission and distribution of electricity is unavailable but in March 2017, the utilities industry, which includes electricity, natural gas, water, and sewage, employed 300 people (Statistics Canada, 2017b). Data for biomass and home heating fuels were unavailable.

5.1.1 ELECTRICITY

MARITIME ELECTRIC

Maritime Electric supplies electricity for 90% of Prince Edward Island. The electricity is transmitted and distributed across the province using approximately 5,000 km of power lines (see Figure 5.3). The electricity supply capacity for the province is approximately 275 MW in 2017 (J. Cunniffe, personal communication, September 7, 2017).
Maritime Electric procures most of its electricity from NB Power (see Table 5.1), which supplies electricity from coal, hydro, oil, natural gas, diesel, wind, and nuclear sources (NB Power, n.d.; J. Cunniffe, personal communication, September 7, 2017). The off-island electricity is delivered via two submarine transmission cables under the Northumberland Strait. The two original 95MW cables were installed approximately forty years ago. The installation of two new 180MW submarine cables was completed in July 2017 (J. Cunniffe, personal communication, September 7, 2017).

The other electricity source Maritime Electric purchases from is on-Island wind farms. Currently, there are seven wind farms on the Island, with one additional wind farm proposed (see Table 5.2).

Maritime Electric owns and operates the Charlottetown Thermal Generating Station (CTGS), which generates electricity using heavy oil (55 MW) and diesel (49 MW) and the Borden Generating Station, which generates electricity using diesel (40 MW) (Maritime Electric, n.d.). These two electricity generating stations are mainly put in operation when there are interruptions to off-Island supplies of electricity or when increased capacity is required during peak periods. The heavy oil generators at the CTGS are expected to be placed in long-term layup in 2018 (J. Cunniffe, personal communication, September 7, 2017).
Table 5.1. Maritime Electric Electricity Supply for 2014
(Data source: Maritime Electric, 2015).

<table>
<thead>
<tr>
<th>Supply %</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Island oil-fired generation</td>
</tr>
<tr>
<td>On-Island wind generation</td>
</tr>
<tr>
<td>Point Lepreau (nuclear), NB Power</td>
</tr>
<tr>
<td>System purchases from NB Power</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Owner</th>
<th>Number of Turbines</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermanville/Clear Spring Wind Farm</td>
<td>PEI Energy Corp</td>
<td>10</td>
</tr>
<tr>
<td>East Point Wind Farm</td>
<td>PEI Energy Corp</td>
<td>10</td>
</tr>
<tr>
<td>North Cape Wind Farm</td>
<td>PEI Energy Corp</td>
<td>16</td>
</tr>
<tr>
<td>North Cape Wind R&amp;D Park</td>
<td>PEI Energy Corp</td>
<td>5</td>
</tr>
<tr>
<td>Norway Prototype Wind Farm</td>
<td>Suez Renewable Energy Corp</td>
<td>3</td>
</tr>
<tr>
<td>Summerside Wind Farm</td>
<td>City of Summerside</td>
<td>4</td>
</tr>
<tr>
<td>Aeolus Wind Farm in Norway</td>
<td>AEolus Wind PEI</td>
<td>1</td>
</tr>
<tr>
<td>West Cape Wind Farm</td>
<td>Suez Renewable Energy Corp</td>
<td>55</td>
</tr>
<tr>
<td>Proposed wind farm</td>
<td>PEI Energy Corp</td>
<td>30 MW</td>
</tr>
</tbody>
</table>

CITY OF SUMMERSIDE

The City of Summerside, through Summerside Electric, supplies the remaining 10% of the province’s electricity needs, mainly servicing customers within its municipal boundaries. Most of the electricity is generated by four wind turbines at the 12 MW Summerside Wind Farm (PEI TIE, 2015). Summerside Electric purchases some electricity from NB Power and owns a generating station that it commissions when there are interruptions to the energy supply (City of Summerside, n.d.).

5.1.2 HOME HEATING

Oil, biomass (e.g. wood), and electricity are the main energy sources for space heating. Firewood is the cheapest home heating option (PEI, 2017). In 2014, 1.4% of households use wood pellets as their primary heating source and 30% use firewood as a supplementary heating source (PEI, 2017). Currently, 22 facilities (e.g., schools) are heated using wood chips with 3 more planned for 2017 (PEI, 2017). Wood
chips constitute half of Charlottetown district heating system’s fuel input (PEI, 2017). Wood is a renewable source and considered to be carbon-neutral. Over 50% of households use oil as their primary heating source, with 70% of households using oil in some way (PEI, 2017). Oil is currently exempted from HST, helping to make it the second cheapest heating option next to firewood (PEI, 2017).

5.1.3 SOLAR ENERGY

While some homes and businesses utilize solar panels, solar energy is not currently used to produce electricity at a utility-scale due to the high cost. However, costs are decreasing and solar is expected to be competitive with wind generation eventually (PEI, 2017).

5.1.4 MOTOR VEHICLES

Gasoline and diesel are used to fuel motor vehicles. There were approximately 74,000 cars and 25,000 trucks registered in Prince Edward Island in 2014 (PEI, 2017). In that year, approximately 200 million litres of gasoline and 40 million litres of diesel were sold for use in road motor vehicles (Statistics Canada, 2016).

5.1.5 PEI ENERGY INITIATIVES

The 2016 Provincial Energy Strategy is a 10-year plan to reduce energy use, establish cleaner energy sources, increase locally produced energy, and moderate future energy price increases. This would make the Island stronger, more sustainable, and more resilient. Its goals include ensuring energy can be provided reliably to meet current and future needs, becoming more self-sufficient so the province is less affected by external influences (e.g., market prices), leveraging current skills and capacity to be innovative, and creating a plan that is appropriate for the local context (e.g., demographics). It will achieve these goals in a way that lowers greenhouse gas emissions, recommends actions that are cost-effective, and generates local economic opportunities. The Strategy focuses on four key areas: energy efficiency and conservation, power generation and management, biomass and heating, and transportation.

The provincial government established efficiencyPEI to help Islanders reduce their energy consumption by providing programs, rebates, and information. It provides financial assistance on conducting energy audits for homes and commercial buildings as well as upgrading equipment (e.g., low flow toilets, furnaces) and building envelope (e.g., doors, windows). Improving energy efficiency lowers greenhouse gas emissions.
5.2 IMPACTS OF CLIMATE CHANGE

Changes to the climate can affect how much energy is produced, delivered and consumed. Disruption to the energy supply can have profound impacts. For example, hospitals and telecommunication networks, both essential to maintaining public health and safety, depend on a reliable and secure supply of electricity to operate.

The natural variability of climate is not new to energy companies; they cope with weather-related issues in their day-to-day operations. However, the climate is shifting away from “normal” conditions and extreme events are increasing in severity and frequency. Some systems have not adapted to present day condition, let alone future climate (Audinet et al., 2014).

Mitigation has thus far been the primary focus of the energy sector in terms of climate change. More emphasis needs to be placed on adaptation because its long-term planning and investment horizons, sensitivity to weather conditions, and dependence on extensive infrastructure make the sector particularly vulnerable to climate change impacts (Government of Canada, 2009).

5.2.1 TEMPERATURE

CHALLENGES

Warming temperatures will present a number of challenges to the sector in the demand, generation, and distribution of energy.

Firstly, fewer heating degree days and more cooling degree days will cause a shift in the energy mix; there will be a higher reliance on electricity for air conditioning during the summer months and a lower reliance on heating oil for heating during the winter months.

Secondly, the increase in the number of extreme hot days will place more strain on the electrical system.

Thirdly, higher temperatures can reduce the capacity of the electrical distribution system. When outside temperature rises beyond a certain level, the capacity of the power lines to carry electrical current is reduced (Braun and Fournier, 2016; Canadian Electricity Association [CEA], 2016). The heat from higher ambient temperatures combined with the additional heat generated by the increase in electricity conducted through the lines in the summer months will create two issues. One, the extra heat will increase the likelihood of the load on the line reaching and surpassing the design temperature. Two, the extra heat will increase sag in power lines.
5.2.2 EXTREME WEATHER EVENTS

CHALLENGES

The increasing intensity and frequency of extreme weather events (e.g., storms, droughts) will present a number of challenges to the sector.

Firstly, extreme weather events may disrupt the supply of fuels and heating oil due to bridge and road closures.

Secondly, high winds brought on by extreme storm events can damage wind turbines (Statham et al., 2014) and cause production to shut down when wind speeds exceed the design maximum (Ebinger and Vergara, 2011).

Thirdly, high winds brought on by extreme storm events can damage power lines. An increase in tree contacts can lead to widespread damage and power loss (Ebinger and Vergara, 2011; CEA, 2016).

Fourthly, storm surge during intense storms can increase the risk of damage to energy infrastructure from coastal flooding and coastal erosion. Damage to power poles, electricity substations, generation plants, storage tanks, etc. located close to the coast can cause supply interruptions and downtime.

Fifthly, ice storms can damage energy infrastructure. Icing on turbine blades can limit their performance and longevity (Ebinger and Vergara, 2011) and even cause damage (CEA, 2016). Ice storms can snap power lines, bring down utility poles, and increase tree contacts (CEA, 2016).

5.2.3 SEA LEVEL RISE

CHALLENGES

The increasing sea levels will present challenges to the energy sector, threaten an increasing number of energy infrastructure and equipment located near the coast, including power lines, electricity substations, generation plants, storage tanks, etc., leading to power outages and damage to assets.

5.2.4 INDIRECT CLIMATE CHANGE IMPACTS

OPPORTUNITIES

Firstly, other jurisdictions, such as the United States, are experiencing an increase in electricity demand (CEA, 2016). This provides a potential opportunity for the export of electricity. Electricity generated by
renewable resources such as wind will be in higher demand as other jurisdictions look to meet emission targets of their own.

Secondly, the increasing popularity of electric vehicles in a low-carbon economy will increase off-peak demand of electricity (Finley and Schuchard, n.d.), increasing revenue for utility companies and providing a network to potentially establish a smart grid of energy storage across the Island.

**CHALLENGES**

Firstly, the sector will be impacted by regulations put in place to address climate change. For example, mitigation efforts by the Canadian Government include putting a price on carbon pollution in provinces and territories that do not have their own carbon pricing structures. The federal price starts at $10 per metric tonne of greenhouse gas emissions in 2018 and increases by $10 per year until 2022 when it reaches $50 per metric tonne (Environment and Climate Change Canada, 2017).

Secondly, with the expectation of mitigation and adaptation policies and regulations imposed by governments, investors will become increasingly concerned about energy companies’ ability to thrive in a low-carbon economy (Finley and Schuchard, n.d.).

Thirdly, climate change impacts on other sectors could change their demand of energy. Agriculture and food processing industries are two examples. The increased need for irrigation for the agriculture sector under a changing climate will raise the use of energy for pumping (Ebinger and Vergara, 2011). For food processing plants that require continuous cooling processes, especially those that exchange heat with the outdoor air, the increasing temperatures under a changing climate will raise energy use for cooling (Ebinger and Vergara, 2001). While increases in the demand for energy could be an opportunity for increased revenue, it could pose a significant challenge if the increased energy use strains the system capacity during peak periods.

5.2.5 **UNKNOWNWS**

While climate modeling is able to forecast how climate change will impact temperature, precipitation, sea level rise, etc. with high levels of confidence, there are limitations to these models. For example, wind energy generation will be impacted by changes in wind speed, patterns, density, quality, distribution, and variability (Ebinger and Vergara, 2011; Asian Development Bank, 2012; Audinet et al., 2014, Gaetani et al., 2015), none of which can be forecasted with a high degree of accuracy. The same applies to cloud cover and atmospheric turbidity, which impacts solar energy generation (Asian Development Bank, 2012) and lightning strikes, which could cause damage to energy infrastructure such as electrical substations and create operational challenges such as the maintenance of wind turbines.

In 2014, about 76% of electricity supplied on Island was procured from NB Power. While new submarine transmission cables increased the transmission capacity, this critical source of electricity is subject to the reliability of the NB Power system, which will be tested by direct climate change impacts as well as
operational challenges (e.g., increase in demand). The reliability of this supply will be dependent on how well NB Power copes with these challenges.

### 5.3 RECOMMENDED ADAPTATION ACTIONS

18. **Relocate, retrofit, and/or protect** critical energy infrastructure and equipment vulnerable to climate change impacts. For example:
   a. locate vulnerable infrastructure and prioritize its relocation, strengthening, or protection based on level and timing of risk, site surveys, cost-benefit analysis, etc.;
   b. relocate, where possible, infrastructure located in areas at risk of flooding and/or erosion now or within its lifetime. It may be a higher cost option but for infrastructure with a long life span, it is the most sustainable and long-lasting, often generating more cost-benefit advantages than building flood-protection for infrastructure (Braun and Fournier, 2016);
   c. protect infrastructure (e.g., elevate, flood proof, armour) at risk of flooding, where relocation from flooding and/or erosion risk zones is inappropriate or impossible. Choose a design beyond the current 1-in-100 year events since those will become more severe over the lifetime of the infrastructure (e.g., 1-in-200, 1-in-1000, etc.), taking into account other factors such as sea level rise, storm heights, and wind speed under a changing climate;
   d. add guying to poles or install special pylons at regular intervals in high risk areas to avoid cascades of falling power poles during high ice load events (Audinet et al., 2014); and,
   e. increase the height of power poles, reduce the spans of power poles, or tighten the power line conductors to compensate for line sagging and meet minimum requirements for distance above the ground for safety reasons.

19. **Lower energy demand** as a complementary approach to addressing peak capacity. Reduction in energy consumption is quicker and more cost effective than increasing capacity (Braun and Fournier, 2016). For example,
   a. educate and sensitize the public to the challenges facing the electricity industry. Make the case that it is in everyone’s interest – the individuals’ businesses’, society’s, utilities’ – to lower demand as much as possible. Demonstrate the financial benefit of reducing energy use;
   b. give the public practical recommendations on how to reduce energy use via energy conservation and energy efficiency. Industry and government should increase support to and work with efficiencyPEI to raise awareness on how to reduce energy usage in homes and businesses. Small behavioural changes by residents and businesses collectively across the Island would have a big impact. For example, using less room heating/cooling by adjusting the thermostat settings by a degree or two would mean a significant reduction on demand for the electrical system (Braun and Fournier, 2016). The government and the utility companies should lead by example and incorporate these initiatives in their operations; savings generated from their efforts should be
reinvested in additional conservation and efficiency initiatives to continually lower energy use;

c. develop a system indicating the current state of its system to its users and suggesting actions based on the type of alert. Maritime Electric can look to ÉcoWatt, a system put in place in France in 2012 that provides alerts via its website, email, text messages, and social media when the grid moves from green (no risk of outage) to orange (moderate risk of outage) or red (high risk of outage) (Braun and Fournier, 2016). When the system moves to orange or red, subscribers to the program receive alerts with suggested actions to reduce consumption based on the type of alert. It successfully reduced peak demand during orange and red alerts by 2-3% (Braun and Fournier, 2016). The public was engaged because it was motivated to help avoid rolling brown-outs;

d. deploy direct load control devices to subscribers to allow the utility companies to cycle off and on air conditioning units/heat pumps during peak demand periods for short periods of time (Morand et al., 2015). This initiative was implemented in Washington D.C., USA to help utilities manage demand during peak period. Homeowners, who voluntarily participated, saved up to 10% on heating and cooling costs and they noticed little or no temperature change in their homes (Morand et al., 2015); and,

e. review the pricing structure for electricity. For example, peak-demand pricing could be used to encourage a shift of usage during off-peak powers, whereas a higher second-block price for electricity will incentivize energy conservation and efficiency.

20. **Decentralize, diversify, and develop redundancy** in the sector to increase its resilience to climate impacts. Having different types of energy generation, multiple sources of the same type of energy, and generation capacity distributed throughout the Island gives the system more capacity to cope with hazardous events and avoid large-scale system failures. For example,

a. encourage individuals and businesses to install energy storage equipment to shift electricity consumption away from peak hours. It will also serve as back-up power during power outages and store wind- or solar-generated electricity when it is produced by not needed. For example, the City of Summerside’s “Heat for Less Now” program has been helping it maximize its use of wind energy for five years. Homeowners who install electric thermal storage water heaters, room heaters, and furnaces receive a discount of $0.08/kWh in exchange for allowing the utility control when the home should use energy from the grid versus the storage equipment, depending on existing wind levels (Tattrie, 2016). The cost of the equipment ranges from $1,400 to $2,200 each (Tattrie, 2016).

b. encourage individuals and businesses to install solar panels with on-site energy storage by providing financial incentives. Solar is a renewable resource that has a more stable output profile than wind. The ability to produce power on site, coupled with on-site energy storage, will make Islanders more resilient against power outages, especially during extreme weather events (e.g., storms, high winds). The correlation between an increased demand for electricity for air condition during hot summer days and the solar
energy available from the sun on these days will help reduce peak demand in the summer months; and

c. increase the use of high-efficiency biomass (e.g., wood chips) and Combined Heat and Power (CHP) as sources for energy at multi-unit residential, commercial, institutional and industrial sites or a combination of these sites (i.e., district energy systems). CHP equipment can be fueled by propane and can generate electricity and hot water heating in a way that is 50% more efficient than conventional methods (Morand et al., 2015). Using alternate sources to generate electricity will lower reliance and demand on the electricity system and increase resilience during extreme weather events.

The government and the utilities should lead by example and begin incorporating these actions at their facilities, starting with essential services.

21. Implement policies and regulations to foster climate change adaptation in the areas such as design and safety standards and permitting, siting and zoning. Regulatory measures can be used to drive businesses to act in a timely manner. To provide harmonization and clarity in its policies, the government should establish a position on climate risk so the energy companies can plan appropriately. For example,

a. require utility companies to submit climate change vulnerability analysis and adaptation plans, along with updates to its adaptation activities;

b. update design and safety standards to ensure new equipment and infrastructure can withstand current and future climate conditions within their lifetimes. For example, increasing the rated design temperature of transmission lines and planning/refurbishing new/existing infrastructure to withstand 1:200 storm events based on 2080s forecasts and protect them from projected sea level rise and erosion for their lifetime; and,

c. include in the permitting process an assessment of climate vulnerabilities and require necessary adjustments to ensure planned infrastructure will be resilient to anticipated climate change impacts.

The government should also assist utilities in achieving its adaptation goals. The rate structure should be reviewed to offset some costs of adaptation. It is important to note that this review needs to factor in the savings from the utilities’ own energy efficiency and conservation initiatives and the inherent cost savings of adaptation actions versus the costs of inaction (see Recommended Adaptation Action #22).

22. Integrate climate change impacts into day-to-day operations as well as planning, risk assessment and management, and decision-making processes. Examples include load and demand forecasting, risk auditing, training, emergency response, asset refurbishment, vegetation management, supply interruption management, project screening, and investment planning.

23. Plan new developments with climate change in mind. As new assets and infrastructure are needed to increase capacity and renewable sources of energy increase its contribution to the energy mix, space for development is required (e.g., wind farm, solar farm). Identify areas
suitable for new developments that are at low risk of damage from climate change impacts during the planning process. New buildings could be designed to be “solar ready” (e.g., design the roof to support the additional weight of solar panels, put necessary wiring in place).

24. Conduct a **cost-benefit analysis** of climate change adaptation options. There is growing evidence that the cost of adaptation far outweighs the cost of inaction (CEA, 2016). Costs of inaction extend beyond damaged assets; they include reduced revenue, higher operational costs, higher insurance premiums, increased regulatory obligations, and legal liabilities (CEA, 2016).

25. **Increase collaboration and communications** among sector stakeholders. For example:
   a. share information such as climate forecasts, climate risks, and best practices; and,
   b. improve communication on operational issues such as planned shutdowns of transmission lines and wind turbines to minimize operational impacts on other parties.

The collaboration of the public, utilities, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and the government will be critical in achieving effective adaptation. The table below summarizes the eight recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. Relocate, retrofit, and/or protect critical energy infrastructure and equipment vulnerable to climate change impacts (e.g., move infrastructure located in areas vulnerable to erosion, add guying to utility poles to avoid cascades of falling poles).</td>
<td>Leads: Utilities Collaborators: Experts</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>19. Lower energy demand as a complementary approach to addressing peak capacity (e.g., develop an alert system with suggested actions to reduce consumption when system is near peak capacity to avoid rolling brownouts).</td>
<td>Leads: Utilities, Provincial Government Collaborators: Public</td>
<td>Increase resilience; Reduce non-climatic factors; Engage in outreach; Leverage regulation</td>
</tr>
<tr>
<td>20. Decentralize, diversify, and develop redundancy in the sector to increase its capacity to cope with hazardous events and avoid large-scale system failures (e.g., solar panels, energy storage equipment, district energy systems).</td>
<td>Leads: Utilities, Provincial Government Collaborators: Public, Businesses, Municipal governments</td>
<td>Increase resilience; Engage in outreach; Address financial concerns</td>
</tr>
<tr>
<td>21. Implement policies and regulations to foster climate change adaptation in the areas such as design and safety standards and permitting, siting and zoning.</td>
<td>Leads: Provincial Government Collaborators: Utilities, Experts</td>
<td>Increase resilience; Promote climate change mainstreaming; Leverage regulation</td>
</tr>
<tr>
<td>22. Integrate climate change impacts into day-to-day operations as well as planning, risk assessment</td>
<td>Leads: Utilities</td>
<td>Promote climate change mainstreaming</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>23.</td>
<td>Plan new developments with climate change in mind (e.g., make buildings “solar ready”, site new developments in areas with low vulnerability to coastal erosion and flooding).</td>
<td>Leads: Utilities, Businesses, Individuals</td>
</tr>
<tr>
<td>24.</td>
<td>Conduct a cost-benefit analysis of climate change adaptation options. There is growing evidence that the cost of adaptation far outweighs the cost of inaction.</td>
<td>Leads: Utilities</td>
</tr>
<tr>
<td>25.</td>
<td>Increase collaboration and communications among sector stakeholders (e.g., share climate forecasts, coordinate planned shutdowns to minimize impacts on other parties).</td>
<td>Leads: Utilities</td>
</tr>
</tbody>
</table>

### 5.4 CONCLUSION

Risks to the energy system will be amplified by the impacts of a changing climate. The system must build resilience in order to continue providing a secure and reliable supply of energy to Islanders. Climate change is often thought of as a gradual phenomenon, with changes occurring slowly and losses taking place evenly and incrementally over time (CEA, 2016). This, coupled with the sector’s long planning horizons make it easy to put off adaptation initiatives. However, there is no room for complacency. Fortunately, there is ample evidence from adaptation actions taken in other jurisdictions that demonstrate the effectiveness and affordability of taking a proactive stance against climate change impacts.

### References


6  FISH AND AQUACULTURE SECTOR

6.1 BACKGROUND

Fishing has been an integral part of Prince Edward Island’s history, economy, and identity for generations. More recently, aquaculture, the production or culturing of aquatic organisms (e.g., fish, shellfish, plants) has also become an important part of the Island’s social and economic fabric. The province is cradled in the Gulf of St. Lawrence between the Magdalen Shallows, a plateau within the Gulf (Fisheries and Oceans Canada [DFO], 2005a) and the Northumberland Strait (see Figure 6.1). The Gulf is partially isolated from the North Atlantic, has the furthest regular annual extension of sea ice in the North Atlantic during the winter, and the warmest surface water temperatures in Atlantic Canada during the summer. Its diverse ecosystem is a product of its unique physical and chemical conditions.

Species fished and cultured in PEI include crustaceans (e.g., lobster, snow crab, rock crab, spider crab); molluscs (e.g., mussels, oysters, quahags, bar clams, soft shell clams, scallops); pelagics and estuarials (e.g. herring, mackerel, silversides, bluefin tuna, eels, gaspereau, cultured finfish such as salmon and trout); and groundfish (e.g. halibut, winter flounder and cod). Seafood is an important source of protein, minerals, vitamins, fatty acids, and nutrients required for normal growth and development; building and repair of body tissues; formation of red blood cells, bones, and teeth; upkeep of immune system health; and prevention of heart disease (DFO, 2012a).

Figure 6.1. Map of the Gulf of St. Lawrence showing the main channels and straits
(Source: Benoit et al, 2012).
Figure 6.2. Prince Edward Island GDP of fishing (including hunting and trapping) and aquaculture (excluding food processing) in 2016 (in $million chained 2007 dollars).
(Data source: Statistics Canada, 2017a)

Figure 6.3. Estimated landed value by species in 2015.
(Data source: PEI Department of Agriculture and Fisheries [PEI AF], n.d.)
The fish and aquaculture sector, along with its secondary industry of seafood processing, is the third largest industry in Prince Edward Island, contributing almost $300 million to the province’s gross domestic product (Prince Edward Island Seafood Processors Association [PEISPA], n.d. a). The estimated landed value from the fishing and aquaculture industries was $219.6 million in 2015, with lobster (68%) and mussels (12%) accounting for 80% of the total (see Figure 6.3). In 2015, mussel leases spanned 11,233 acres and oyster and clam leases spanned 7,853 acres (PEI AF, n.d.). Seafood processing generates over $200 million in export revenue (PEISPA, n.d. b). Together, fishing, aquaculture, and food processing employed, 8,500 employees worked during peak production in 2015 (PEI AF, n.d.).

![Figure 6.3. Seasonally adjusted employment in the fishing and aquaculture sectors (combined with agriculture, forestry, and natural resources sectors; excluding food processing) compared to total employment in March 2017 (Data source: Statistics Canada, 2017b).](image)

<table>
<thead>
<tr>
<th>Table 6.1. Commercial fishery statistics for the East Coast region, 2011. (Data source: Savard et al., 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Province</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Prince Edward Island</td>
</tr>
<tr>
<td>Nova Scotia</td>
</tr>
<tr>
<td>Quebec</td>
</tr>
<tr>
<td>Newfoundland and Labrador</td>
</tr>
<tr>
<td>New Brunswick</td>
</tr>
</tbody>
</table>

There were 46 small-craft fishing harbours operating on the Island in 2011, bringing in over 30,000 metric tonnes and $111 million of catch (see Table 6.1). While these numbers were the lowest within the East Coast region given the size of the province and the industry, the landed value per tonne of catch is by far the highest. There are also a number of fish hatcheries and production facilities on the Island. The hatcheries develop and hatch eggs to help replenish fish stocks; the production facilities grow the fish until they reach market size.
Recreational fishing refers to non-commercial fishing. It includes recreational angling and sport fishing. There were a total of 8,680 anglers in Prince Edward Island in 2010, with 6,779 or 78% of them residents of the Island. Anglers in Prince Edward Island spent $9.6 million in direct expenditures (e.g., transportation, food, lodging); fishing services, fishing supplies and other direct recreational fishing expenditures (e.g., boat rentals, guide services, licence fees, lures, bait, lines); and, major purchases and investments (e.g., boats, motors, camping gears, fishing equipment) in 2010 (DFO, 2012b). In 2010, the top three species fished by anglers were freshwater brook trout, mackerel, and sea-run brook trout (DFO, 2012b). Other species fished by anglers include rainbow trout, Atlantic salmon, striped bass, white perch, smelts, cod, flounder, and brown trout. Fishing for freshwater species is more popular, with over 120,000 days spent fishing for freshwater species and almost 60,000 days spent fishing for saltwater species in 2010 (DFO, 2012b). Anglers on PEI fishing more on average than those in any other province or territory at 20.9 days per angler (DFO, 2012b) in 2010.

6.2 IMPACTS OF CLIMATE CHANGE ON PEI FISH AND AQUACULTURE

Ecosystems are naturally dynamic. However, climate change impacts are expected to increase the rate of change and the unpredictability of change. Some areas of the sector may benefit while others may face challenges. It is critical to note that opportunities and challenges resulting from climate change cannot be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the advantages in the increase of food conversion efficiency and growth rate from warmer sea temperature could be offset by the increased productivity of parasites that those temperatures bring.

6.2.1 TEMPERATURE

Rising air temperatures do not translate to a uniform rise in water temperatures. The water in the Gulf of St. Lawrence is made up of three distinct layers: the surface layer (0 to 50 m), a cold intermediate layer (50 to 150 m), and a deeper layer (exceeding 150m) (Benoît et al., 2012; Savard et al., 2016). Since the surface layer waters are warmed by solar radiation, this layer is affected by rising air temperatures. Studies have shown that increases in surface-water temperature in the Gulf are comparable to the increases in air temperature over the same region (Savard et al., 2016). The cold intermediate layer waters originate primarily from the cooling of water within the Gulf in the winter as well as from the transport of cold water from the Labrador Shelf through the strait between the Labrador peninsula and the island of Newfoundland (Drinkwater et al., 2002). The deeper layer contains warmer waters from the Atlantic Ocean between the continental shelves and the Gulf Stream (Drinkwater et al., 2002). Although the waters in the deeper layer are warmer than that in the cold intermediate layer, their density is higher because of the higher salinities (Drinkwater et al., 2002).
The term “temperature” described in the remainder of this chapter refers to water temperature, unless otherwise indicated.

**OPPORTUNITIES**

Firstly, an increase in temperature will accelerate the growth rate of some species (e.g., Atlantic salmon) (Pinnegar *et al.*, 2012; Savard *et al.*, 2016), as long as it remains within the thermal tolerance of those species and is not limited by other factors such as food availability (Reid and Jackson, 2014).

Secondly, warmer waters could reduce winter natural mortality (Savard *et al.*, 2016).

Thirdly, the spatial distribution of species will shift. Generally, the centres of commercial production and harvest of important fish species (e.g., tuna, mackerel) will shift northward or inshore (Campbell *et al.*, 2014). There is a potential for greater access to these species (Campbell *et al.*, 2014).

**CHALLENGES**

Firstly, it will negatively affect the growth of some organisms, such as cold-water species (e.g., cod, Atlantic halibut) (Pinnegar *et al.*, 2012) in multiple ways. As temperature nears the limits of a species’ tolerance range, the energy allocated towards its growth and reproduction declines (Brennan *et al.*, 2016), thus diminishing its size and abundance. For example, increasing temperatures were found to decrease Atlantic cod size (Brennan *et al.*, 2016). The increase in temperature can also impair immune function of cold-water species and make them more prone to disease (Pinnegar *et al.*, 2012; Doubleday *et al.*, 2013; Reid and Jackson, 2014). Some increases in temperature during spawning can affect egg mortality and hatching, reducing survival rates in some species (Savard *et al.*, 2016). Globally, increased surface level temperatures in high latitudes caused most of the ocean productivity decline since the early 1980s (Savard *et al.*, 2016).

Secondly, it will shift the timing of the species’ lifecycle stages. For example, some lobsters begin their molting process earlier in warmer waters, which can affect the quality and value of the meat as well as the traditional harvest period (PEI Department of Communities, Land and Environment, 2016). Similarly, the soft-shell phase for crabs could increase, during which they cannot be harvested or processed (Brennan *et al.*, 2016). This shift in timing also impacts the relationships among species (Pinnegaret *et al.*, 2012). The timing of life events may change relative to their predators, prey, and competitors (Brennan *et al.*, 2016). For example, the later arrival of mackerel creates a mismatch in the spring lobster fishing season (Savard *et al.*, 2016). Since mackerel is a staple bait species, it may have to be purchased elsewhere, increasing the cost of transportation and refrigeration (Savard *et al.*, 2016).

Thirdly, the spatial distribution of species will shift. There is a general poleward shift of species. Native species could move away from their current locations to maintain their preferred temperature range. Species requiring the coldest temperatures – such as the snow crab and Greenland halibut – would experience the most drastic declines (Benoît *et al.*, 2012; Brennan *et al.*, 2016). Meanwhile, non-indigenous invasive species and diseases currently south of the Island could be introduced to and
proliferate within the region. Non-indigenous invasive species cause harm to the ecosystem by destabilizing the conditions of native species (Benoît et al., 2012). They are considered a leading cause of biodiversity loss and threat to fishing and aquaculture industries worldwide (Benoît et al., 2012). This was evident in Chesapeake Bay in the United States, where a rise in maximum summer temperatures was an important driver in the disappearance of marine eelgrass near its southern distribution limit (Savard et al., 2016). Healthy eelgrass beds provide food, shelter, and protection for many species, especially juvenile fish. Similarly, a number of non-indigenous invasive species has caused issues in Island waters. Since 1998, four new turnicate species have established in the Gulf of St. Lawrence (see Figure 6.4). These filter feeders attach themselves to rocks, surfaces of the sea floor, mussel socks, aquaculture equipment, etc. They impact the aquaculture industry operationally and economically – the increased weight of tunicates growing on mussel socks and other equipment and structures used requires increased handling costs and leads to loss of mussels that fall off the socks (Benoît et al., 2012). The green crab is another important non-indigenous invasive species found in Island waters (see Figure 6.4). It is notorious for its aggressiveness and severe impacts on a wide variety of prey, especially molluscs; even damaging and modifying the habitat when it digs for prey (Benoît et al., 2012). It competes with baby lobsters for food and destroy eel grass beds. Its introduction to the local ecosystems coincides with the steep decline of a unique strain of Irish moss that can only be found on Prince Edward Island and is therefore suspected to be responsible for the decline (Benoît et al., 2012; Yarr, 2017). Given the lack of natural predators, abundance of food availability (mussels), lack of human market demand, and its tolerance of a wide temperature range (0 to 35°C) (Brennan et al., 2016), the green crab is expected to continue to thrive.

Furthermore, by disturbing the ecosystem, an initial invasion of non-native species lays the groundwork for subsequent non-native species to establish themselves (Benoît et al., 2012). This is of considerable concern since they are better adapted to the new aquatic conditions than the native species (DFO, 2005b).
Fourthly, some parasites experience an increase in productivity in warmer waters. For example, sea lice eggs need temperatures above 4°C to complete their lifecycle (Reid and Jackson, 2014). This is evident in lower incidences of infection during winter months and reduced time to complete their life-cycle in warmer months (Reid and Jackson, 2014). As temperatures increase under a changing climate, the salmon aquaculture industry could experience negative impacts.

Fifthly, increasing air and water temperatures will increase the melting of Arctic ice cover. This cold freshwater flow into the Gulf will lead to stronger stratification of the water layers, inhibiting the upward flow of nutrients from the deeper waters (DFO, 2005b; Bush et al., 2014) to the near-surface waters where phytoplankton grows and influencing the vertical exchange of important dissolved and suspended materials (e.g., reduced dissolved oxygen in subsurface waters) (Bush et al., 2014).
Sixthly, studies show that warming temperatures lead to reduced long-chain polyunsaturated fatty acid content in phytoplankton and cold-water pelagic fish (Myers et al., 2017). The nutrient content of marine life has consequent effects up the food chain (Myers et al., 2017).

6.2.2 SEA ICE

CHALLENGES

In the east coast region, sea-ice cover has decreased over the last century and will likely decrease by more than 95% by the end of this century (Savard et al., 2016). Within the Gulf of St. Lawrence, sea ice will continue to decrease in area, thickness, concentration, and duration until it ceases to form (Savard et al., 2016). Winter air temperatures over the Gulf account for more than half of the inter-annual variability of sea-ice coverage in thicker areas (Benoît et al., 2012).

Firstly, fewer nutrients will be available to primary producers such as phytoplankton as sea ice formation decreases. Sea ice plays an important role in water-convection processes, which assist in the production of phytoplankton (Savard et al., 2016). As surface water forms sea ice, the salt content of the water is released from the ice as dense brine. This sinks to deeper waters, displacing the less dense and nutrient-rich water, bringing it toward the surface. This upwelling brings nutrients for primary producers (Savard et al., 2016). Phytoplankton is the foundation of the marine food web (Myers et al., 2017). The reduction in nutrients can affect the timing of the spring phytoplankton bloom, impacting the recruitment of species. A study estimated that the changes in size and distribution of plankton communities would decrease fish catch potential by 3-13% globally by 2050 compared to recent decades (Myers et al., 2017).

Secondly, changes in ice cover can lead to other changes in the habitat such as salinity levels, water quantity, composition and quality, silt deposits, river flows, etc. (DFO, 2005b).

6.2.3 OCEAN ACIDIFICATION

CHALLENGES

Some of the carbon dioxide in the atmosphere is absorbed by marine waters, changing the chemical composition of the water and lowering the pH level, making the water more acidic. Globally, it is estimated that since pre-industrial times, about one-third of the carbon dioxide produced by human activities has been absorbed by the ocean (Benoît et al., 2012). If the emission rates continue at its present rate, a 100% increase in acidity is anticipated by the end of the century, to a level possibly unseen over the last 55 million years (Benoît et al., 2012). The ability of marine life to adapt is unknown. The acidification of marine waters will present challenges to the sector.
Firstly, an increase in the acidity of marine waters raises the solubility of calcium carbonate, which forms the shells and skeletons of shellfish. It will make it more difficult for shellfish to develop hard shells, diminishing the protection they provide. Shell deformation has also been observed – a potential issue for the marketability of shellfish.

Secondly, the growth and health of fish and shellfish are jeopardized. For example, the increase in acidity has been found to lower the hatching success, survival, final weight, growth rate, swimming performance, calcification rate, development rate, settle success, cellular activity, respiratory activity, protein synthesis, and feeding efficiency of fish and shellfish (Brennan et al., 2016). Acidification can also change species composition and dominance within an ecosystem (Savard et al., 2016).

### 6.2.4 EXTREME WEATHER EVENTS

#### CHALLENGES

Firstly, heavy precipitation events can introduce significant amounts of sediments and contaminants via runoff, negatively impacting important species such as seagrass, which can be damaged or killed by polluted run-off containing herbicides. In addition, contaminated runoff promotes the growth of unwanted species. Extreme events provide ideal conditions for sea lettuce to grow. Sea lettuce quickly proliferates in areas of substrates cleared of other organisms by disturbances such as storms (Capital Region District, n.d.). Sewage and agricultural contaminants in the runoff encourage sea lettuce growth, which thrive in moderate levels of nutrient pollution while other plants suffocate (University of Rhode Island Environmental Data Centre [URI EDC], n.d.). The growth of sea lettuce can lead to anoxic events (i.e., complete depletion of oxygen below the water surface). Where there is a bloom or high concentration of sea lettuce, sunlight to submerged vegetation such as eelgrass is blocked, preventing photosynthesis and killing the vegetation (URI EDC, n.d.). When the sea lettuce dies and rots, the bacteria feeding on it uses up a significant amount of oxygen in the water, depleting the oxygen available to other species (e.g., mussels), suffocating them or driving them away (URI EDC, n.d.). In the past, anoxic events caused by sea lettuce would happen once per season within any given area. Recently, there have been incidences of these events occurring twice per season within the same area. Another unwanted species that benefit from runoff is blue-green algae, or cyanobacteria. It is a non-indigenous invasive species that produces toxins, affecting human and animal health. Nutrients from runoff, along with increasing temperatures, increase the frequency of blue-green algae blooms (Gillette and Myvette, 2008), which may result in the lost productivity or mortality of other marine life (Campbell et al., 2014). It has also been linked to an off-flavour in fish in other regions (Reid and Jackson, 2014).

Secondly, to address concerns regarding the sanitation of shellfish sold for export after “unusual weather events”, flooding, spills of sewage, etc., a protocol for emergency closure of shellfish growing areas have been put in place jointly by the Canadian Food Inspection Agency (CFIA), Environment and Climate Change Canada, and Fisheries and Oceans Canada (CFIA et al., 2014). A rainfall-based closure will be determined based on a number of factors, including the amount and intensity of precipitation,
duration, time of year, ground saturation, likelihood of flooding and sewage overflows, and adjacent land use activities (CFIA, 2014). Once the protocol is enacted, the closure of the area will be in place for a minimum seven days to allow for proper cleansing of shellfish (CFIA, 2014). After that time, water sampling and shellstock testing will be conducted to ensure sanitation requirements are met before the area can be reopened (CFIA et al., 2014). As extreme weather events increase in frequency, these closures are expected to increase in frequency as well.

Thirdly, extreme events bring about increased wave action that can cause damage to infrastructure and equipment such as small craft harbours, aquaculture facilities, vessels, traps, etc. As a result, the cost of insurance, maintenance, repair, and adaptation of infrastructure and equipment will increase under a changing climate.

Fourthly, extreme weather events limit the fishers’ and producers’ access to their sites. Change in sedimentation from run-off and wave action could increase the need to dredge channels for boat access. Access to harbours and land-based aquaculture sites such as hatcheries could be temporarily restricted due to road closures.

Fifthly, an increase in storm activity and wave energy can reduce the catch through a reduction in the number of fishing days (e.g., preventing fishers from going out) and availability of fish (Gillett and Myvette, 2008; Holbrook and Johnson, 2014).

6.2.5 SEA LEVEL RISE

CHALLENGES

Firstly, rising sea levels can damage properties and infrastructure within the near-coastal zone via flooding and erosion. As a result, the cost of insurance and maintenance, repair, and adaptation of infrastructure (e.g., adjusting wharves) and equipment will increase under a changing climate.

Secondly, rising seas could increase salinity in bays and estuaries via salt water intrusion (DFO, 2005b). Fish and shellfish each have a defined tolerance of salinity levels. If the levels reach or exceed the upper limits of their tolerance, their ability to thrive and survive will be threatened.

Thirdly, any coastal wetlands and habitats that serve as nurseries could be compromised or lost (Gillett and Myvette, 2008). The changes in estuarine dynamics could limit seedstock availability (Gillett and Myvette, 2008).

Fourthly, a change in sea levels could prompt a change in aquaculture zoning (Savard et al., 2016)

Fifthly, bridge clearance will decrease as sea levels rise. This would impact shellfishers and pleasure boaters, who need to pass underneath.
6.2.6 INDIRECT CLIMATE CHANGE IMPACTS

CHALLENGES

Firstly, warmer temperatures could lead to an increase in tourism and recreational use of waterways, leading to more human activity and traffic. Pollution from these activities could result in contamination of the water bodies and the potential introduction of invasive species from ballast water (DFO, 2005b) negatively impacting local marine life.

Secondly, the increased use of armouring to protect properties and infrastructure from flooding and erosion would alter the shoreline and could impact aquatic habitats (DFO, 2005b).

6.2.7 UNKNOWNS

Under a changing climate, food access and security will become increasingly valued. However, the impact on the sector in Prince Edward Island is difficult to project. Recent assessments by DFO suggest that drastic changes in fisheries yield and value are unlikely over the next decade (Campbell et al., 2014). However, over the longer term, catch and production of individual species locally and in other regions will vary and remain uncertain. For example, in 2012, an ocean heat wave resulted in a glut in the supply of lobsters from the New England states before the close of the Canadian lobster season, driving the price of lobster down (Savard et al., 2016).

6.3 RECOMMENDED ADAPTATION ACTIONS

26. Conduct research and collect data to form a foundation for evidence-based adaptation planning. Standardized equipment and methodology should be used, and the data should be made accessible from a centralized database. For example:
   a. create an inventory and map habitats of significant marine species, water temperatures, and population numbers, where possible;
   b. create an inventory of the major species’ range in temperature, pH levels, salinity, etc.;
   c. investigate preventive treatments of anticipated diseases;
   d. identify alternative feeds and feeding practices;
   e. study effective responses against non-indigenous invasive species; and,
   f. determine the impact of climate change impacts on major marine species.

27. Reduce non-climatic stressors to increase the ability of marine life to cope with climate change impacts. Climate change introduces stress to the natural systems (e.g., changes in temperature, pH, salinity), impacting the native species’ ability to survive and thrive. Since some of these
stresses cannot be easily counteracted, increasing the resilience of marine life is essential. For example,

a. reduce land-based sources of pollution (e.g., agricultural and sewage run-off). The effectiveness of the current buffer zone should be evaluated under future climate conditions;
b. prevent translocation of pathogens and non-indigenous invasive species;
c. prevent the filling in of estuaries and channels;
d. adjust quotas based on changes in recruitment, growth, survival, and reproductive success (Shelton, 2014), as necessary, to limit overfishing. The quota should be revisited annually and adjusted up or down, as needed, to changes in the natural systems and climate change impacts. Fish stocks will not be able to sustain past and current levels of fishing. Well managed fish stocks are more resilient, better handle climate impacts (HM Government, 2013), and provide a more sustainable future for the sector;
e. use fish stocking to maintain critical levels of fish;
f. reduce habitat loss. Local watershed groups can be engaged to improve and restore coastal habitats. For example, a small levy can be applied to fund coastal/wetland restoration training and projects with known benefits to the environment and the sector (e.g., plant eel grass beds, remove/harvest sea lettuce overgrowth, monitor harmful blue-green algal blooms); and,
g. raise public awareness on the importance of healthy and diverse coastal systems. For example, demonstrate the use of wetlands, rain barrels, living shorelines techniques, berms, etc. to adapt to flooding and erosion rather than hard structures (e.g., seawalls, armouring), which decrease fisheries habitat and biodiversity. The public can be incentivized to help by demonstrating to them how the consequences of poorly managed ecosystems (e.g., marine diseases, blue-green algae blooms, run-off) can negatively impact recreational use of coastal areas and human health.

28. Manage risks and adapt to increased variability in the sector via diversification. For example:

a. diversify sources and types of fish meal and fish oil (e.g., wild-caught seed versus propagated seed, suppliers of seed);
b. diversify livelihoods (e.g., ecotourism, fishing tours);
c. avoid investing heavily in specialized equipment;
d. diversify product range (e.g., algae cultivation);
e. decentralize and spread out locations of hatcheries, storage facilities, food processing plants, etc. Should one location be inundated environmentally (e.g., pollution) or physically (e.g., flooding), other sites can continue to operate; and,
f. diversify markets for products. Proactively seek out and establish new markets to prevent impacts from a glut in traditional market driving down prices.

29. Invite other jurisdictions to share best practices. Other regions are facing similar challenges brought on by climate change. Long-term sustainability and adaptive capacity need to be the goal, rather than yield or profit maximization. By sharing best practices with other regions (e.g.,
immerse mussel seed in a continuous flow of freshwater before transferring them from an infested area to a new area), they could reciprocate with adaptation strategies of their own (e.g., ways to cope with green crab). It would be mutually beneficial for ecosystems and sectors to be as healthy and sustainable as possible.

30. **Relocate, retrofit, and/or protect** existing properties and infrastructure and redesign new properties and infrastructure to reduce flooding and erosion vulnerabilities. Green measures should be used where possible (see Recommended Adaptation Action #27g). For example,
   a. raise harbours over time to cope with sea level rise;
   b. build onshore storage facilities for boats and gear to prevent damage and loss during extreme events; and,
   c. include climate change considerations during the siting and design of new infrastructure. For example, building an aquaculture production facility that requires saltwater for its operation as close to the coast as possible will reduce the cost of piping and trenching during the construction stage and the use of electricity for pumping during its operation stage. However, the cost of protecting it from increasing rates of flooding and/or erosion overtime will overwhelm the initial capital and operational savings.

31. **Utilize regulatory measures to harmonize adaptation objectives** and approaches among different stakeholders that are reliant on the same resource. The government should collaborate with stakeholders to design clear and transparent policies that promote adaptive capacity and the sustained resilience and success of natural resources and the industries that depend on them. For example,
   a. design flexibility into the policies. For example, fishing season start and end dates can be adjusted to climate factors, extended to compensate for closures due to shellfish sanitisation regulations, etc.;
   b. seek the input of indirect stakeholders. For example, collaborate with the agriculture sector to reduce inputs before a forecasted extreme precipitation even to reduce contaminants in run off. This also benefits farmers, since inputs are costly and any that leave the crop area are wasted;
   c. prioritize the sustainability of the industry and the environment over short-term profit and yield. It would be a lose-lose scenario for all stakeholders if the long-term sustainability of the industry was sacrificed for short-term gain; and,
   d. address overcapacity proactively. For any part of the sector that is facing declining yield and productivity with no reasonable method of adaptation, policies can offer permit or vessel buybacks and subsidy reductions as ways to reduce overcapacity in the sector.

32. **Employ financial mechanisms** such as insurance and other innovative instruments to help limit business losses caused by climatic events. Establish a committee with the industry, Department of Fisheries and Aquaculture, and Department of Finance to discuss establishing a co-operative that offers fishing and aquaculture insurance. It could provide insurance against production
losses related to natural hazards, diseases, invasive species, damage to vessels from weather-related events, and more. Incentives (e.g. lower premiums) could be put in place to encourage adaptation. Co-financing may be required during the pilot stage but this program was used in another jurisdiction and the cooperative became self-sustaining. Profits from the insurance program could be used by the cooperative in ways that benefit the industry (e.g. invest in raising awareness of climate change impacts and adaptation, purchase safety equipment).

33. Recognize opportunities. Low-lying coastal land will eventually become permanently inundated via sea level rise and could be suitable for fishing and aquaculture. Improvements in technology and farming practices (e.g. selective breeding) could help compensate for climate change impacts.

The collaboration of fishers, environmental groups, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and the government will be critical in achieving effective adaptation. The table below summarizes the eight recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

<table>
<thead>
<tr>
<th>Recommended Adaptation Action</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>26. Conduct research and collect data to form a foundation for evidence-based adaptation planning (e.g., create an inventory and map habitats of significant marine species and environmental variables, study effective responses against invasive species).</td>
<td>Leads: Sector, Provincial Government Collaborators: Experts, Environmental groups</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td>27. Reduce non-climatic stressors to increase the ability of marine life to cope with climate change impacts (e.g., reduce runoff, restore coastal habitats).</td>
<td>Leads: Sector, Provincial Government, Federal Government Collaborator: Fishers, Experts, Public</td>
<td>Increase resilience; Reduce non-climatic factors; Engage in outreach</td>
</tr>
<tr>
<td>28. Manage risks and adapt to increased variability in the sector via diversification (e.g., diversity livelihoods, decentralize and spread out locations of facilities).</td>
<td>Leads: Fishers, Sector Collaborators: Experts</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>29. Invite other jurisdictions to share best practices (e.g., seek ways to cope with green crab, share local methods when transferring mussel seed from an infested area to a new area).</td>
<td>Leads: Fishers, Sector Collaborators: Experts</td>
<td>Increase collaboration</td>
</tr>
<tr>
<td>30. Relocate, retrofit, and/or protect existing properties and infrastructure and redesign new properties and infrastructure to reduce flooding and erosion vulnerabilities.</td>
<td>Leads: Infrastructure owners</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>31. Utilize regulatory measures to harmonize adaptation objectives and approaches among different stakeholders that are reliant on the same</td>
<td>Leads: Provincial Government, Federal Government</td>
<td>Leverage regulation; Increase collaboration</td>
</tr>
</tbody>
</table>
resource (e.g., prioritize sustainability of the industry and the environment over short-term profit and yield).

32. Employ financial mechanisms such as insurance and other innovative instruments to help limit business losses caused by climatic events (e.g., create a co-operative that offers insurance against production losses).

33. Recognize opportunities (e.g., improvements in technology and farming practices such as selective breeding).

6.4 CONCLUSION

The fish and aquaculture sector is vital to Prince Edward Island. Aside from its role in the Island’s economy and society, its provision of healthy food is critical. The sector is inherently sensitive to climate and specific timing and manifestation of impacts are unknown. However, the sector can act proactively, such as restoring and improving natural systems via biodiversity enhancement and diversification, to increase the resilience of marine life and its ability to cope with the challenges that the future climate will bring.

References


7 FORESTRY AND BIODIVERSITY SECTOR

7.1 INTRODUCTION

Forests are an important resource. Not only are they a home for plants and animals, they are also a source of timber (e.g., softwood for lumber and hardwood for fuelwood), food (e.g., maple syrup), and medicine (e.g., dwarf ginseng). Forests also act as natural carbon sinks, support socio-economic activities, conserve biodiversity, control flood and erosion, and regulate climate and atmospheric composition (Bourque and Hassan, 2010). In turn, biodiversity supports the ability of natural capacity to deliver these services (e.g., pollination, forest productivity) (Nantel et al., 2014). The diversity and identify of animals, plants, and microbial species impact the function of an ecosystem. The loss of biodiversity decreases plant production, diminishes the ecosystem’s resistance to environmental disturbances (e.g., drought), and increases variability in soil nitrogen levels, water usage, and pest and disease cycles (Naeem et al., 1999). Biodiversity also contributes to human health. Studies have tied declines in local and regional biodiversity to increasing rates of allergies in adolescents and increasing population of carriers of the West Nile virus and Lyme disease (Nantel et al., 2014).

Prince Edward Island is part of Canada’s Acadian Forest region, which covers the Maritime Provinces (Prince Edward Island, n.d.). Across Canada, only 6% of forested land is privately owned; the rest are owned by the federal, provincial, or territorial governments (Natural Resources Canada, n.d.). On Prince Edward Island, however, over 86% of forested land is privately owned by approximately 16,000 individuals and organizations (Dunsky Energy Consulting, 2017). Land clearing created fragmented small woodlots from large contiguous forest (PEI Department of Agriculture and Fisheries [PEI AF], 2013). Out of the Island’s 1.4 million acres of land, approximately 0.62 million acres are forest lands (see Figure 6.1). One primary cause of the decline in the area of forest land is land clearing for agricultural use.

Figure 6.1. Forestry land use in 2010. (Data source: PEI AF, 2013)
In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the forestry, hunting, trapping, and fishing subsectors contributing $79.2 million or 1.7% (see Figure 6.2). In March 2017, the forest and fishing subsectors employed approximately 2,500 people, out of 70,200, or 3.6% across all industries in the province (see Figure 6.3). Commercial fishing would constitute the majority of the GDP and employment figures; unfortunately, Statistics Canada does not separate fishing\(^3\) from these categories. In addition, the intrinsic, social, ecological, environmental, etc. value of forestry and biodiversity is not captured in GDP data. Placing an economic valuation of ecosystem services is a relatively new area of study. For example, for the Greater Toronto Area, the Rouge National Urban Park and its surrounding water sheds are expected to contribute $28.2 million per year in pollination services, $17.8 million per year in carbon storage, and $17.1 million per year in wetland habitat (Nantel et al., 2014).

\[\text{Figure 6.2. Prince Edward Island GDP of forestry, fishing, hunting, and trapping in 2016 (in $million chained 2007 dollars). (Data source: Statistics Canada, 2017b)}\]

\(^3\)Refer to the Fish and Aquaculture Sector chapter for additional details on commercial fishing.
7.2 CLIMATE CHANGE IMPACTS

Climate change will bring about warmer weather, changes in precipitation patterns, more intense storms, and rising sea levels in Prince Edward Island.

It is critical to note that opportunities and challenges resulting from climate change cannot be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the advantages of increased productivity in warmer temperatures could be offset by the invasive pests and diseases that those temperatures bring.

7.2.1 TEMPERATURE

OPPORTUNITIES

Firstly, warmer temperatures could increase forest productivity, lengthen growing seasons (Nantel et al., 2014), add growing degree days for some hardwood species, and expand suitable habitat for others (Bourque and Hassan, 2010).

Secondly, bird species that currently breed in the northern portion of eastern United States could expand north into Canada, increasing bird species richness (Nantel et al., 2014).

CHALLENGES

Firstly, the suitable range for cold-hard species such as white spruce (see Figure 6.4), balsam fir, and white birch could shift northward in search for cooler temperatures (Bourque and Hassan, 2010; Nantel...
The suitable habitats for these species could become fragmented, or contract, causing a decline of the existing population (Nantel et al., 2014).

Secondly, the pests (e.g., bark beetle) and pathogens that are currently limited by winter temperatures will increase in productivity, expanding the range and increasing the severity of diseases and pest outbreaks (Nantel et al., 2014).

Thirdly, the lifecycles of some species will be affected. The increase in metabolism of some insects may see their population peak earlier in the season, potentially causing a phenological mismatch to the arrival of migratory birds, affecting hatchling growth and development (Nantel et al., 2014).

Fourthly, an earlier start to the growing season may increase frost exposure for plants (Nantel et al., 2014).

Fifthly, shorter winter seasons could shorten the winter soil water recharge period (Glen, 2008).
7.2.2 PRECIPITATION

CHALLENGES

Firstly, with an overall decrease in precipitation and number of rain events, drought-like conditions could occur with greater frequency in the future. In turn, this could increase the occurrence of forest fire. Not only do fires kill trees, intense fires can change the soil composition of a forest.

Secondly, tree species suited to the future climate of the Island may move here from the south but if local soil properties do not suit (e.g., dryer soils from changing precipitation patterns), assisted tree migration could be unsuccessful.

Thirdly, intense rain storms could cause inundation of trees in areas where the water cannot drain away.

7.2.3 EXTREME WEATHER EVENTS

CHALLENGES

Firstly, the increasing intensity and frequency of extreme weather events such as windstorms and ice storms could increase damage to public forest land and private woodlots (Nantel et al., 2014).

Second, storm surge and coastal flooding inundate and kill trees.

7.2.4 CARBON DIOXIDE

OPPORTUNITIES

Although the increasing concentrations of atmospheric carbon dioxide is the primary driver of climate change and is responsible for the impacts described above, the carbon dioxide itself could also benefit the productivity of trees. The carbon dioxide accelerates the rates of photosynthesis, raises the efficiency of water use in plants, and may strengthen plant defences against pests and pathogens (Myers et al., 2017).

CHALLENGES

The presence of carbon dioxide can reduce timber strength and may cause nutrient imbalances (Glen, 2008).
7.2.5 INDIRECT CLIMATE CHANGE IMPACTS

OPPORTUNITIES

Firstly, the sector could be impacted by regulations put in place to address climate change. For example, mitigation efforts by the Canadian Government include putting a price on carbon pollution in provinces and territories that do not have their own carbon pricing structure. The federal price starts at $10 per metric tonne of greenhouse gas emissions in 2018 and increases by $10 per year until 2022 when it reaches $50 per metric tonne (Environment and Climate Change Canada, 2017). This could encourage better forest management as it would give owners financial incentive to sequester more carbon with their lands.

Secondly, the mitigation efforts describe above could increase the use biomass as a fuel source for heating, since it is considered to be carbon-neutral.

7.2.6 NON-CLIMATIC MULTIPLIERS

There are two noteworthy characteristics of the sector that multiplies the challenges posed by the climate change impacts discussed above.

AWARENESS

There is a general lack of awareness among the general public of the services that forests and biodiversity provide. As a result, there is less attention paid and fewer resources allocated to the monitoring, research, and reduction of the detrimental impacts caused by climate change in this sector.

FRAGMENTATION

Fragmentation is one of the major non-climatic stressors within the sector. The small fragmented nature of woodlots in Prince Edward Island may cause habitat loss and impede the range expansion by birds, colonization of forest plants, migration of native species to maintain genetic diversity, and adaptation success in some species (Nantel et al., 2014). This problem is most acute in areas of intensive agriculture.

7.3 RECOMMENDED ADAPTATION ACTIONS

34. Reduce non-climatic stressors to keep forests healthy and productive and maintain biodiversity. This will increase their resilience to climate change. For example,
a. maintain or increase genetic diversity (e.g., seeding or sowing multiple species of native plants) (Nantel et al., 2014);
b. limit overharvesting;
c. create small canopy gaps to promote development of ground cover (Diamond Head Consulting, 2014);
d. reduce pollution (e.g., increase fines and enforce penalties for dumping of waste in natural areas);
e. restore the environment of natural wooded areas. Assess areas where natural recovery is feasible and where intervention (e.g., assisted migration) or human engineering actions are required. Develop strategies and priorities for areas requiring intervention or human engineering actions and ensure they are sustainable under a future climate (e.g., select species with some drought tolerance for seed transfer);
f. review natural areas to identify zones critical for the conservation of biodiversity and regulate activities in those areas. For example, protect migratory routes from harvesting and development;
g. establish a voluntary conservation covenant or easement, which prohibit development on a portion or all of the property or removal of native vegetation, in areas that are sensitive to climate change impacts in exchange for a property tax reduction or credit (Richardson and Otero, 2012). The owner could continue to own the land, live on it, sell it, or pass it on but the covenant would continue regardless. This should be reviewed on a case-by-case basis and entered into only when the preservation of land has measurable benefits (e.g., protect migratory routes); and,
h. promote the use of the municipal power ‘tree preservation and protection’ among municipalities by framing the benefits and assisting in the drafting of its inclusion in their official plans.

35. **Support research and data collection** in climate change impacts and adaptation to create a foundation for evidence-based adaptation. For example,
   a. study precipitation patterns (e.g., number of intense rain events, days without rain in between);
   b. establish a baseline to determine the current state of biodiversity;
   c. develop strategies to help wildlife (e.g., terrestrial and avian species) adapt; and,
   d. collaborate with PEI Invasive Species Council to monitor climate variables, collect and map data on invasive species, and develop a comprehensive invasive species management strategy.

36. **Increase natural connectivity** among natural areas. Isolated habitat patches limit the movement of certain species across the landscape (Diamond Head Consulting, 2014). The reduction of landscape fragmentation facilitates migration, gene flow, and other autonomous adjustments (Nantel et al., 2014). This can be accomplished by preserving large core habitat areas, ensuring connectivity between the habitat areas (e.g., hedgerows), and providing a diversity of habitat features (Diamond Head Consulting, 2014) (see Figure 6.4). Considerations
for connecting edge habitats, which are more common across the Island, should be given. Abandoned agricultural areas within the network can be actively restored into wood lots. Types of habitat areas include: forests, parks wetlands, marine foreshore, oldfields, and agricultural land. Where roads, especially major highways, create a significant barrier to movement, reduce wildlife mortality by providing safe passage (e.g., construct underpasses alongside of roads, culverts or bridges upgrades or maintenance) (Diamond Head Consulting, 2014).

![Figure 6.4. Example of a green infrastructure network showing how natural areas can be connected to improve biodiversity. (Source: Diamond Head Consulting, 2014)](image)

37. **Increase natural areas.** For example,
   a. encourage biodiversity in the urban environment;
   b. increase canopy cover, especially over streams to reduce evaporative loss and promote water recharge;
   c. actively restore abandoned agricultural fields;
   d. select trees that are suitable in the future climate when planting, using the study completed by Glen (2008) for the Prince Edward Island National Park; and,
   e. promote the sale of tree saplings as school fundraising activities.

38. **Leverage regulation to promote needed adaptation** where existing incentive is lacking. For example:
   a. prevent the draining of wetlands to retain their ability to control reduce flooding;
   b. limit hedgerow removals, which is important for connectivity and water retention;
   c. plan urban sprawl developing with connectivity and biodiversity in mind (e.g., developers must submit multi-year forestry plans to maintain or re-establish green spaces and trees);
   d. review the effectiveness and objectives of “cash in lieu” land use planning options;
   e. limit cutting in areas (e.g., watersheds) where canopy coverage is low; and,
   f. protect and expand the buffer zone, with increased enforcement efforts and penalties.
39. Demonstrate the importance of forestry and biodiversity conservation and enhancement initiatives by **assigning an economic value** to the ecosystem services they provide (e.g., pollination and carbon storage services). These benefits and their economic values should be highlighted when generating support for adaptation actions in the sector.

40. **Engage in outreach** to generate additional support for adaptation actions. For example,
   a. frame the benefits of forests and biodiversity in ways that resonate with the public (e.g., their impact on public health);
   b. develop visitor experience programs at provincial parks that include hands-on activities such as restoration efforts;
   c. create a system for the public to report invasive plant and animal species;
   d. develop training programs in provincial and municipal departments to raise awareness of new biodiversity objectives and provide opportunities for interdepartmental and intergovernmental cooperation to implement biodiversity initiatives; and,
   e. make the public and woodlots owner aware of the adaptation strategies available.

41. **Connect** with other environmental groups, community groups, and sectors to raise support for adaptation activities. There are parallels that provide an opportunity to collaborate, cooperate, and share resources. For example, habitat restoration by watershed groups is a recommended adaptation action in the Fish and Aquaculture sector and could fit well with habitat restoration activities for the Forestry and Biodiversity sector; use of rain gardens to control stormwater management is a recommended adaptation action for the Water sector and the Properties and Infrastructure sector that could increase biodiversity.

42. Collaborate with local Indigenous groups to **incorporate Traditional Ecological Knowledge** (TEK) in designing climate change adaptation actions. This knowledge consists of generations of observations and experiences and its holistic approach could help alter typically linear methods used by Western cultures into complex ecological system management (University of Manitoba Aboriginal Planning Program, n.d.). For example, a talking circle can be used to:
   a. discover the observations, concerns, and perspectives of the First Nations;
   b. understand how TEK could be applied in maintaining healthy forests and biodiversity; and,
   c. discuss what TEK-informed adaptation looks like.

43. **Increase capacity within the government** to augment the sustainability of forests and biodiversity. For example, dedicate more staff to outreach efforts, capture institutional knowledge of staff, etc.

44. Develop a **coordinated approach** to implement the Recommended Adaptation Actions (#34 to #43) for the Forestry and Biodiversity sector. Host ongoing meetings among sector stakeholders...
(e.g., woodlot owners, land use planners, parkland conservationists, educators) and conduct on-site demonstrations (e.g., data collection, restoration).

The collaboration of woodlot owners, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and governments will be critical in achieving effective adaptation. The table below summarizes the eleven recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

Table 7.1 Summary of recommended adaptation actions for the Forestry and Biodiversity sector.

<table>
<thead>
<tr>
<th>Recommended Adaptation Action</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Reduce non-climatic stressors to keep forests healthy and productive and maintain biodiversity (e.g., reduce pollution, promote development of ground cover).</td>
<td>Leads: Sector, Provincial Government, Woodlot owners Collaborators: Environment Groups, Municipal Governments</td>
<td>Reduce non-climatic stressors; Increase resilience</td>
</tr>
<tr>
<td>35. Support research and data collection in climate change impacts and adaptation to create a foundation for evidence-based adaptation (e.g., forecast precipitation patterns, determine current state of biodiversity).</td>
<td>Leads: Sector, Provincial Government Collaborators: Environmental Groups, Experts</td>
<td>Full knowledge gaps; Increase collaboration</td>
</tr>
<tr>
<td>36. Increase natural connectivity among natural areas (e.g., preserve core habitat areas, increase hedgerows).</td>
<td>Leads: Provincial Government Collaborators: Sectors, Municipal Governments, Public, Environmental Groups</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>37. Increase natural areas (e.g., restore abandoned agricultural fields, sell tree saplings as school fundraisers).</td>
<td>Leads: Provincial Government, Environmental Groups</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>38. Leverage regulation to promote needed adaptation where existing incentive is lacking (e.g., expand the buffer zone).</td>
<td>Lead: Provincial Government Collaborators: Public</td>
<td>Leverage regulation; Reduce non-climatic factors</td>
</tr>
<tr>
<td>39. Assign an economic value to the ecosystem services that forests provide (e.g., pollination and carbon storage services).</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Address financial concerns</td>
</tr>
<tr>
<td>40. Engage in outreach to generate additional support for adaptation actions (e.g., frame the benefits of forests and biodiversity in ways that resonate with the public).</td>
<td>Lead: Provincial Government Collaborators: Sector, Environmental Groups, Experts</td>
<td>Engage in outreach; Increase collaboration; Fill knowledge gaps</td>
</tr>
<tr>
<td>41. Connect with other environmental groups, community groups, and sectors to raise support for adaptation activities (e.g., coordinated habitat restoration for Fish and Aquaculture and Forestry)</td>
<td>Leads: Environmental Groups, Sectors Collaborators: Provincial Government, experts</td>
<td>Increase collaboration</td>
</tr>
</tbody>
</table>
42. Collaborate with local Indigenous groups to incorporate Traditional Ecological Knowledge.

| Lead: Sector Collaborators: Indigenous groups, Provincial Government, Environmental groups |
| Increase collaboration; Fill knowledge gap |

43. Increase capacity within the government (e.g., dedicate more staff to outreach)

| Lead: Provincial government |
| Fill knowledge gap; Engage in outreach |

44. Develop a coordinated approach to implement the Recommended Adaptation Actions for the sector (#34 to #43) (e.g., stakeholder meetings, on-site demonstrations).

| Leads: Provincial government, Sector Collaborators: Woodlot owners, Environmental groups, outreach groups |
| Increase collaboration; Engage in outreach; Fill knowledge gaps |

7.4 CONCLUSION

Forests and wildlife have autonomous processes to adapt to climatic changes. However, it is uncertain how these processes will affect ecosystem composition, structure and function (Nantel et al., 2014). For some species, the rates of climate change may overwhelm their natural ability to adapt, threatening biodiversity. Given the long generation times of tree species, decisions made today will continue to be felt in the sector for over 100 years (Nantel et al., 2014). It is important to the environment, society and economy that the decision is to act quickly to maintain the sustainability of the sector.

References


8 INSURANCE SECTOR

8.1 BACKGROUND

Insurance provides a financial safety net by transferring some of the risk of large financial losses associated with unpredictable events such as automobile accidents and natural disasters. The property industry in Canada is over 200 years old (Kovacs and Thistlewaite, 2014). The property and auto insurance industry is Canada’s most competitive financial industry, with several hundred companies providing coverage (Kovacs and Thistlewaite, 2014).

In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the insurance sector contributing $70 million or 1.5% (see Figure 8.1). There were 63,642 equivalent annual full time jobs in 2016 across all industries in Prince Edward Island and the finance and insurance sector provided 792, or 1.2% of those jobs (see Figure 8.2). In 2015, the Island received $20 million in taxes and levies from the property and casualty insurers (Insurance Bureau of Canada [IBC], 2017). The insurers paid approximately $125 million in direct claims in 2015 in Prince Edward Island for damaged home and business repairs, replacement of stolen property, and benefits for motor vehicle collision victims (IBC, 2017). The industry has been active in the promotion of road safety, building code improvements, and coordinated preparation and response to natural disasters (IBC, 2017).

![Figure 8.1. Prince Edward Island GDP of the insurance sector in 2016 (in $million chained 2007 dollars). (Data source: Statistics Canada, 2017b)](image-url)
8.1.1 INSURANCE COVERAGE FOR WEATHER-RELATED IMPACTS

Currently, the Insurance Bureau of Canada (IBC), an industry association representing private home, car, and business insurers across Canada, is looking to work with the federal government on developing a National Flood Strategy. It is important to understand how the sector defines and insures different types of floods (see Table 8.1). Coverage is available for certain types of water damage only, and even then, not all insurance companies offer it.

<table>
<thead>
<tr>
<th>Event</th>
<th>Type of Coverage</th>
<th>Availability of Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water damage to buildings caused by burst pipes and appliances</td>
<td>Home insurance</td>
<td>Usually covered by all homeowner and business insurance policies</td>
</tr>
<tr>
<td>Water damage to buildings caused by back up through sewers, floor drains, toilets, and showers</td>
<td>Sewer back up coverage</td>
<td>Most homeowner and business policies do not cover sewer back up unless it is specifically added to the policy</td>
</tr>
<tr>
<td>Water damage to buildings caused by water entering through sudden openings caused by wind or hail (e.g., flying debris, falling tree branch)</td>
<td>Home insurance</td>
<td>Most homeowner and business policies cover wind or hail damage</td>
</tr>
<tr>
<td>Water damage to buildings caused by seepage of surface water from rain or snowmelt overwhelming drainage systems</td>
<td>Overland flood coverage</td>
<td>Some insurers are offering the coverage but only to certain areas in Canada</td>
</tr>
<tr>
<td>Water damage to buildings caused by seepage of overflow from bodies of (fresh)water such as rivers and dams</td>
<td>Overland water coverage</td>
<td>Some insurers are offering the coverage but only to certain areas in Canada</td>
</tr>
<tr>
<td>Water damage from coastal (saltwater) flooding</td>
<td>N/A</td>
<td>No coverage exists for this type of event in Canada</td>
</tr>
</tbody>
</table>
Flood damage is costly; a 6-inch flood in a 2,000-square-foot home could cause approximately $40,000 in damage (Aviva, n.d.). Canada was the last G8 country to have overland flood coverage made available to homeowners (Thistlewaite and Feltmate, 2013). Overland flood coverage was first introduced to the market in 2015 by Aviva; coverage is currently available in all provinces except Quebec (Nadarajah, 2016). Before then, Canadians relied on physical defences, disaster relief programs, and flood plain maps to minimize their risk of flood damage (Thistlewaite and Feltmate, 2013).

Coverage for other weather-related impacts such as coastal flooding, coastal erosion is unavailable at this time.

8.2 IMPACTS OF CLIMATE CHANGE

Climate change will bring about changes in precipitation patterns, more intense storms, and rising sea levels in Prince Edward Island.

For the insurance sector, it is difficult to separate opportunities and challenges. For insurers providing overland water coverage, some of the climate impacts described below would be characterized as opportunities to increase revenue. However, for insurers opposed to overland water coverage or have not yet established coverage, they are limiting their exposure to financial risks but could suffer from reputational risk.

8.2.1 TEMPERATURE

CHALLENGES

Rising temperatures will result in warmer winters. When winter precipitation occurs in the form of rain, the frozen ground cannot absorb any water so it becomes runoff, causing inland flooding. This was the case in Prince Edward Island in December 2014, when a rain storm cost the province $9 million in damages, mainly from runoff washing out roads and bridges (Wright, 2015).

8.2.2 PRECIPITATION

CHALLENGES

Climate change will alter the precipitation patterns. The frequency of precipitation events will also decrease, leading to higher intensity events. During the December 2014 rainstorm described above, Foxley River received 156 mm of rain within 24 hours, close to the record amount for the Island (Wright,
2015). Incidents of overland water damage could be expected to increase. The likelihood of car accidents during these events due to poor visibility and vehicle traction would increase.

8.2.3 EXTREME WEATHER EVENTS

CHALLENGES

Extreme weather events are expected to occur more frequently and increase in frequency. Payouts from extreme weather doubled, or more, every five to ten years from 1980s until present (The Co-operators, n.d.). As damages from coastal flooding and coastal erosion increase, homeowners and businesses may look to insure against these impacts. However, no such coverage exists. These types of events are not well-suited for the industry, which traditionally provides insurance for high-risk low-frequency events. But as the public and private sector become increasingly concerned about coastal flooding and coastal erosion, reputational risk for insurers may rise. In addition, the likelihood of car accidents during these events due to poor visibility and vehicle traction would increase.

8.2.4 SEA LEVEL RISE

CHALLENGES

Rising sea levels will permanently flood coastal properties and infrastructure that have experienced coastal flooding only occasionally in the past. They will also begin to inundate properties and infrastructure that never experienced coastal flooding in the past. Since no product exists for damage caused by coastal flooding, reputation risk for insurers may rise and the public and private sector become increasingly concerned about these impacts.

8.2.5 UNKNOWNS

CHALLENGES

While climate modeling is able to forecast how climate change will impact temperature, precipitation, sea level rise, etc. with high levels of confidence, there are limitations to these models. For example, freezing rain is one of the most difficult events to forecast: it occurs in very narrow bands, usually less than 50 km wide, and a change in temperature as small as tenths of a degree could turn freezing rain into rain, sleet, or snow (University of Illinois, n.d.). Generally speaking, warmer winters are associated with an increased occurrence of freezing rain and black-ice conditions (Rapaport et al., 2017). Freezing rain adds weight to trees and power lines, causing them to break or fall, potentially damaging a nearby
car or building. It also creates dangerous operating conditions for vehicles and airplanes, reducing traction/stability.

Overall, the public’s reaction to natural disasters such as extreme storm events is reactive, rather than preventive, in nature. In 2011, the reputational risk for insurers increased substantially after policyholders realized they had no coverage for damage from floods in Queensland, Australia (Thistlewaite and Feltmate, 2013). The federal government responded by launching a review of the industry and recommended that insurance contracts include river and creek flooding (Thistlewaite and Feltmate, 2013). A change in public opinion and regulations from increasing climate change impacts could negatively impact unprepared insurers.

8.3 RECOMMENDED ADAPTATION ACTIONS

45. **Gather required data to address concerns of risk exposure.** Under a changing climate, there will likely be a growing demand for overland water coverage. Some insurers are hesitant to offer it – reasons include the lack of effective flood risk maps and the concern that increased exposure of risk cannot be offset by revenue generated. Insurers depend on accurate risk assessments to develop products. However, the lack of coverage could increase reputational risk and result in loss of policyholders to better prepared insurers should this coverage become regulated. To overcome these challenges, the sector should:
   a. collaborate with experts (e.g., climate science, hydrologists) to create and update flood risk maps periodically as climate change projections are updated;
   b. support mitigation efforts through public awareness and partnerships. For example, IBC supplied 1,000 rain barrels to residents in Stratford, PEI, where extreme weather events have flooded basements and roads;
   c. restrict coverage to policyholders who implement necessary mitigation actions to minimize risk exposure (e.g., similar to the installation of a back water valve to qualify for sewer back up coverage); and,
   d. work with government to balance the need for disaster relief with the need for mitigation. Disaster relief is a reactive measure that is much needed, especially for uninsurable areas (e.g., floodplains). However, it can create a false sense of security and hamper mitigation efforts. For example, the federal government could use a portion of its disaster relief funds to help individuals relocate from flood risk zones.

46. **Raise public awareness** on the different types of flooding and the different types of coverage to lower reputational risk. A study showed that 70% of Canadian homeowner believed they had full flood coverage (Nadarajah, 2016). Just as importantly, the sector should make clear to policy holders what types of coverage are unavailable (e.g., coastal flooding) and why. Policy language and nuances/specificities in industry terms (e.g., flood coverage versus overland water coverage) make it difficult for policyholders to navigate their policies on their own.
47. **Look for opportunities to develop new products.** Demand for coverage from other weather-related impacts could arise as damages to homes and businesses become more frequent and severe under a changing climate (e.g., coastal flooding, coverage for saltwater intrusion in drinking wells, wind damage). The sector should identify these prospects by understanding the needs of the general public and reviewing how other jurisdictions have taken advantage of such opportunities. For example, the sector could organize a workshop to bring together climate and coastal scientists and insurance companies to discuss what coastal science data is available for coastal flooding so the insurance companies can make an informed decision on the possibility of extending coverage for coastal flooding or coastal erosion.

48. **Promote adaptation actions**, especially where coverage is limited or unavailable. For example:

   a. collaborate with the Water sector to share best practices in stormwater management. This would benefit many stakeholders beyond the homeowners (e.g., infrastructure owners). This information, along with mitigation initiatives, should be made public and available at a centralized location (e.g., website);

   b. utilize visualization techniques to encourage adaptation (e.g., Coastal Impacts Visualization Environment);

   c. collaborate with the Outreach and Public Safety sectors on effective communication strategies, platforms; and,

   d. discourage development in and encourage relocation from areas of high flood risk.

The collaboration of the public, insurers, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and the government will be critical in achieving effective adaptation. The table below summarizes the four recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

| Table 8.2. Summary of recommended adaptation actions for the Insurance sector. |

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>45. Gather required data to address concerns of risk exposure (e.g., create and update flood risk maps).</td>
<td>Lead: Sector, Insurers Collaborators: Experts, Federal government</td>
<td>Fill knowledge gaps; Increase Collaboration</td>
</tr>
<tr>
<td>46. Raise public awareness on the different types of flooding and the different types of insurance coverage.</td>
<td>Lead: Sector, Insurers</td>
<td>Engage in outreach</td>
</tr>
<tr>
<td>47. Look for opportunities to develop new insurance products (e.g., insure against coastal flooding).</td>
<td>Lead: Sector Collaborators: Insurers,</td>
<td>Fill knowledge gaps; Increase Collaboration</td>
</tr>
</tbody>
</table>

---

Please refer to the Properties & Infrastructure for more details.
Experts

48. Promote adaptation actions, especially where insurance coverage is limited or unavailable (e.g., use visualization techniques to inspire adaptation, encourage relocation from areas of high flood risk)

Lead: Sector, All levels of government
Collaborators: Other sectors, Experts

8.4 CONCLUSION

It is easy to think of climate change as a slow, gradual process with increases in loss occurring incrementally (Canadian Electricity Association, 2016). However, the recent extreme storm events in Prince Edward Island, including the December 2014 rainstorm, demonstrate that near-record setting events and significant damages could occur at any time. In Prince Edward Island, more than 1 in 10 homes are at risk of river or storm water flooding (IBC, 2017). Therefore, adaptation needs to be implemented as soon as possible. As Islanders brace themselves for climate change impacts, they will increasingly look to the insurance sector for help in transferring some of that risk, especially after a major disaster.

References


9 PROPERTIES AND INFRASTRUCTURE

9.1 BACKGROUND

Infrastructure systems are indispensable, supporting a wide range of social, economic, and environmental goals. They provide access to essential services; facilitate trade; deliver clean drinking water and prevent contaminants from polluting the environment\(^5\); distribute power to homes and businesses\(^6\); and shelter Islanders from the elements. In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the construction and transportation industries contributing $346 million or 7.8% (see Figure 9.1). Of the 63,462 jobs in PEI over 2016, 6.5% or 4,128 of them were from the construction and truck transportation industries (see Figure 9.2).

---

\(^5\)Refer to the Water Sector chapter for in-depth overview and analysis on water, stormwater, and waste water assets and infrastructure.

\(^6\)Refer to the Energy Sector chapter for in-depth overview and analysis on energy assets and infrastructure.
9.1.1 INFRASTRUCTURE

All levels of government, along with the private sector, have a role to play in overseeing and managing assets and infrastructure in a safe, sustainable, and efficient way. For example, the federal government’s responsibilities include small craft harbours and international and interprovincial transportation (e.g., aviation, marine); the provincial government’s responsibilities include transportation within the province (e.g., highways, roads); the municipal governments’ responsibilities include urban transportation (e.g., transit, local roads); and the private sector act as owners, operators, and managers of various infrastructure and assets (e.g., public and private buildings, energy infrastructure, vehicles, sea vessels, aircrafts) (Andrey and Palko, 2017).

9.1.2 PROPERTIES

The majority of land on Prince Edward Island, 88%, is privately owned; the remainder is publicly-owned and managed by the province for the benefit of all Islanders (PEI Department of Communities, Land and Environment, 2015). Public and private buildings and properties will contribute approximately $123.4 million in real property tax and real property transfer tax to the 2017-18 provincial budget (PEI Department of Finance, n.d.).

Within Prince Edward Island, no property is over 16 km from the sea (Rapaport et al., 2017). Over a third of all civic addresses are located in the coastal area (i.e., within 500 m of the coast) and these properties
and buildings account for almost half of the total property assessments across the Island (J. Harper, personal communication, August 16, 2017).

9.2 CLIMATE CHANGE IMPACTS

Climate change will bring about warmer weather, changes in precipitation patterns, more intense storms, and rising sea levels in Prince Edward Island.

It is critical to note that opportunities and challenges resulting from climate change cannot be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the advantages in reduced winter maintenance from warmer temperatures could be offset by the increased coastal erosion that those temperatures bring.

9.2.1 TEMPERATURE

OPPORTUNITIES

Firstly, less salt may need to be spread on the road network (Toplis, 2015). This would lead to a reduction of operating costs and corrosion of vehicles and highway assets.

Secondly, warmer temperatures would also extend the construction season, allowing for additional time for the outdoor maintenance and construction of assets and infrastructure.

CHALLENGES

Firstly, warmer temperatures will lead to less sea-ice, which often acts as a buffer between coastal impacts and properties and infrastructure built within the coastal zone. The loss of sea ice could lead to increased rates of coastal erosion, sedimentation along marine infrastructure, and increased incidents of storm surge flooding of coastal properties and infrastructure during the winter months.

Secondly, warmer winters could lead to more rain events when the ground is still frozen. This was the case in December 2014 when water from an intense rain event could not be absorbed by the ground. The runoff caused flooding and washed out roads and bridges.
9.2.2 EXTREME WEATHER EVENTS

CHALLENGES

Firstly, periods of intense precipitation can cause severe damage to properties, buildings, and infrastructure via flooding, erosion, washouts, and scouring. During an extreme rain event, the ground cannot absorb the water quickly enough and stormwater management systems may not have the capacity to cope. As a result, the excess water, or runoff, can cause gully erosion as it flows over land toward the coast (see Figures 9.3 and 9.4); create depressions and weak embankments of roads (Palko, 2017); cause slope failure; wash out roads and bridges; and flood buildings and infrastructure. For example, the 2014 December rain storm brought 156 mm of rain in Foxley River within 24 hours (Wright, 2015). The intense rain event washed out bridges and roads, causing millions of dollars in damage (Wright, 2015). Extreme snowfall can also cause damages to buildings that were not designed to handle the increased snow loads.

Secondly, periods of intense precipitation can also disrupt infrastructure from an operational point of view via reduced vehicle traction/stability and visibility create dangerous driving conditions causing closures of the road network and decreased traction on runways at airports causing flight delays (Palko, 2017). This has significant impacts on other sectors. For example, many dairy farmers had to discard milk collected from their herds because trucks could not travel on unplowed roads after a blizzard in February, 2015 brought close to 90 cm of snow (CBC News, 2015).

Thirdly, the energy from storm surge and waterflow associated with extreme storm events can lead to bridge scour, damage of causeways and port facilities, coastal erosion, and flooding of buildings and infrastructure.
Fourthly, wave action from extreme storm events can also disrupt transportation from an operational point of view, such as vessel navigation hazards for boats and ferries.

Fifthly, high winds from extreme storm events can damage homes, buildings, road structures (e.g., signage and traffic signals), create obstructions (e.g., fallen trees), cause bridge closures and flight delays, and reduce traction/stability of vehicles.

9.2.3 SEA LEVEL RISE

CHALLENGES

Firstly, sea level rise will permanently flood coastal properties and infrastructure that have experienced coastal flooding only occasionally in the past. They will also begin to inundate properties and infrastructure with increasing frequency, affecting some that never experienced coastal flooding in the past.

Secondly, combined with stronger storm surges, damage caused by coastal erosion will increase as the reach of coastal erosion extends further inland at a more rapid rate than it has in the past. For example, the average erosion rate for the Island increased from 28 cm per year between 1968 and 2010, to 40 cm per year between 2000 and 2010 (Rapaport et al., 2017). For the north shore of Prince Edward Island, it has been projected that almost 10% of coastal properties present in 2001 could be lost within 20 years, increasing to almost 50% by the end of the century (Shaw and CCAF, 2001).

9.2.4 INDIRECT CLIMATE CHANGE IMPACTS

There are indirect climate change impacts that can affect the sector. As climate change impacts become increasingly felt, there will be a push for more climate resilient buildings and infrastructure – by either customer demand, regulatory pressure, or financial liability (e.g., more stringent lending conditions) (Kovacs and Thistlewaite, 2014). Builders, asset owners and asset managers must be prepared to adapt.

9.2.5 UNKNOWNS

While climate modeling is able to forecast how climate change will impact temperature, precipitation, sea level rise, etc. with high levels of confidence, there are limitations to these models. For example, impacts on freeze-thaw cycles and freezing rain are more difficult to predict. Nevertheless, it is important to be aware of the associated impacts should these event occur more frequently under a changing climate.
Generally speaking, freeze-thaw cycles are expected to occur more often throughout most of the Atlantic region over the short term, then decline over the long term as winter temperatures rise (Boyle et al., 2013). Freeze-thaw cycles pose risks to the stability of aviation runways (Rapaport et al., 2017); change the timing of spring weight restrictions on roadways; and damage pavement on roads, bridges, and overpasses via deformation, shearing, cracking, and rutting (United States Environmental Protection Agency, n.d.; Palko, 2017).

Freezing rain is one of the most difficult events to forecast: it occurs in very narrow bands, usually less than 50 km wide, and a change in temperature as small as tenths of a degree could turn freezing rain into rain, sleet, or snow (University of Illinois, n.d.). Generally speaking, warmer winters are associated with an increased occurrence of freezing rain and black-ice conditions (Rapaport et al., 2017). Freezing rain adds weight to road structures (e.g., signage and traffic signals), trees, and power lines, causing them to break or fall. It also creates dangerous operating conditions for vehicles and airplanes, reducing traction/stability.

9.3 RECOMMENDED ADAPTATION ACTIONS

49. **Address budgetary constraints through financial planning.** The up-front costs of adaptation are often a barrier to implementing adaptation actions but this could be partly addressed through improved financial planning. This approach applies to individuals, businesses, sectors, and governments. For example, when an individual purchases a home, the age and condition of the roof is often part of the home inspection and factored in the purchase price. The repair and replacement of the roof is an accepted aspect of homeownership. The roof is generally replaced before it deteriorates to a point that rain leaks through. Similarly, asset and infrastructure owners and managers need to consider the costs and timing of adaptation actions in relation to the costs associated with the increase in damage liability, increase in maintenance, shorter lifespan, etc. While implementing adaptation actions incur an upfront cost, it can save a considerable amount of money over the lifetime of assets and infrastructure, often resulting in a net positive financial position overall. For example, the province and municipalities should create an inventory of all roads and bridges within the coastal zone with information such as usage, age, type, current condition, availability of alternate routes; determine the cost of different adaptation actions such as abandonment, repair as required, relocation, and upgrade/replacement; perform a cost-benefit of each action and prioritize. This would allow them to act quickly when there are funds available.

---

7Insurance plays an important role in climate change adaptation. Refer to the Insurance Sector chapter for more details.
50. **Make erosion and coastal and inland flood risk maps available** to all asset owners (private sector, municipalities, the public) so they can:
   a. identify when and how critical assets and infrastructure (e.g., hospitals, major roads, fire stations, waste disposal sites, water and energy infrastructure, homes) will be impacted;
   b. determine if the asset should be retrofitted, protected, replaced, or relocated;
   c. understand the level of flood and erosion risks before purchasing a property;
   d. determine if adaptation actions are required immediately or if they can wait until the next planned upgrade; and
   e. prioritize the adaptation actions.

For example, culverts are a critical and vulnerable component of the road network. When a climate event washes away an undersized culvert and damages the road, it is often replaced with a larger culvert. The province and municipalities should create an inventory of all culverts with information such as sizing, current condition, age, traffic intensity; calculate the correct sizing of each one based on an agreed upon future climate scenario; complete a vulnerability assessment on each one; and rank them in order of priority for replacement. This would allow them to act quickly when there are funds available.

51. **Set a future climate scenario to establish design standards** based on the expected lifespan of the infrastructure when building, upgrading, or retrofitting assets and infrastructure. For example, should roads be built to withstand 1-in-50 year or 1-in-100 year rain events? Should they consider these events under the 2020, 2050, or 2100 time frame? Should the roads be set back from the coast based on 30, 60, or 90 times the historic annual rates of erosion? Asset owners and managers need to choose a future climate scenario and apply it consistently across the system. Since infrastructure is so interconnected, weak links from an inconsistent (i.e., lower) standard will reduce the resilience of the entire network.

52. **Incorporate future climate considerations into land use and building regulations.** Land use planning policies and regulations (e.g., zoning, setbacks, permits) can prompt the development of climate-resilient buildings and infrastructure where incentive for preventive action is not strong enough. The province should update its Land Use Planning Act and Regulations, to:
   a. set a future climate scenario standard (see Recommended Adaptation Action #51);
   b. maintain current projections of climate change impacts (e.g., update flood and erosion risk maps when orthomagery and LiDAR data for the Island is collected) when processing development and subdivision permit applications;
   c. build flexibility into minimum provincial standards to cope with a changing climate (e.g., review and update horizontal and vertical setbacks when flood and erosion risk maps are updated);
   d. adapt regulations to suit local conditions, where possible (e.g., use site-specific flood and erosion risk maps);
   e. identify/re-designate different types of high risk zones with different regulations for each (e.g., no basements allowed in flood prone areas, no development allowed in erosion prone areas). For example, the Council of Beaubassin-est, NB (population
6,200) passed a bylaw in 2011 that identifies a “protection zone” associated with sea level rise, in which the minimum ground floor elevation of new buildings must be at least 1.43 metres above the current 1-in-100 year flood mark (Richardson and Otero, 2012). This new protection zone is an overlay zone, where all previous zoning conditions (e.g., building height restrictions) still apply (Richardson and Otero, 2012);

f. increase redundancy in the road network and require dual access where possible for emergency management purposes;

g. expand setbacks to include servicing (e.g., septic tanks);

h. require additional information during the development permit process to ensure the asset/infrastructure owner has considered climate change impacts and met the future climate scenario standard (e.g., lot drainage plans, survey plans);

i. require an environmental impacts assessment on developments within the coastal zone;

j. increase inspections to ensure compliance;

k. impose higher fees and stricter penalties for non-compliance; and,

l. establish a voluntary conservation covenant or easement, which prohibit development on a portion or all of the property or removal of native vegetation, in areas that are sensitive to climate change impacts in exchange for a property tax reduction or credit (Richardson and Otero, 2012). The owner could continue to own the land, live on it, sell it, or pass it on but the covenant would continue regardless. This should be reviewed on a case-by-case basis and entered into only when the preservation of land has measurable benefits (e.g., improve climate resilience).

Property owners and developers may be resistant to new regulations. However, they should be made aware that by preventing development in at-risk areas, the regulations are helping to keep assets, infrastructure, people, and the environment safe from climate impacts, saving money in the long run.

53. **Explore the issue of liability** surrounding developments and real estate transactions within flooding and erosion risk zones.

54. **Utilize complementary green infrastructure** when upgrading or designing stormwater management systems. Traditional upgrades of existing equipment and infrastructure are costly but increasingly intense precipitation events leave infrastructure owners/managers with little choice. Studies show that green infrastructure is more cost-effective and less energy intensive than traditional stormwater management infrastructure (Morand et al., 2015). For example, green roofs have been successfully used in Basel, Switzerland and New York City, USA. Basel is a town of 195,000 people and has more than 1.2 million square meters of rooftops covered with vegetation as of 2014 (Morand et al., 2015). This adaptation action was driven by the desire to reduce energy costs (green roofs provide added insulation value to buildings) and climate change mitigation but added benefits include stormwater management, local ambient air temperature moderation, increased property values, and public health improvement (Morand...
et al., 2015) (see Figure 6.5). Rain gardens and wetlands are other examples of alternate stormwater management techniques.8

Figure 6.5. Green roofs in Basel, Switzerland. (Source: Morand et al., 2015)

55. **Encourage a bottom-up approach** by making property and infrastructure owners and managers aware of projected climate change impacts; adaptation actions available to them; and how those actions should be implemented. Currently, builders and contractors may not have the necessary knowledge or experience to implement adaptation actions (e.g., armouring coastline, installing green roofs). Combined with a lag in regulations and policies such as the building code and land use planning, it highlights the need to:
   a. increase awareness of climate change impacts;
   b. make public and widely available information on the hazards anticipated under future climate (e.g., flood and erosion risk maps);
   c. address any gaps in information (e.g., culvert sizing tool/resource for homeowners and contractors);
   d. make public and widely available guidance on adaptation actions to manage different climate change impacts (e.g., best practices for protection from shoreline erosion); and,
   e. demonstrate the application of adaptation actions by constructing a demonstration building that incorporates climate resilient design strategies (e.g., green roof, proper building setbacks, extended overhang to protect windows and doors from heavy rain, use of flood resilient materials such as plastic doors and ceramic tiles in the basement) and landscape design techniques to cope with erosion and coastal flooding (e.g., redirect water to prevent gully erosion, living shorelines techniques to reduce erosion).

The project could involve students from UPEI Climate Lab, UPEI School of Sustainable Engineering Design, Holland College Environmental Applied Science Technology, and Apprenticeship programs in the design, construction, and maintenance phases. Exhibits with information for the public will be available on site. This demonstration site can

---

8 These (plus others) are explored further in the Water Sector chapter.
incorporate adaptation actions from other sectors as well (e.g., solar energy panels and electricity storage). An interactive display featuring the Coastal Impact Visualization Environment (CLIVE) could help raise awareness among the public on future coastal flooding and erosion risks.

56. Provide a forum (e.g., website, Facebook group, monthly workshops, and community schools) for asset and infrastructure owners and managers (e.g., communities, homeowners) to learn and share best practices. For example, clear snow and vegetation from ditches prior to an intense rain event to prevent flooding; design roads so they are perpendicular to the coast; choose appropriate vegetation for rain gardens that can withstand Island climate; and utilize combination ploughing and salting/sanding vehicles to better react to freezing rain conditions (Langis, 2013).

The collaboration of property and infrastructure owners, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and governments will be critical in achieving effective adaptation. The table below summarizes the eight recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>49. Address budgetary constraints through financial planning (e.g., create an inventory of</td>
<td>Leads: Property and infrastructure owners (e.g., individuals, businesses, governments)</td>
<td>Address financial concerns; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>roads and bridges in coastal zone and perform a cost-benefit analysis to prioritize adaptation).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50. Make erosion and coastal and inland flood risk maps available to all asset owners.</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Fill knowledge gaps</td>
</tr>
<tr>
<td>51. Set a future climate scenario to establish design standards (e.g., should roads be built</td>
<td>Lead: Provincial Government Collaborators: Experts</td>
<td>Promote climate change mainstreaming</td>
</tr>
<tr>
<td>to withstand 1-in-50 year or 1-in-100 year rain events and are the events taking place in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2020, 2050 or 2100?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52. Incorporate future climate considerations into land use and building regulations (e.g.,</td>
<td>Lead: Provincial and Municipal governments Collaborators: Other sectors, Experts</td>
<td>Leverage regulation; Promote climate change mainstreaming</td>
</tr>
<tr>
<td>increase horizontal and vertical setbacks, require additional information during the development permit process).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53. Explore the issue of liability surrounding developments and real estate transactions within flooded and erosion risk zones.</td>
<td>Leads: Provincial Government Collaborators: Experts</td>
<td>Fill the knowledge gaps</td>
</tr>
<tr>
<td>54. Utilize complementary green infrastructure when upgrading or designing stormwater management systems (e.g., rain gardens).</td>
<td>Leads: Stormwater management system managers and owners, Homeowners</td>
<td>Increase resilience</td>
</tr>
</tbody>
</table>
Collaborators: Experts, Other sectors

<table>
<thead>
<tr>
<th>55. Encourage a bottom-up approach by making property and infrastructure owners and managers aware of projected climate change impacts, adaptation actions available to them, and how those actions should be implemented.</th>
<th>Lead: Provincial Government Collaborators: Educators, Other sectors</th>
<th>Engage in outreach; Fill knowledge gaps</th>
</tr>
</thead>
<tbody>
<tr>
<td>56. Provide a forum for asset and infrastructure owners and managers to learn and share best practices.</td>
<td>Lead: Provincial Government Collaborators: Municipal governments, Sector, Public</td>
<td>Fill knowledge gap; Engage in outreach; Increase collaboration</td>
</tr>
</tbody>
</table>

## 9.4 CONCLUSION

Properties and infrastructure have always been vulnerable to damage and disruptions caused by weather events; the risks will be amplified under a changing climate. The cost to maintain infrastructure will increase and the effectiveness and lifespan of the built environment will be shortened. Given their long-term nature and critical role in the society and economy, it is important to be proactive in protecting Island assets and infrastructure from the known and unknown impacts that climate change will inevitably bring.

### References


10 PUBLIC HEALTH AND SAFETY SECTOR

10.1 INTRODUCTION

Publicly-funded health services in Prince Edward Island are delivered by Health PEI, a crown corporation. Health PEI is overseen by the Health PEI Board, which is composed of appointed directors with a varied range of knowledge and experiences that benefits the health care system. The Board ensures that Health PEI follows the frameworks of the Provincial Health Plan, provincial policy, and applicable legislation. The Provincial Government’s Department of Health and Wellness sets standards for health services, institutes accountability framework, creates policy and guidelines for operations and delivery of services, and approves budgets and business plans. Most of Health PEI’s operating budget comes from the Department of Health and Wellness, which provided grants totalling $592 million in 2016 (Health PEI, 2016).

![Figure 6.1. Prince Edward Island health system organizational chart (Source: Health PEI, 2013)](image)

In 2016, the total value of all goods and services produced in Prince Edward Island was $4.8 billion, with the health care sector contributing $641 million, or 13% (see Figure 6.2). In fiscal year 2015-2016, Health PEI employed 4615 staff members (e.g., physicians, specialists, nurses, lab technicians, management staff, administrative staff, other health professionals) out of an average of 63,100 employees across all industries in the province over 2015 - 2016 (see Figure 6.3).
Health PEI operates two main referral hospitals, four community hospitals, one in-patient psychiatric hospital, ten long-term care facilities, the PEI Cancer Treatment Centre, the Youth Recovery Centre, and flu vaccination clinics. It also provides health services such as primary care, chronic disease prevention and management, hospital services, pharmacy services, children’s development services, diagnostic imaging, emergency health and planning services, laboratory services, long-term care, pharmacare, home care, palliative care, geriatric care, and mental health and addiction services (Government of Prince Edward Island [PEI], n.d.).
Public safety organizations include police departments, fire departments, and the provincial Emergency Management Organization (EMO). The Emergency Measure Act gives the responsibility of the coordination and management of emergency management activities to the EMO (PEI Department of Justice and Public Safety, 2016). EMO offers emergency management training courses for those acting on behalf of communities during emergencies and provide outreach services to communities, service groups, and businesses.

### 10.2 CLIMATE CHANGE IMPACTS

The health of individuals is affected by a number of factors. They include the social and economic status (e.g., income and education levels), the physical environment (e.g., air and water quality, workplace health), and the person’s individual characteristics and behaviour (e.g., genetics, gender, diet) (World Health Organization [WHO], n.d.). Climate change will affect the physical environment negatively and its impacts on health will disproportionately affect the elderly, pregnant women, children, the chronically ill, Aboriginal people, those with compromised immune systems, the poor, the socially disadvantaged, and those living in vulnerable geographic areas (e.g., rural areas) (Public Health Agency of Canada [PHAC], 2013).

#### 10.2.1 TEMPERATURE

**Challenges**

Firstly, rising temperatures could increase the risk of vector-borne and zoonotic diseases by changing the geographic distribution of disease-carrying arthropod vectors and animals, extending the transmission season, and increasing the maturation speed of the pathogens (Berry et al., 2004). These changes could potentially introduce new and previously-eradicat ed diseases to the Island as well as increase the incidence of the diseases (Berry et al., 2014). For example, Lyme disease can be caused by the bacteria *Borrelia burgdorferi* carried by *Ixodes scapularis* (backlegged ticks). Symptoms include skin rash, headache, fever or chills, spasms, weakness, numbing sensation, fatigue, swollen lymph nodes, dizziness, abnormal heart beat, muscle and joint pain, paralysis, confusion, and nervous system disorders (Government of Canada, 2016). The range of blacklegged ticks has already expanded into central and eastern Canada (PHAC, 2011). Migratory birds carry these and other ticks throughout Canada and the warmer temperatures allow these ticks to reproduce and thrive where they are dropped (PHAC, 2011). The *Ixodes scapularis* vector is likely to emerge from northeastern United States and enter Prince Edward Island within the next decade (see Figure 6.4).
Secondly, the formation of ground-level ozone (O$_3$), a toxin, could increase with rising temperature (Myers et al., 2017). According to the United States Environmental Protection Agency (n.d.), O$_3$ can “cause shortness of breath; inflame and damage the airways; aggravate lung diseases such as asthma, emphysema, and chronic bronchitis; increase the frequency of asthma attacks; make lungs more susceptible to infection; and, cause chronic obstructive pulmonary disease”. Children, seniors, those with pre-existing respiratory or cardiac conditions, and those who are active outdoors are at higher risk to adverse effects (PHAC, 2015).

Thirdly, increasing temperatures could lead to the earlier onset and extension of pollen season, provide more favourable growing conditions for trees and plants that give off pollens and allergens, and lead to an increase in the allergenicity of pollen (Berry et al., 2014). The aeroallergens (e.g., dust mites, pollens from trees, grasses, molds) can trigger allergic reactions once inhaled. They can exacerbate respiratory diseases such as asthma and chronic obstructive pulmonary disease (Berry et al., 2014).

Fourthly, incidences of food-borne bacterial illness could increase with rising temperatures. The replication rates and persistence of pathogens increase with the increasing temperatures of the summer season (Berry et al., 2014). They also have a greater opportunity to survive cooking at barbeques and picnics, which are more common during the summer season (Berry et al., 2014).

Fifthly, ultraviolet radiation will increase with increasing temperatures. A warming climate changes the stratospheric ozone chemistry and delays the recovery of the ozone hole (Berry et al., 2014). Increasing temperatures will also change human behaviour and increase exposure to ultraviolet radiation (e.g., spending more time outdoors). Human exposure to ultraviolet radiation leads to sunburns, skin cancers,
cataracts, eye damage, various immune disorders, DNA damage, and immune suppression. Prince Edward Island has the highest age-standardized incidence rate of melanoma among women across all provinces in 2016 at 24.3 cases per 100,000 people compared to the national rate of 15.8 (Canadian Cancer Society, 2016). PEI has the second highest rate of melanoma among men across all provinces in 2016 at 25.4 cases per 100,000 people in compared to the national rate of 20.5 (Canadian Cancer Society, 2016).

### 10.2.2 PREcipitation

#### CHALLENGES

Firstly, decreasing precipitation, combined with warming temperatures, increase the risk of forest fires (Berry et al., 2014). The primary health consequences of wood smoke from forest fires include smoke inhalation, burns and injury to the respiratory tract, and oxygen deficiency (Berry et al., 2014). It could also exacerbate existing conditions such as asthma, chronic lung diseases, and cardiovascular disease (Berry et al. 2014). Secondary impacts of forest fires include injury from radiant heat, heat exhaustion, dehydration, increase likelihood of mortality, anxiety, depression, and post-traumatic stress disorder related to loss of friends, relatives, neighbours, homes, and livelihoods (Berry et al., 2014).

Secondly, the increasing intensity of rain events could increase the transport of pollutants such as silt, chemicals, hydrocarbons, and heavy metals from industrial operations to uncontaminated drinking water and recreational water areas, impacting water quality via run-off. This is especially problematic with drier summers, which may lead to longer periods of low soil moisture and an increase in soil shrinkage cracks, creating a more extensive and connected macropores (i.e., large soil pores) system for run-off to flow through (Boxall et al., 2009). Furthermore, changes in precipitation levels could reduce water levels in rivers, increasing the concentration of pathogens and contaminants in the water.

Thirdly, an increase in nutrient-rich run-off after intense precipitation events increase the proliferation of cyanobacteria blooms, or blue-green algae blooms, which produce toxins that are harmful to human health. The growth is also increased by warming temperatures. The toxins can cause irritations of the skin and eyes of swimmers, boaters, or anyone who comes into contact with them (PEI, 2016). Ingesting large amounts of the toxins by drinking the water or eating fish or shellfish from the water could result in nausea, vomiting, cramps, diarrhea, and sore throat (PEI, 2016).

Fourthly, an increase in runoff increases the likelihood of outbreaks of waterborne diseases. These diseases are caused by bacteria, viruses, and/or parasites, carried in water, and infect humans via exposure to contaminated water. For example, heavy rainfall played a role in the E. coli O157:H7 contamination of groundwater via farm run-off in Walkerton, Ontario in 2000. The outbreak caused seven deaths and 2,300 people to fall ill, in a community of fewer than 5,000 (CBC, 2010). Thomas et al. (2006) studied waterborne disease outbreaks in Canada from 1975 to 2001 and found rainfall events greater than the 93rd percentile increased the odds of an outbreak by a factor of 2.283.
Fifthly, changes in precipitation patterns could affect the rate and timing of groundwater recharge. Combined with sea-level rise, this could affect the saltwater-freshwater interface in groundwater. Elevated levels of saline in drinking water cause serious health implications such as hypertension and stroke (Vineis et al., 2011). Under a changing climate with rising sea levels, higher storm-surge levels, and drier conditions, incidents of saltwater intrusion could become more commonplace.

### 10.2.3 Extreme Weather Events

**Challenges**

An increase in the frequency and intensity of extreme weather events could lead to an increase frequency and severity of health and safety impacts related to floods and severe storms. These weather events can cause direct health consequences such as physical injury (e.g., lacerations, sprains), psychological health effects (e.g., stress-related illnesses), heart attacks and strokes from exertion and stress, and death (e.g., motor vehicle accidents). Secondary impacts can include anxiety, depression, and post-traumatic stress disorder related to loss of friends, relatives, neighbours, homes, and livelihoods (Berry et al., 2014). These extreme weather events can also cause indirect health consequences such as interrupting medical care (e.g., power outages, infrastructure damage), dehydration (e.g., power outages prevent drinking well pumps from operating), and respiratory illnesses from mold, bacterial, and fungal growth on water-damaged structures (Berry et al., 2014).

### 10.2.4 Sea Level Rise

**Challenges**

Rising sea levels, along with higher storm surge, could increase incidences of saltwater intrusion of drinking wells by inundating the wellheads.

### 10.2.5 Carbon Dioxide

**Challenges**

Although the increasing concentrations of atmospheric carbon dioxide is the primary driver of climate change and is responsible for the impacts described above, the carbon dioxide itself also impacts public health. Carbon dioxide changes the nutritional composition of crops; experiments have shown a 7-15% decrease in the protein content in edible portion of wheat, barley, and potatoes (Myers et al., 2017).
10.2.6 INDIRECT CLIMATE CHANGE IMPACTS

CHALLENGES

Firstly, the impact of climate change on other sectors can indirectly affect public health. The warming temperatures and changing precipitation patterns could increase irrigation requirements for agricultural lands and golf courses. Irrigation reduces water levels in rivers, potentially increasing the concentration of any pathogens and contaminants in the water.

Secondly, efforts to mitigate the effects of climate change by shifting to renewable and carbon-neutral energy sources such as biomass (e.g., wood) could affect public health. The burning of wood produces fine particulate matter. Exposure to fine particulate matter can exacerbate asthma, bronchitis, and respiratory symptoms; negatively impact cardiac health; increase lung cancer mortality; and lead to premature mortality (Berry et al., 2014).

Thirdly, the warming temperatures also increase human exposure to vector borne and zoonotic diseases as well as pollutants and diseases in recreational water by bringing about behaviour changes (e.g., extended swimming season) thus elevating the risk to human health (Berry et al., 2014).

10.2.7 UNKNOWNS

CHALLENGES

While climate modeling is able to forecast how climate change will impact temperature, precipitation, sea level rise, etc. with high levels of confidence, there are limitations to these models. For example, freezing rain is one of the most difficult events to forecast: it occurs in very narrow bands, usually less than 50 km wide, and a change in temperature as small as tenths of a degree could turn freezing rain into rain, sleet, or snow (University of Illinois, n.d.). Generally speaking, warmer winters are associated with an increased occurrence of freezing rain and black-ice conditions (Rapaport et al., 2017). Freezing rain could cause slips and falls and reduce access to medical care due to unsafe driving conditions and failure of infrastructure. Milder winters could lead to more freezing rain and wet snow events, which occur close to the freezing mark (0°C). In addition to slip and falls and unsafe road conditions, these types of events are particularly problematic for infrastructure. An accumulation of ice or heavy snow on tree branches or electric equipment could damage conductors or poles, disrupting electrical power to homes, businesses, health care facilities, etc.
10.3 RECOMMENDED ADAPTATION ACTIONS

57. Invite other jurisdictions to **share best practices and innovative approaches**. Other regions may be facing similar challenges brought on by climate change. By sharing successes in local adaptation efforts, they could reciprocate with strategies on their own. There are also numerous resources available online, such as the tool to estimate health and adaptation costs developed by the WHO Regional Office for Europe (2013) which assists policymakers compare the costs and benefits of adaptation when making adaptation decisions.

58. **Integrate climate change impacts** in all existing vulnerability assessments, management activities, policies, programs, etc. For example, the financial management of organizations that provide public health and safety services (e.g., hospitals, clinics, Emergency Measures Organization, police departments, fire departments) should be reviewed to ensure enough resources are allocated in the operating budget to allow for an increased demand for these organizations’ services under a changing climate.

10.3.1 PUBLIC HEALTH

59. **Develop a public outreach strategy** for the general public to help them adapt to climate change. Ensure that they are not provided with mixed messaging on climate-related risks (e.g., exercising later in the day to avoid extreme heat or ultraviolet radiation while remaining indoors at night to avoid contracting West Nile virus) (Berry et al., 2014). The information should be practical and relevant on a personal level and does not have to discuss climate change. Examples include informing those with pre-existing conditions on how to access the Air Quality Health Index score to minimize exposure to poor air quality and developing a flyer on residential home heating best practices to recommend the use of high-efficiency wood stove or fireplace, which could reduce emissions of fine particulate matter by up to 90 percent and burning dry, well-seasoned wood that has been split properly to reduce smoke (Natural Resources Canada, 2002).

60. **Evaluate the knowledge gaps** in the existing system and identify data, skills, or expertise required to address climate change impacts (e.g., environmental health indicators of climate change, risk maps). **Develop multidisciplinary partnerships** across sectors, organizations, levels of government, etc. to recruit/access data, skill sets and knowledge that may not be available within the public health system. **Support interdisciplinary research** to address these knowledge gaps.

61. **Monitor and map environmental factors** and other events (e.g., algae bloom outbreaks, fish kills, water quality, air quality, temperature, precipitation) related to public health so models could be created to identify high-risk areas. Develop strategies to minimize the public health risks.
62. **Reduce non-climatic factors.** Healthy communities are resilient communities. For example, by preventing chronic disease in Islanders, their bodies will become more resilient and able to cope with climate change impacts. Engage in outreach efforts to educate the public on how they could increase their resilience.

### 10.3.2 PUBLIC SAFETY

63. Create a mechanism at the community-scale to **identify and assist vulnerable groups** (e.g., elderly, pregnant women, children, the chronically ill, those with compromised immune systems) when emergencies arise so first responders can focus on those with the greatest needs.

64. **Conduct training exercises** involving emergency services and local responders to respond to severe, wide area flooding. For example, consider water levels caused by storm surge under high-tide conditions for 1-in-200 year storms. Use flood risk maps to exclude the use of inundated infrastructure during the exercise to mimic actual impacts. Determine how response time and delivery of service could be improved given the circumstances.

65. **Ensure dual access to properties** when possible to assist in the emergency management response should one access route be impassable (e.g., flooded, washed out, surrounded by forest fire).

66. **Create lists of safe spaces** within communities where residents are directed to go during an extreme weather event and establish a mechanism to communicate the choice of safe space to the residents before/during/after the event. These spaces should have dual access roads, be accessible safely by roads safe from flooding, able to generate electricity (e.g., diesel generator) and have emergency supplies (e.g., food, water, radio).

The collaboration of the sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and governments will be critical in achieving effective adaptation. The table below summarizes the ten recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

*Table 10.1. Summary of recommended adaptation actions for the Public Health and Safety sector.*

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invite other jurisdictions to share best practices</td>
<td>Lead: Provincial</td>
<td>Fill knowledge gaps; Increase</td>
</tr>
</tbody>
</table>
and innovative approaches (e.g., WHO developed a tool to estimate costs and benefits of adaptation decisions).

<table>
<thead>
<tr>
<th>58. Integrate climate change impacts in all existing vulnerability assessments, management activities, policies, programs, etc. (e.g., adjust the operating budget to allow for increased demand for services).</th>
<th>Government Collaborators: Experts</th>
<th>Lead: Provincial Government Collaborators: Experts</th>
<th>Promote climate change mainstreaming</th>
</tr>
</thead>
</table>

59. Develop a public outreach strategy for the general public to help them adapt to climate change. The information should be practical and relevant on a personal level and does not have to discuss climate change.

<table>
<thead>
<tr>
<th>59. Develop a public outreach strategy for the general public to help them adapt to climate change. The information should be practical and relevant on a personal level and does not have to discuss climate change.</th>
<th>Lead: Provincial Government Collaborators: Educators</th>
<th>Engage in outreach, Fill knowledge gaps</th>
</tr>
</thead>
</table>

60. Evaluate the knowledge gaps in the existing system and identify data, skills, or expertise required to address climate change impacts; develop multidisciplinary partnerships; and, support interdisciplinary research.

<table>
<thead>
<tr>
<th>60. Evaluate the knowledge gaps in the existing system and identify data, skills, or expertise required to address climate change impacts; develop multidisciplinary partnerships; and, support interdisciplinary research.</th>
<th>Lead: Provincial Government Collaborators: Educators, Other sectors</th>
<th>Fill knowledge gaps; Increase collaboration</th>
</tr>
</thead>
</table>

61. Monitor and map environmental factors and other events related to public health to identify high-risk areas (e.g., algae bloom outbreaks, fish kills, water temperature, air quality).

<table>
<thead>
<tr>
<th>61. Monitor and map environmental factors and other events related to public health to identify high-risk areas (e.g., algae bloom outbreaks, fish kills, water temperature, air quality).</th>
<th>Lead: Provincial Government Collaborators: Experts</th>
<th>Fill knowledge gaps</th>
</tr>
</thead>
</table>

62. Reduce non-climatic factors (e.g., prevent chronic disease so Islanders will become more resilient and able to cope with climate change impacts).

<table>
<thead>
<tr>
<th>62. Reduce non-climatic factors (e.g., prevent chronic disease so Islanders will become more resilient and able to cope with climate change impacts).</th>
<th>Lead: Provincial Government Collaborators: Educators</th>
<th>Fill knowledge gaps; Engage in outreach</th>
</tr>
</thead>
</table>

63. Create a mechanism at the community-scale to identify and assist vulnerable groups when emergencies arise so first responders can focus on those with the greatest needs.

<table>
<thead>
<tr>
<th>63. Create a mechanism at the community-scale to identify and assist vulnerable groups when emergencies arise so first responders can focus on those with the greatest needs.</th>
<th>Leads: Municipal governments, EMO Collaborators: Public</th>
<th>Increase collaboration</th>
</tr>
</thead>
</table>

64. Conduct training exercises involving emergency services and local responders to respond to severe, wide area flooding and improve response time.

<table>
<thead>
<tr>
<th>64. Conduct training exercises involving emergency services and local responders to respond to severe, wide area flooding and improve response time.</th>
<th>Lead: EMO</th>
<th>Fill knowledge gap</th>
</tr>
</thead>
</table>

65. Ensure dual access to properties when possible to assist in the emergency management response should one access route be impassable (e.g., flooded, washed out, surrounded by forest fire).

<table>
<thead>
<tr>
<th>65. Ensure dual access to properties when possible to assist in the emergency management response should one access route be impassable (e.g., flooded, washed out, surrounded by forest fire).</th>
<th>Lead: Property owners Collaborators: EMO</th>
<th>Increase resilience</th>
</tr>
</thead>
</table>

66. Create lists of safe spaces within communities and establish a mechanism to communicate the choice before/during/after the event.

<table>
<thead>
<tr>
<th>66. Create lists of safe spaces within communities and establish a mechanism to communicate the choice before/during/after the event.</th>
<th>Lead: Municipal governments, EMO</th>
<th>Increase resilience; Increase collaboration</th>
</tr>
</thead>
</table>

### 10.4 CONCLUSION

The health of individuals is affected by a number of factors. They include the social and economic status (e.g., income and education levels), the physical environment (e.g., air and water quality, workplace health), and the person’s individual characteristics and behaviour (e.g., genetics, gender, diet) (WHO, n.d.). Climate change will affect the physical environment negatively and its impacts on health will disproportionately affect the elderly, pregnant women, children, the chronically ill, Indigenous groups, those with compromised immune systems, the poor, the socially disadvantaged, and those living in...
vulnerable geographic areas (e.g., rural areas) (PHAC, 2013). However, the sector can act proactively by engaging citizens, addressing knowledge gaps, adopting best practices, and preparing for larger-scale emergencies.

References


PEI Climate Change Adaptation Recommendations Report – DRAFT


11 TOURISM SECTOR

11.1 BACKGROUND

Tourism is an important industry within Prince Edward Island. In 2016, it generated an estimated $430 million of revenue and attracted an estimated 1.5 million visitors (Tourism Development International, 2016). Over 80% of all visitors in 2015 were Canadian, with the majority of them from New Brunswick and Nova Scotia (see Figure 11.1). Tourism represents 7% of the Island’s GDP, generating approximately $43 million in provincial tax revenues (Opportunities PEI, n.d.). This sector provides an equivalent of 7,700 full-time year-round jobs (The Employment Journal, n.d.).

Prince Edward Island’s tourism products include beaches, golf, coastal drives, artistic and cultural heritage, and culinary experiences. Motor coaches, cruise ships, and meetings and conventions also attract visitors to the Island. The peak months for tourism are July and August. In 2016, 89% of non-resident revenues were generated in those two months (Tourism Development International, 2016). Most visitors accessed the Island via the Confederation Bridge, followed by the ferry service at Wood Island and air travel via the Charlottetown airport (see Figure 11.2).
11.2 IMPACTS OF CLIMATE CHANGE

Climate change will bring about warmer weather, changes in precipitation patterns, more intense storms, and rising sea levels in Prince Edward Island.

It is critical to note that opportunities and challenges resulting from climate change cannot be taken in isolation. While there are anticipated impacts both positive and negative, the extent of them is unknown at this time. For example, the advantages in a longer tourism season from warmer temperatures could be offset by the impact of coastal erosion on beaches that more intense storms bring.

11.2.1 TEMPERATURE

OPPORTUNITIES

Firstly, rising temperature will lead to longer and warmer summers, increasing the number of days suitable for activities such as golfing, biking, hiking, and camping. Golf courses in the East Coast of Canada may see increases of up to 40-48% and visitation to National Parks could increase by 10-40% (Ecology Action Centre [EAC], 2012). The projected increase in golf seasons could be reasonably used to expect potential extension of seasons for theme/water parks, boating, cycling, fishing, and beach recreation (Kovacs and Thistlewaite, 2014). The extension of these seasons could lead to the growth of “shoulder seasons” of May to June and September to October, when capacity is underutilized (Reiling, n.d.).
Secondly, rising temperatures in hotter regions can boost summer tourism for the Island. With an abundance of beaches and coastline and relatively cooler temperatures, tourists may visit the Island looking to escape the heat. In addition, warmer summer temperatures will encourage locals to enjoy a “staycation”, rather than travel to southern destinations (PEI Department of Communities, Land and Environment, 2016). According to the EAC (2012), “domestic tourism may double in colder countries since people won’t have to travel as far to find more desirable weather and it may fall by 20% in warmer countries as people try to escape uncomfortably hot temperatures”.

Thirdly, a warmer climate may result in the establishment or growth of new tourism products. For example, more vineyards being established could support a tourist industry around wine production (PEI Department of Communities, Land and Environment, 2016).

**CHALLENGES**

Firstly, in contrast to the boost warmer temperatures bring to summer tourism, winter tourism is expected to be impacted negatively. With increased temperature, reduced snowfall and decreased reliability of natural snow cover, winter sports such as skiing and snowmobiling will be affected (Kovacs and Thistlewaite, 2014). The ski seasons will be shortened and resorts will become more dependent on snowmaking, facing decreasing revenue and increasing operating costs.

Secondly, the additional visitors expected to visit the provincial and national parks are likely to create a more significant ecological footprint (Kovacs and Thistlewaite 2014).

**11.2.2 PRECIPITATION**

**CHALLENGES**

Under a changing climate, it is expected that there will be fewer rain events but each event will bring more intense rain. Changing precipitation patterns will be particularly challenging for the golf industry.

Dry periods between rain events, combined with an overall reduction in precipitation and greater evapotranspiration from warmer temperatures could lead to higher reliance on irrigation management to maintain ideal conditions for greens and fairways.

**11.2.3 EXTREME EVENTS**

**CHALLENGES**

The increasing intensity and frequency of extreme weather events, along with rising sea levels, will worsen the severity of flooding and erosion impacts on coastal properties and infrastructure such as
beaches, boardwalks, tourist accommodations, scenic routes, wharves, parks etc. (see Table 11.1). The cost to protect, retrofit, repair, or relocate some of these assets could be cost-prohibitive.

Table 11.1. Projected Coastal Erosion at PEI Provincial Parks (Source: Jardine, 2015)

<table>
<thead>
<tr>
<th>Prov. Park</th>
<th>2010 Area</th>
<th>2040 Area % loss</th>
<th>2070 Area % loss</th>
<th>2100 Area % loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argyle Shore</td>
<td>0.1864 km²</td>
<td>2.86</td>
<td>5.75</td>
<td>8.80</td>
</tr>
<tr>
<td>Cabot Park</td>
<td>1.4649</td>
<td>2.88</td>
<td>6.84</td>
<td>10.13</td>
</tr>
<tr>
<td>Campbells Cove</td>
<td>0.0924</td>
<td>2.75</td>
<td>6.05</td>
<td>9.15</td>
</tr>
<tr>
<td>Chelton Beach</td>
<td>0.0532</td>
<td>2.53</td>
<td>5.80</td>
<td>9.23</td>
</tr>
<tr>
<td>Jacques Carrier</td>
<td>0.0636</td>
<td>25.22</td>
<td>46.45</td>
<td>58.88</td>
</tr>
<tr>
<td>Linkletter</td>
<td>0.1662</td>
<td>0.98</td>
<td>1.79</td>
<td>1.60</td>
</tr>
<tr>
<td>PEI National Park</td>
<td>20.679</td>
<td>4.29</td>
<td>8.74</td>
<td>13.50</td>
</tr>
<tr>
<td>Red Point</td>
<td>0.2882</td>
<td>1.71</td>
<td>3.28</td>
<td>4.93</td>
</tr>
<tr>
<td>Tignish Shore</td>
<td>0.0196</td>
<td>15.90</td>
<td>31.93</td>
<td>47.32</td>
</tr>
<tr>
<td>Union Corner</td>
<td>0.0321</td>
<td>9.69</td>
<td>19.86</td>
<td>30.72</td>
</tr>
<tr>
<td>Victoria Prov.</td>
<td>0.0461</td>
<td>27.88</td>
<td>55.60</td>
<td>77.37</td>
</tr>
</tbody>
</table>

11.2.4 INDIRECT CLIMATE CHANGE IMPACTS

CHALLENGES

Beyond the direct impact of climate on infrastructure and activities, there are indirect consequences of climate change that should also be considered.

Firstly, rural regions may become vulnerable to climate change due to their distance from metropolises and transportation hubs because rising price of fuel from potential carbon offsetting could increase travel costs for visitors (EAC, 2012).

Secondly, the rising price of fuel could impact the snowmobiling and boating industries (Daniel et al., 2009).

Thirdly, golf course operators will be competing against other major users of water (e.g., farmers) to meet irrigation needs. This could be complicated by restrictions applied to irrigation permits during hot dry summers with low groundwater levels, a scenario that could become more likely under a changing climate.
11.3 RECOMMENDED ADAPTATION ACTIONS

67. **Forecast future climate** for variables that impact tourism. For example, determine the:
   a. number of “comfort days” for golf, soft adventure, etc.;
   b. number of frost free days for golf season;
   c. change in temperature for the shoulder seasons; and,
   d. seasonality of wind affects soft adventure, fishing excursions, etc.

68. Develop **more offerings for the shoulder seasons** (e.g., festivals, events, experiential tourism products) to meet the needs for the higher traffic that warmer temperatures may bring.

69. **Promote Prince Edward Island as an escape** from urban heat. Different tourism themes have been used to promote Prince Edward Island as a tourist destination (e.g., “Come to the Island – Stay for the Party”, “True Island Flavour”, “Come Find your Island”, “Only in PEI”). Providing a diverse offering is important in attracting tourists. Data should be collected (e.g., exit surveys) to best determine the ideal markets for this marketing campaign.

70. **Protect assets and infrastructure** (e.g., attractions, tourist accommodations, scenic routes) that are vulnerable to the effects of flooding and erosion. The asset/infrastructure owners or managers should:
   a. identify existing assets/infrastructure that are or will be in the flood risk and erosion risk zones;
   b. protect, relocate, retrofit, or abandon assets/infrastructure⁹, as required;
   c. site new developments away from flood risk and erosion risk zones; and
   d. monitor rates of erosion on-site utilizing methodologies developed by the UPEI Climate Lab.

71. Golf course operators may need to consider **new irrigation methods** and select **different turfgrass** that would be suitable under a changing climate.

72. **Diversify their product offering** (e.g., eco-tourism, cultural heritage, and culinary experiences) to include more all-weather products in order to cope with changing precipitation patterns and more frequent extreme storm event.

73. Determine the viability of **storm-watching** as an attraction on the North Shore, similar to what is offered by Tofino or Pacific Rim areas in British Columbia.

The collaboration of tourism operators, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and the government will be critical in achieving effective adaptation.

⁹Refer to the Property and Infrastructure Sector chapter for additional information.
The table below summarizes the seven recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

### Table 11.2. Summary of recommended adaptation actions for the Tourism sector.

<table>
<thead>
<tr>
<th>Recommended Adaptation Actions</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
</table>
| 67. Forecast future climate variables that impact tourism (e.g., number of “comfort days” for golf, soft adventure). | Leads: Sector, Provincial Government  
Collaborators: Experts | Fill knowledge gaps |
| 68. Develop more offerings for the shoulder seasons (e.g., festivals, events, experiential products). | Lead: Sector  
Collaborators: Tourism operators | Increase resilience |
| 69. Promote Prince Edward Island as an escape from urban heat. | Lead: Provincial Government  
Collaborator: Sector | Increase resilience |
| 70. Protect assets and infrastructure that are vulnerable to the effects of flooding and erosion (e.g., relocate at-risk tourist accommodations, protect scenic routes, site new attractions away from flood and erosion risk zones). | Lead: Provincial Government, Asset and infrastructure owners  
Collaborator: Sector, Tourism operators | Increase resilience |
| 71. Golf course operators may need to consider new irrigation methods and select different turfgrass that would be suitable under a changing climate | Lead: Golf course operators  
Collaborators: Experts | Increase resilience |
| 72. Diversify product offering (e.g., eco-tourism, cultural heritage, and culinary experiences) to include more all-weather products. | Lead: Tourism operators  
Collaborator: Sector | Increase resilience |
| 73. Determine the viability of storm-watching as an attraction on the North Shore. | Lead: Parks Canada, Tourism operators  
Collaborator: Sector | Increase resilience |

### 11.4 CONCLUSION

Tourism is one of Prince Edward Island’s main economic drivers. It is easy for tourists to substitute the destination, timing, and activities related to travel so offering consistent and quality products to visitors is critical. Given the climate’s large impact on many of the Island’s tourism products, the success and sustainability of the sector will depend on its resilience under changing climate. In the short term, climate change brings many opportunities to the tourism sector. All stakeholders should take advantage of these while planning and bracing for the challenges that climate change inevitably brings.
References


12 WATER SECTOR

12.1 INTRODUCTION

Water is one of the most vital substances on this planet; the existence of plants and animals depend on it. Water security has been defined as a goal to ensure “sustainable access, on a watershed basis, to adequate quantities of water of acceptable quality, to ensure human and ecosystem health” (TRCA and ESSA, 2012).

Water infrastructure is necessary to supply water for flood control, storm water management, and community, industrial, and agricultural use (Andrey et al., 2014). There are different types of infrastructure related to water: marine (e.g., wharves, piers, seawalls, docks), water (e.g., dam, reservoirs, aquifers) and wastewater (treatment facilities, culverts, sewers, pipes, storm drains) (Boyle et al., 2013).

12.1.1 WATER INFRASTRUCTURE

On Prince Edward Island, approximately 84% of Islanders use tap water as their primary source of drinking water (Yarr, 2016). There are 14 communities on the Island that provide treated water through the water distribution facilities they operate (PEI Department of Communities, Land and Environment [PECLE], 2017). However, the majority of Islanders (57%) depend on private wells, the highest percentage in the country (National Collaborating Centre for Environmental Health [NCCEH], 2014).

There are approximately 250 watersheds on the Island, ranging from a few square kilometres each to approximately 150 km². A watershed is an area of land over or under which water flows from the land toward a stream, river, or ocean. Evaporation and transpiration send about 40% of the island’s precipitation to the atmosphere; the remaining 60% becomes streamflow (PEI Department of Fisheries and Environment and Environment Canada, 1996).

In Prince Edward Island, wells and water distribution facilities draw water from groundwater. Wells are drilled into aquifers, the zone beneath the water table that is saturated with water. Aquifers are recharged when precipitation infiltrates down to the aquifer or when water from streams enters the

---

10 These are discussed in the Fish and Aquaculture sector chapter.
aquifer (see Figure 12.1). Poor water quality can be detrimental to human health. Waterborne diseases, run-off, saltwater intrusion, and cyanobacteria are areas of concern for the Island\textsuperscript{11}.

![Figure 12.1. Groundwater and aquifer.](http://www.livinghistoryfarm.org/farminginthe50s/media/water1201.jpg)

### 12.1.2 WASTEWATER INFRASTRUCTURE

Approximately 55\% of Islanders rely on central sewage collection and treatment systems (NCCEH, 2014). There are 30 communities on the Island that provide wastewater treatment services through the facilities they operate (PE CLE, 2017). Many industrial sites operate their own treatment facilities (NCCEH, 2014). Islanders not serviced by these systems rely on septic systems. Household wastewater is treated by the system before it returns to the environment (see Figure 12.2).

\textsuperscript{11} These are discussed in the Public Health and Safety sector chapter.
12.2 CLIMATE CHANGE IMPACTS

Climate change will bring about warmer temperatures, changes in precipitation patterns, more frequent and severe extreme weather events, and rising sea levels. These will present a number of challenges to water quantity and water quality on Prince Edward Island\textsuperscript{12}.

\textsuperscript{12}This chapter will be focused on the impacts on water infrastructure. Effects of climate change related to other aspects of water are covered in the relevant sector chapters. For example, irrigation (Agriculture, Tourism), salinity and surface water temperature (Fish and Aquaculture), waterborne diseases (Public Health & Safety), flooding (Insurance, Properties & Infrastructure), and so forth.
12.2.1 TEMPERATURE

CHALLENGES

Firstly, warmer temperatures will lead to a decrease in the extent and duration of snow cover (Toronto and Region Conservation and ESSA Technologies, 2012). This will reduce the amount of water that infiltrates down to recharge aquifers during spring melt. The timing of this process will also be affected.

Secondly, warmer temperatures could lead to more rain events in the winter months when the ground is frozen. This causes the rain water to run off the surface rather than infiltrate down to the aquifer. Some of this water will enter wastewater systems, increasing operational costs (Audrey et al., 2014).

Thirdly, rising air temperature increases evapotranspiration (i.e., loss of water to the atmosphere via evaporation and plant transpiration). If the water is lost to the atmosphere before it can filter from the surface down to the aquifer, water quantity in the aquifers would be reduced.

Fourthly, winter thaw events will occur more frequently with rising temperatures. In systems where sewer and stormwater management functions are combined, the cold runoff can reduce the system’s to perform its biological nitrogen removal and secondary clarification functions (Andrey et al., 2014).

Fifthly, higher temperatures could affect the taste and odour of treated water (Andrey et al., 2014).

12.2.2 PRECIPITATION

CHALLENGES

Firstly, reduced precipitation could lead to changes in the extent and timing of stream and aquifer recharge, affect levels of freshwater.

Secondly, runoff from intense rainfall events increases the risk of overwhelming wastewater treatment systems, causing overflows.

Thirdly, intense rain events create runoff that can carry contaminants from land (e.g., silt, chemicals, hydrocarbons, heavy metals) to uncontaminated areas (e.g., wells, rivers, beaches), affecting the quality of drinking and recreational water.

Fourthly, reduced precipitation means less water is available at wastewater treatment facilities for dilution. This could lead to accumulation of solid waste sediments in conduits that could cause clogging (Nedvedova, n.d.).

Fifthly, changes in precipitation patterns could lead to a higher risk of wildfires, which can negatively affect the quality of source water for many years (Andrey et al., 2014). For example, the 2003 Lost
Creek fire in Alberta caused years of increased turbidity, total organic carbon and nitrogen in runoff, especially during spring melt and after rainstorms (Andrey et al., 2014)

12.2.3 EXTREME WEATHER EVENTS

CHALLENGES

Firstly, higher wave energy from more intense extreme weather events could damage effluent pipes from wastewater treatment systems. It could also increase coastal erosion, putting water infrastructure located in the coastal zone (e.g., septic systems) at risk.

Secondly, lift stations for wastewater treatment facilities located in the flood risk zone will be more likely to be inundated by higher storm surge.

12.2.4 SEA LEVEL RISE

CHALLENGES

Firstly, rising sea levels could affect the saltwater-freshwater interface in the aquifers, leading to saltwater intrusion of wells (see Figure 12.3). Elevated levels of saline in drinking water cause serious health implications such as hypertension and stroke (Vineis et al., 2011). Some coastal communities in Prince Edward Island have already experienced saltwater intrusion.

Secondly, saltwater intrusion from rising sea levels could degrade sewer conduits and affect the quality of waste water (Andrey et al., 2014)

Thirdly, rising downstream levels from higher sea levels may necessitate the pumping effluent (rather than rely solely on gravity flow), increasing operating costs (Danas et al., 2012).
12.3 ADAPTATION ACTIONS

74. Integrate climate change considerations in **financial planning**. This applies to property owners and water infrastructure owners and managers. Budgetary constraints are often a barrier to implementing adaptation actions but this could be partly addressed through improved financial planning. For example, when an individual purchases a home, the age and condition of the roof is often part of the home inspection and factored in the purchase price. The repair and replacement of the roof is an accepted aspect of homeownership. The roof is generally replaced before it deteriorates to a point that rain leaks through. Similarly, water infrastructure owners and managers need to consider the costs and timing of adaptation actions in relation to the costs associated with the increase in liability, increase in maintenance, shorter lifespan, etc. While implementing adaptation actions incur an upfront cost, it can save a considerable amount of money over the lifetime of assets and infrastructure, often resulting in a net positive financial position overall.

75. **Set a future climate scenario** to establish design standards for the building, upgrading, or retrofitting of water infrastructure, based on the expected lifespan of the infrastructure\(^\text{13}\). For example, should stormwater treatment facilities be designed for 1-in-50 year or 1-in-100 year rain events? Should they consider these events under the 2020, 2050, or 2100 time frame? Once a scenario is set, **analyze the resilience of existing infrastructure** and retrofit or upgrade where necessary.

76. Put **back-up systems** in place at water distribution and wastewater treatment facilities (e.g., spare flood pumps, back up electricity source) to limit disruptions to service during extreme weather events.

77. **Utilize land use planning** policies and regulations (e.g., zoning, setbacks, permits) to prompt the development of climate-resilient water infrastructure where incentive for preventive action is not strong enough. Incorporate future climate considerations into land use and building regulations. The province should update its Land Use Planning Act and Regulations, to:
   a. set a future climate scenario standard (see Recommended Adaptation Action #75);
   b. preserve and augment natural features to manage flooding (e.g., limit development to allow rivers to expand into side channels and wetland areas);
   c. include septic tanks and wells in building setback requirements;
   d. require additional information during the development permit process to ensure the asset/infrastructure owner has considered climate change impacts and met the future climate scenario standard (e.g., lot drainage plans, survey plans);

\(^\text{13}\) Refer to the Properties and Infrastructure sector for additional considerations when siting new facilities (e.g., coastal erosion).
a. require stormwater management at source (i.e., on-site);
b. increase inspections to ensure compliance;
c. impose higher fees and stricter penalties for non-compliance; and,
e. establish a voluntary conservation covenant or easement, which prohibit development on a portion or all of the property or removal of native vegetation, in areas that are sensitive to climate change impacts in exchange for a property tax reduction or credit (Richardson and Otero, 2012). The owner could continue to own the land, live on it, sell it, or pass it on but the covenant would continue regardless. This should be reviewed on a case-by-case basis and entered into only when the preservation of land has measurable benefits (e.g., improve climate resilience).

78. **Reducing demand** on water infrastructure is quicker and more cost effective than increasing capacity. This can be accomplished in several ways; for example:
   a. educate and sensitize the public to the limitations of and challenges facing groundwater. Canada’s wealth in freshwater resources could otherwise make water quantity an afterthought.; and,
   b. give the public and industries practical recommendations on how to reduce demand (e.g., behavioural changes, low-flow showerheads, onsite water retention techniques). Consider the model used by efficiencyPEI to promote energy conservation and energy efficiency.

79. Consider **complementary green infrastructure** when upgrading stormwater management systems (see Figure 12.4). However, increasingly intense precipitation events leave infrastructure owners/managers with little choice. Studies show that green infrastructure is more cost-effective and less energy intensive than traditional stormwater management infrastructure (Morand et al., 2015). They can be installed by individuals and businesses due to their often small-scale, decentralized nature. One example of green infrastructure is green roofs, which have been successfully used in Basel, Switzerland and New York City, USA. Basel is a town of 195,000 people and has more than 1.2 million square meters of rooftops covered with vegetation as of 2014 (Morand et al., 2015). This adaptation action was driven by the desire to reduce energy costs (green roofs provide added insulation value to buildings) and climate change mitigation but added benefits include stormwater management, local ambient air temperature moderation, increased property values, and public health improvement (Morand et al., 2015) (see Figure 12.5).
Another example of green infrastructure is rain gardens, which could remove 40-97% of nutrients and metals found in stormwater runoff (Chisholm, 2008). Rain gardens are dug below-grade (between 6 to 12 inches) to temporarily store stormwater, allowing the water extra time to evaporate and infiltrate into the ground, thereby decreasing the demand on stormwater management systems (Chisholm, 2008) (see Figure 12.6). At a larger scale, overflow drains could be added and connected to municipal wastewater treatment system to handle the excess flow (Chisholm, 2008). The mulch and soil in a rain garden absorb some of the pollutants and provide a habitat for microorganisms that degrade the contaminants (Chisholm, 2008). Water-tolerant vegetation should be chosen to slow runoff, absorb nutrients, and trap sediment (Chisholm, 2008). In urban areas, rain gardens can be placed in the center of roundabouts, alongside streets, etc.
80. Create a pilot project to demonstrate bioretention techniques (see Recommended Adaptation Action #79). Currently, builders and contractors may not have the necessary knowledge or experience to implement adaptation actions (e.g., installing green roofs). The project could involve students from UPEI Climate Lab, UPEI School of Sustainable Engineering Design, Holland College Environmental Applied Science Technology, and Apprenticeship programs in the design, construction, and maintenance phases. Exhibits with information for the public will be available on site. This demonstration site can incorporate adaptation actions from other sectors as well (e.g., solar energy panels and electricity storage). An interactive display featuring the Coastal Impact Visualization Environment (CLIVE) could help raise awareness among the public on future coastal flooding and erosion risks.

81. Supply flood risk maps to municipalities with water infrastructure. Municipalities should complete a vulnerability assessment of their water infrastructure components. The map could also be used to identify potential sites for complementary elements such as retention ponds.

82. Identify needs for data, training, knowledge and tools. This could include:
   a. additional weather stations to collect local data for accurate high-resolution modeling and projections;
   b. improved understanding of groundwater recharge and discharge rates (e.g., impact of snow cover on water supplies);
   c. forecasting for low water levels and drought conditions;
   d. strategies to respond to low water levels (e.g., viability of a desalination plant);
   e. research on point source pollution and controls;
   f. training on watershed monitoring and restoration;
   g. visualization model demonstration groundwater recharge and other issues (for public outreach);
   h. soil moisture monitoring; and, 

Figure 12.6. Anatomy of a rain garden. (Source: http://ext10.wsu.edu/raingarden/wp-content/uploads/sites/74/2016/01/rg-schematic.png)
i. downscaling of soil aridity models.

83. **Engage in public outreach.** Provide guidance to individuals and businesses on how to minimize their risk of flooding and improve water security. For example, clear snow and vegetation from ditches prior to an intense rain event to prevent flooding, choose appropriate vegetation for rain gardens that can withstand Island climate, install sewer backwater valve, etc.

84. Provide **financial incentive** to property owners to manage stormwater on site (e.g., rain gardens, permeable surfaces, ditches).

85. **Coordinate with other sectors** and share best practices in maintaining water quality and sustaining water quantitative (e.g., retention of water to reduce irrigation requirements for golf courses and agriculture lands, drainage strategies for woodlot owners; reduce runoff to aquaculture areas).

86. **Decommission unused wells** to prevent the risk of contamination (e.g., from runoff or flood waters).

The collaboration of the public, water infrastructure owners, sector (e.g. industry organizations), experts (e.g., climate scientists, biologists, engineers), and governments will be critical in achieving effective adaptation. The table below summarizes the thirteen recommended adaptation actions for the sector and proposes how the responsibilities for implementing them could be shared. Leadership in an adaptation action could include championing for the need to implement the action, securing necessary funding, and managing the collaborative efforts. Collaboration in an adaptation action could include providing expertise, resources (e.g., financial, time), and support.

---

**Table 12.1: Summary of recommended adaptation actions for the Water sector.**

<table>
<thead>
<tr>
<th>Recommended Adaptation Action</th>
<th>Responsibility</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>74. Integrate climate change considerations in financial planning. Water infrastructure owners and managers need to consider the costs and timing of adaptation actions in relation to the costs associated with the increase in liability, increase in maintenance, shorter lifespan, etc.</td>
<td>Leads: Property owners, Water infrastructure owners and managers</td>
<td>Address financial concerns</td>
</tr>
<tr>
<td>75. Set a future climate scenario to establish design standards and analyze the resilience of existing infrastructure (e.g., should stormwater management systems be built to withstand 1-in-50 year or 1-in-100 year rain events and are the events taking place in 2020, 2050 or 2100?)</td>
<td>Leads: Provincial Government, Water infrastructure owners and managers Collaborators: Experts</td>
<td>Promote climate change mainstreaming</td>
</tr>
<tr>
<td>76. Put back-up systems in place to limit disruptions to service during extreme weather events (e.g., spare flood pumps, back up electricity source).</td>
<td>Leads: Water infrastructure owners and managers</td>
<td>Increase resilience</td>
</tr>
<tr>
<td>77. Utilize land use planning policies and regulations</td>
<td>Leads: Provincial</td>
<td>Leverage regulation; Promote</td>
</tr>
<tr>
<td>Action Number</td>
<td>Description</td>
<td>Lead</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>78.</td>
<td>Reducing demand on water infrastructure (e.g., sensitize public to the challenges facing groundwater, provide practical recommendations on how to reduce demand).</td>
<td>Provincial Government</td>
</tr>
<tr>
<td>79.</td>
<td>Consider complementary green infrastructure when upgrading stormwater management systems (e.g. green roofs, rain gardens).</td>
<td>Property owners, Water infrastructure owners and managers</td>
</tr>
<tr>
<td>80.</td>
<td>Create a pilot project to demonstrate bioretention techniques (see Adaptation Action #79).</td>
<td>Provincial Government</td>
</tr>
<tr>
<td>81.</td>
<td>Supply flood risk maps to municipalities with water infrastructure.</td>
<td>Provincial Government</td>
</tr>
<tr>
<td>82.</td>
<td>Identify needs for data, training, knowledge and tools (e.g., install weather stations, improve understanding of groundwater recharge and discharge rates, provide training on watershed monitoring and restoration).</td>
<td>Provincial Government, Water infrastructure owners and managers</td>
</tr>
<tr>
<td>83.</td>
<td>Engage in public outreach. Provide guidance on how to minimize the risk of flooding and improve water security.</td>
<td>Provincial Government</td>
</tr>
<tr>
<td>84.</td>
<td>Provide financial incentive to property owners to manage stormwater on site (e.g., ditches, permeable surfaces).</td>
<td>Provincial Government, Municipal governments, Water infrastructure owners and managers</td>
</tr>
<tr>
<td>85.</td>
<td>Coordinate with other sectors and share best practices in maintaining water quality and sustaining water quantitative.</td>
<td>Provincial Government</td>
</tr>
<tr>
<td>86.</td>
<td>Decommission unused wells to prevent risk of contamination.</td>
<td>Provincial Government</td>
</tr>
</tbody>
</table>

### 12.4 CONCLUSION

Some of the most pervasive impacts of climate change will be related to water resources (Andrey et al., 2014). Water is one of the most precious resources and maintaining water quality and keeping water quantity at sustainable levels are critical. Every region in Canada will experience a reduction in water quality and quantity on a seasonal basis (Andrey et al., 2014). Maintaining water quality and sustaining...
water quantity on Prince Edward Island is everyone’s responsibility. It will require a concerted effort to work together to effectively address the challenges that climate change will bring to the sector.

References


13 CONCLUSION

13.1 IMPLEMENTING ADAPTATION ACTIONS

Different groups – individuals, businesses, grassroots organizations, sectors, governments, etc. – would likely take different paths in adapting to climate change. However, there are a number of phases that may be common for all groups: awareness of climate change, awareness of the need to adapt, mobilizing resources, building capacity to adapt, implementing adaptation actions, measuring and evaluating progress, and learning, sharing knowledge with others, and adjusting (Eyzaguirre and Warren, 2014). The last phase involves the refinement of adaptation actions and application of knowledge to inform future adaptation actions. This highlights the need to understand that adaptation is an evolving process, requiring research to ensure that it is cost effective, efficient, and equitable (HM Government, 2013).

Throughout the sector consultation sessions, the consensus on climate change and the need to adapt was clear. However, barriers to adaptation exist across all groups and sectors and are preventing efficient adaptation from taking place. There were high levels of awareness and adaptive capacity observed at the consultation sessions but these do not necessarily translate to effective adaptation. The common barriers and the associated potential solutions include:

1. Uncertainty
   Gaps in knowledge increase the concern of over-, under-, or maladaptation. These gaps can be addressed by collaborating with experts outside of the sector (e.g., climate scientists); gathering customized, user-oriented, and high-resolution data; and, selecting ‘win-win’ and ‘low-regret’ adaptation strategies while provide short-term benefits at low costs in the meantime.

2. Lack of Funding
   Adaptation actions often require up-front investments, competing for funds already earmarked for day-to-day operations. Many preventive adaptation options are less costly than inaction over the long run. As with other business and personal decisions, growth and sustainability of a business require careful financial planning, with a long-term view in mind.

3. Insufficient Incentive
   Motivations to implement adaptation actions are often muted by the overwhelming nature of global climate change (e.g., “bigger than self”) or limitations in funding. However, in instances where public health and safety, environmental or economic sustainability are at risk, adaptation must occur. The different levels of government may need to use regulatory approaches to compel individuals and businesses to adapt.
4. Lack of Guidance
The willingness to adapt must be matched with the availability of guidance, particularly for the general public, in order for effective adaptation to take place. This can be accomplished via access to decision support tools and demonstrations of successful approaches.

5. High Level of Coordination
The need for expertise from different groups within the sector, other sectors, and different levels of government makes effective coordination and partnerships challenging. The sectors should nominate a champion, someone with a passion for environmental and sectoral issues, and the ability to work in an interdisciplinary manner to lead the charge. The champion would be tasked with identifying opportunities for collaboration, pinpointing relevant experts across different sectors, and providing leadership in adaptation.

6. Gradual Nature of Climate Change
It is easy to think of climate change as a slow, gradual process with increases in loss occurring incrementally (Canadian Electricity Association, 2016), making the promotion of immediate climate change action difficult. Rather than rely on this as an opportunity to delay adaptation, it should be viewed as an opportunity to utilize effective adaptation strategies that require long lead-times to develop.

Similarly despite the unique characteristics of each sector, common themes emerged from the recommended adaptation actions: fill knowledge gaps, increase resilience, reduce non-climatic factors, promote climate change mainstreaming, increase collaboration, engage in public outreach, leverage regulation (e.g., land use planning), and address financial concerns.

13.2 SHARED RESPONSIBILITY
Climate change is a shared problem that requires shared responsibility from everyone – individuals, businesses, non-governmental organizations, sectors, different levels of government, etc. Joint action is required in instances where different groups and sectors are impacted.

The provincial government could play a critical role in leading the development of a medium- and long-term strategy in adapting to climate change. They have expertise across all sectors, the authority to compel action, and ability to coordinate and implement large-scale initiatives. For example, water quality impacts all sectors, including Public Health. Stormwater management is a capital intensive undertaking that benefits the public, the environment, and all sectors. A coordinated plan to reduce runoff and improve groundwater recharge would improve the resilience of the society and the economy. This would involve a multi-pronged approach: encouraging farmers to invest in rainwater storage, providing guidance on water management to woodlot owners, conduct public outreach to encourage homeowners to install rain gardens and update regulations to widen buffer zones. Not only would this improve water quality, it would have additional benefits such as reduced need for irrigation,
reduction in erosion, fewer washouts of infrastructure, and lowered probability of homes and buildings flooding, increased biodiversity, etc.

13.3 MOVING FORWARD

Climate change adaptation needs to be mainstreamed, that is to say climate change considerations should be integrated into existing all decision-making processes (e.g., financial planning, risk estimation and evaluation). Similar to safety, climate change adaptation is not a “priority” – it must be considered a normal way of life.

It is time to shift from coping to adapting. Planned adaptation takes time. Fortunately, the gradual nature of climate change affords us that time, but the work must begin immediately.

References

