International Journal of Sustainability in Higher Education

Beyond reduction: climate change adaptation planning for universities and colleges

Rochelle Owen, Erica Fisher, Kyle McKenzie,

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Rochelle Owen, Erica Fisher and Kyle McKenzie
Dalhousie University, Halifax, Canada

Abstract

Purpose – The purpose of this paper is to outline a unique six-step process for the inclusion of climate change adaption goals and strategies in a University Climate Change Plan.

Design/methodology/approach – A mixed-method approach was used to gather data on campus climate change vulnerabilities and adaption strategies. A literature review highlighted common themes in adaption research. Meetings, surveys, and a specialized workshop with climate scenarios were created to elicit campus and community input.

Findings – The majority of the peer-reviewed and grey literature surrounding climate change adaptation planning is aimed at larger levels of organization than a University campus (e.g. nations, populations, regions, and cities). An original planning process was created to identify vulnerabilities, risks and strategies. Key vulnerabilities fell into three main areas of concern: energy, transportation, and built environment. Adaptation goals, objectives and strategies were outlined for the Dalhousie University Climate Change Plan, based on risk levels associated with vulnerabilities.

Research limitations/implications – The adaption survey and workshop was created for this research. Small improvements were suggested for future use. The six weather scenarios presented at the workshop emphasized extreme events. Some participants felt that scenarios should be developed that feature smaller climate changes over a longer period of time. The prioritization activity used to establish risk needed to clarify the definition of risk being used. Future scenarios could include more consideration of socio-economic factors.

Originality/value – Specific planning frameworks to create campus-level climate adaptation strategies are sparse. A unique planning framework and workshop was developed to identify key climate change adaption strategies for universities.

Keywords Universities, Canada, Climate change, Climate change adaptation, Climate change planning, Adaptation assessment

Paper type Case study

1. Background

The Intergovernmental Panel on Climate Change (IPCC, 2007b) confirmed climatic change is occurring as a result of human activities. The impacts of climate change affect every aspect of society. Common impacts include flooding; droughts; habitat shifts; water and air pollution; infrastructure damage to structures such as roads and buildings; spread of disease; human migration; food and fuel prices; and political instability as natural resources become more impacted (CNA Corporation, 2007; Berry *et al.*, 2008; Bizikova and Burton, 2008). The consequences of the changing climate have been globally acknowledged as areas of concern, with two main avenues of response: mitigation and adaptation (Fussel and Klein, 2006). Mitigation most commonly refers to changes in anthropogenic behaviors to reduce the degree of climate change and associated influences. Adaptation strategies seek to reduce the severity of adverse impacts of climate change on vulnerable communities or infrastructure (Fussel, 2005).

International Journal of Sustainability in Higher Education
Vol. 14 No. 2, 2013
pp. 146-159

1467-6370
DOI 10.1108/14676371311312860

Globally organizations, businesses, and governments are releasing climate change plans aimed at reducing green house gases (GHGs) to mitigate the climate change impacts. Strategies include increasing energy efficiency and renewable energy, fuel switching to lower carbon fuels, and enhancing carbon sequestration. In recent years, additional efforts have focused on climate change adaptation planning as the impacts of climate change are already being realized (Pew Center on Global Climate Change and Pew Center on the States, 2011). Examples of adaptation strategies currently employed include creating green and white roofs, planting vegetation, employing pervious pavement, re-using grey and rain water, using renewable energy systems, and protecting land for floodplain uses (Bizikova and Burton, 2008). The development of mitigation and adaptations plans has evolved often separately. Emerging policy trends are focusing on the importance of the integration of mitigation and adaptation strategies for economic and strategy effectiveness (Klein *et al.*, 2005).

Key elements in creating a climate adaptation plan include: defining the scope, definitions, and frameworks; determining and prioritizing vulnerabilities; and creating adaptation strategies to address key vulnerabilities. Vulnerability is defined by the IPCC (2007a, p. 883) as:

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

Many planning processes engage those who will be most affected by the impacts of climate change along with technical and community stakeholders. Doing so ensures an assessment that is informed by both expert and experiential knowledge of both the biophysical and social systems (Lindley *et al.*, 2006; Lynch *et al.*, 2008).

The scope, in a climate change vulnerability assessment, can be a community, an institution, or a place (Downing and Patwardhan, 2005). A vulnerability assessment has the potential to encompass elements such as built infrastructure, livelihoods, the natural environment, and human health; thus the suite of associated vulnerabilities can be extremely diverse. Further prioritization is useful to hone in on key vulnerabilities. The type of assessment can differ depending on the framework being used and the value sets held by the assessor. Some examples include assessing vulnerability of: biophysical changes to a system, values, policies, and social effects (Fussel and Klein, 2006; Lynch *et al.*, 2008).

There are many variations in methodology for assessing the vulnerability of a system. The IPCC sets forth a seven-step method for vulnerability assessment (Carter *et al.*, 2007). Classified as an impact assessment the IPCC recommends:

(1) defining the problem;
(2) selecting a method;
(3) testing the method and sensitivity;
(4) selecting scenarios;
(5) assessing biophysical and socio-economic impacts;
(6) assessing autonomous adjustments; and
(7) evaluating adaptation strategies (Carter *et al.*, 2007).

The Canadian Climate Impacts and Adaptation Research Network provides municipalities with a five-step vulnerability assessment method in order to develop adaptation strategies for infrastructure (Mehdi *et al.*, 2006). Municipalities should:

(1) engage affected parties and decision makers;
(2) assess current vulnerability using past experiences to understand critical thresholds and adaptive capacity;
(3) estimate future conditions using climate scenarios that take into account environmental and socio-economic conditions;
(4) use these scenarios to estimate future vulnerabilities and identify potential adaptation strategies; and
(5) make decisions about which strategies to implement and how (Mehdi *et al.*, 2006).

The majority of the peer-reviewed and grey literature surrounding climate change adaptation planning is aimed at larger levels of organization such as nations, regions, and municipalities rather than universities. Specific planning frameworks for campus-level climate adaptation are difficult to find. Most university climate change plans address mitigation, not adaptation, nor the integration between the two.

Universities and colleges are often large property owners with civically minded missions. University housing, food, medical and recreational services are provided to students, employees, and community members across the globe. Identifying climate change adaptation strategies at a university and college level is important for the: maintenance and building of infrastructure; health and well-being of students, employees, visitors, and community members; continuity of teaching and research; and the campus biophysical environment.

2. Purpose

The Office of Sustainability spearheaded the development of the Dalhousie Climate Change Plan and GHG inventory. As part of this work, a climate change adaptation process was created to identify adaption goals, objectives, and strategies. These adaptation strategies and targets were integrated with mitigation approaches under six key action areas in the university climate change plan.

3. Context

Dalhousie University is located in the Halifax Regional Municipality (HRM), Nova Scotia, Canada.

The university is within 500 m of the ocean at the eastern tip of the campus (Barrington Street near Halifax Harbour) and at the Western tip of campus (Oxford Street near the Northwest Arm). In both cases, the campus is at a significantly higher elevation than sea-level, making storm surge and coastal erosion damage unlikely compared to properties closer to the ocean.

In a climate modeling presentation on 23 June 2010 G. Lines provided local modeling information that shows the potential for the mean annual temperature for HRM to be approximately 4°C warmer (HRM, 2007) and the rate of sea-level rise increasing up to 100 cm by 2100. Annual precipitation levels are expected to increase by 100 mm by 2100. Climate change in the HRM will likely affect extreme weather events, with one in 100 year storms becoming one in 50 year events by the end of the century (HRM, 2006, as cited in PIEVC – Canadian Council of Professional Engineers, 2008). Each of these projected regional changes has the potential to impact everyday operations directly at Dalhousie.

4. Methods

The following methods were used to create a climate change adaptation planning process (Table I). The process was implemented from May to August 2010. Funding for a master student to work on the project was secured through a grant from the provincial environment department. Organizations and individuals provided free technical resources and their time. For the workshop, room costs were free and the Office of Sustainability covered lunch costs.

5. Findings

5.1 Scope

The literature review provided guidance on elements to consider when conducting a climate change adaptation process, though no specific examples for universities were found. The geographical scope chosen was the physical campus of Dalhousie University. Key sustainability values related to economics (service, infrastructure), natural environment, and social health (safety, food, water, and shelter) were identified. Survey questions and workshop scenarios were used to elicit vulnerabilities, associated level of risk (severity and probability), and adaptation strategies.

5.2 Vulnerabilities

Vulnerable areas of the university were initially identified through a university-wide survey. The survey was completed by staff, students, and faculty members, with a total of 166 responses. Some of the vulnerabilities most referenced by survey respondents were downed power lines, concerns surrounding flooding storm and/or sewage systems, blocked roads, damage to trees, and interruption to daily university services. These vulnerabilities were then further analyzed during a climate change workshop, with a more specific participant group of facilities management staff, Office of Sustainability staff, citizens, students, faculty, and government and organizational representatives. Workshop participants brainstormed potential areas of vulnerability, but also assigned each vulnerability an associated level of risk (Table II).

Based on these results, climate change vulnerabilities are generally grouped into three main areas of concern: energy, transportation, and built environment.

5.2.1 Energy. The Dalhousie community ranked all services and infrastructure related to energy (e.g. electricity generation, transmission lines) as a vulnerable area that is both high risk and high priority. The high level of risk is generally associated with how dependent day-to-day university operations are on access to energy. A downed power line, for example, has the potential to disrupt sensitive research or interfere with food storage. Regarding energy infrastructure, a university infrastructure assessment found multiple vulnerabilities:

- Currently the Central Heating Plant (CHP) has a capacity of 170,000 lb/h ($2 \times 85{,}000$ lb/h boilers) (Dalhousie University, 2009). However, since the peak winter demand is approximately 162,000 lb/h if there is a boiler failure in the winter there would be interruptions to daily campus operations.

Table I.
Climate change adaptation planning process – steps and methods

Step	Method
1. Defining the scope, identifying assessment methods	Literature review – May 2010 – a copy of the literature review is posted on the Dalhousie University Office of Sustainability web site under publications and reports Peer-reviewed literature pertaining to "climate change", "vulnerability" and/or "adaptation" was searched for in the web of science database, using the three keywords identified above. As the purpose of this literature review was to inform methods for a vulnerability assessment and develop adaptation strategies for the Dalhousie campus, sources were selected for their relevance to campus Grey literature was consulted as an additional source of potential articles to be included in the literature review. The Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report on Climate Change, Working Group II Report Impacts, Adaptation and Vulnerability, was selected as a source because it is an authority in the climate change field. Publications at the federal, provincial and municipal levels of government were reviewed. Sources were obtained either through traditional research methods or materials were sent or referred from government and community representatives
2. Elicit advice technical advisors and Climate Change Sub-committee of the President's Advisory Council on Sustainability	The Nova Scotia Department of Environment provided a staff technical resource (Kyle McKenzie) and funds for a student researcher. A climate change expert with Environment Canada, Gary Lines, provided a presentation on climate modeling to the Climate Change Sub-committee of the President's Advisory Council on Sustainability and HRM climate modeling data for scenario creation The Climate Change Sub-committee provided advice on the development of the climate change plan and adaptation strategies The university climate change committee representatives and departments tasked with the implementing the plan were involved in the all aspects of the planning including mitigation and adaptation strategy development
3. Identifying vulnerabilities and adaptation strategies	Adaptation survey – 21 May-4 June 2010 – a copy of the Adaptation Survey Report is posted on the Dalhousie University Office of Sustainability web site under publications and reports A survey of the general university community was selected as a tool to gather opinions on potentially vulnerable areas. Survey questions were reviewed by the Climate Change Sub-committee, and revisions were completed. The survey itself was created using the Opinio software. It consisted of 20 questions and was live from 21 May 2010 to 4 June, receiving 166 responses. Many students were not on campus at this time. A high percentage of respondents were university employees. Dalhousie has approximately 6,000 full-time employees. Approximately 2.5 per cent of the campus population, at this summer time, completed the survey

(*continued*)

Step	Method
	The survey asked participants to describe any impacts they observed as a result of Hurricane Juan or White Juan (two recent major storms). It also asked respondents about their observations of day-to-day weather events with negative impacts on the campus. The next section of the survey required respondents to consider areas of the university (built infrastructure, natural environment, and services) and rank them on a vulnerability scale if an extreme weather event occurred today. Finally, respondents were asked for their opinions on potential adaptation strategies
4. Prioritizing vulnerabilities and adaptation strategies	Adaptation workshop – a copy of the Adaptation Workshop Report is posted on the Dalhousie University Office of Sustainability web site under publications and reports A half-day workshop was attended by 24 university, community and government representatives on Wednesday 23 June 2010. Participants represented a broad cross-section of the local community concerned and/or working on climate change adaptation including university buildings and housing staff; municipal, provincial, and federal government representatives, students, professors, local citizens and university neighbours, local business and non-profit organizational representatives. The workshop aimed to, (1) identify where/how the university may be vulnerable to climate change; (2) assign each of these vulnerabilities a level of risk; and (3) suggest adaptation strategies to address the potential risks and impacts (A) The workshop began with a brief talk by Gary Lines, from Environment Canada, on climate change models and expected changes for the Atlantic region. An increase in mean maximum temperature, and average precipitation levels is likely (B) With this framework of expected climate changes, participants were presented with a summary of the Climate Change Vulnerability and Adaptation survey results. A list of the vulnerabilities identified in the survey was provided on flip-chart paper for participants to view (C) Six weather scenarios were presented to participants. The scenarios were created using the climate model data provided by Environment Canada. The three years, 2020, 2050, and 2080, were used because they represented dates from the climate models. Two scenarios were created for each year 2020 Repetitive freeze/thaw Ice storm 2050 Snow loading Hurricane

(*continued*)

Table I.

Table I.

Step	Method
	2080 Heat wave Flooding The Office of Sustainability staff wrote a weather report for each scenario that incorporated various Dalhousie locations. For a more interactive workshop experience, scenarios were turned into mini-movie clips. Each written draft was then read by staff members and recorded using Sound Recorder software. Images that corresponded to each scenario were selected, mainly from iStock and Kyle McKenzie. To link the audio files and their associated pictures Windows Movie Maker was used to create the six, approximately 1-min long weather clips. All six clips were played during the workshop for participants (D) For the vulnerability assessment, participants were split into six groups of four to five individuals. A text version of the weather scenario and empty chart with a column for vulnerabilities, risks, and adaptations, were randomly distributed to each table. Groups were given 45 min to assess and list campus vulnerabilities, risk levels, and adaptations associated with their weather event. Following the exercise each small group was asked to share its lists with the entire workshop. As groups shared, all of the vulnerabilities, risks, and adaptation strategies were written on a large flip-chart table at the front of the room. After this group exercise, all participants had the opportunity to contribute to the master list, and discuss entries (E) After participants were satisfied with the list, the final aspect of the workshop focused on individual participants identifying four vulnerabilities, risks, and adaptations they felt were important. Each participant was given 12 dots (four yellow, four red, and four blue) to place on the flip-chart next to whichever items they selected as high priority/importance. The purpose of this activity was to prioritize vulnerable areas, risks, and adaptations
5. Creating goals, objectives, vulnerabilities, strategies	Data from the literature review, survey, and workshop along with data from elevation maps created by the Office of Sustainability and meeting information with facilities staff were used to draft goals, objectives, vulnerabilities and strategies
6. Finalizing details	Elicit final advice – technical advisors and subcommittee members provided feedback on draft goals, objectives, vulnerabilities and strategies. Final versions were incorporated into the Dalhousie University Climate Change Plan

Vulnerabilities	Risks
Loss of power	
Downed transmission lines (most likely from severe wind events) (20)	High (22)
Changes in laboratory environments that threaten research animal health (5), interrupt research (3), disrupt hazardous material handling	High (10)
Hypothermia if students/staff/faculty on campus without heat	High
Damage to buildings and systems (12)	
ITS, data storage facilities, and communications technology (12)	High (17)
Collapse of the Dalplex roof (3)	High (3)
Freezing pipes causing flooding and water damage (2)	High
Storm drains backing up	Medium (3) to high (6)
Flooding on campus	Medium
Erosion or flooding of natural systems (2)	Low
Impacts on the tunnels that supply buildings with electricity, heating, cooling (1)	Low
Impaired transportation systems	
Flooded roads, damage to vehicles, blocked roads, etc. (11)	Medium (3)
Individuals stranded on campus	
Service interruptions	
Food availability (1)	High (1)
Classes interrupted	High (2)
Interruption to waste management services	High
Potable water availability (2)	Medium (1)
Natural gas shortages or inaccessibility	Low (1)
Housing services has a responsibility for students, who are often vulnerable because they are away from home and/or transient (2)	
Other	
Cases of respiratory distress or heat stroke	High
Falls as a result of snow/ice, with financial liability (4)	Medium (1)
Dalhousie's reputation	Medium (1)
Dalhousie as a place of refuge in extreme weather (3)	

Note: Numbers represent numbers of people who identified vulnerability and a corresponding risk

Table II. Climate change vulnerabilities, as identified by workshop participants, and their corresponding assigned levels of risk

- Some of the steam lines that run from the CHP are currently at capacity and would need to be upgraded if the CHP is expanded, or for future campus expansion.
- The steam line for the Sexton campus has problems with flooding, especially at the intersection of Morris-Brenton (Dalhousie University, 2009).

5.2.2 Built environment. The Dalhousie campus comprises approximately 110 structures, many are between 40 and 80 years old. As a result, university buildings were identified as a vulnerable area in the face of climate change. There was particular concern around the resilience of built infrastructure in the event of flooding. Of highest priority was the building that houses the Information Technology Systems (ITS) Data Centre. Through the use of campus elevation mapping, personal communications, and the vulnerability survey, additional areas with a high flood potential were identified. With a changing climate, built infrastructure is also vulnerable to the effects of increased weathering, i.e. more freeze-thaw cycles, or extreme precipitation events (PIEVC – Canadian Council of Professional Engineers, 2008).

5.2.3 Transportation. The Dalhousie community felt transportation systems were a medium level of risk. As mentioned in both the survey responses and vulnerability workshop, routine daily operations of the university depend on individuals and/or goods being able to move to and from its campuses. Normal university functioning rapidly becomes compromised when mobility is impaired, as witnessed following Hurricane Juan in September 2003. Cleared sidewalks are of equal importance since walking is a primary mode of transportation for the majority of students.

5.3 Adaptation strategies

The following adaptation strategies were identified and prioritized through the literature review, survey, and workshop findings:

(1) *Bury power lines*. Service disruptions are less likely when lines are buried, and protected from storm events. Undergrounding transmission lines also offers a financial benefit in terms of reduced maintenance costs (Sawyer and Cuddihy, 2010).

(2) *Emergency generators for key facilities*. Places such as the Killam Data Centre and sensitive research facilities should be equipped with back-up energy supplies to ensure failure of the primary power supply will not interrupt required operations.

(3) *Energy master planning*. Develop energy master plan that covers the use, distribution, measurement and minimization of energy. Key focuses will include conservation and efficiency, security and reliability, and renewable energy.

(4) *Utility projects*. Explore utility projects that provide energy and water security and reliability in a climate that is potentially warmer and wetter with more severe weather. Co-generation and renewable energy projects are listed as key priorities.

(5) *New buildings*. Follow building guidelines and standards that incorporate new climate change temperature, precipitation, storm surge, and severe weather projections.

(6) *Existing buildings*. Explore additional assessment of priority buildings using tools such as the *PIEVC Engineering Protocol for Climate Change Infrastructure Vulnerability Assessment* (PIEVC – Canadian Council of Professional Engineers, 2009).

(7) *Promote shared transportation methods*. Reducing the number of drive-alone commuters, whether through the use of public transit, or a university sponsored shared ride system, is another strategy to reduce GHGs and Dalhousie's vulnerability to blocked transportation infrastructure. Often in an extreme weather event (e.g. hurricane, snow storm), main transportation routes are cleared first to allow public transit to start functioning.

(8) *Emergency measures and communications plan*. While EMO plans are generally used for emergency situations, it is important to note climate change will likely cause more weather related emergencies through a likely increase in the frequency of extreme weather events. Through an EMO plan Dalhousie can effectively act in an anticipatory manner in adapting to climate change. Emergency measures planning should consider the following steps:

- *Be inclusive*. EMO plan should include strategies for: waste management, food systems, potable water management, hazardous waste materials, and interruptions to research, organizing volunteers, or weather monitoring.
- *Prioritize*. Identify facilities, services, or systems that must remain functional.
- *Communicate efficiently*. Make use of web or text resources to keep staff/students/faculty informed.
- *Start teleworking*. Allowing employees to work from home not only reduces GHG emissions, but also decreases the size of a potentially at-risk population on campus in the event of extreme weather.
- *Engage the neighbours*. As an urban campus Dalhousie is located in a primarily residential neighbourhood. With several large, open areas (i.e. Dalplex), the university could serve as a place of refuge for the surrounding community in times of extreme weather events.

(9) *Create and update flood maps*. Identifying areas that currently flood. Improving drainage not only provides an immediate benefit, but is an effective adaptation strategy for a future that likely includes more precipitation.

(10) *Develop/utilize "green infrastructure"*. Create green roofs, green belts, or parks to combat heat island effects. Green space can also function as a natural method to reduce storm water runoff (Birkmann *et al.*, 2010). Green infrastructure exists in varying shapes, from patches to corridors, or matrices, each with associated benefits. A matrix for example (made up of many small areas of green space, such as lawns) has a high infiltration capacity for water runoff, while a corridor is more effective as a flood storage tool (Gill *et al.*, 2007).

(11) *Use alternative building materials*. With precipitation levels likely increasing, materials such as gypsum sheets or plywood are very vulnerable to moisture. Once moisture penetrates the building envelope (the walls, roof/ceiling) it can cause a loss in structural integrity, or allow mould to grow (PIEVC – Canadian Council of Professional Engineers, 2008, p. 192).

6. Discussion

In constructing the scenarios, consideration of a two-axis model to address the critical uncertainties was rejected as being unnecessarily complicated for the scope of the project. Instead, a linear timeline was used and projected climate data from one climate model (based on one greenhouse gas emission scenario) were determined for three points in the future. Because the Dalhousie University was interested in planning for hazardous impacts of climate change, six weather scenarios (two for each time period) were prepared and presented to the workshop participants for discussion (Fisher, 2010).

While this weather scenario-based approach (as opposed to longer term climate scenario-based approach) simplified the climate change details enough to produce useful results from participants in a short period of time, some drawbacks were noticed. The emphasis on extreme events left some participants feeling that it was more of an emergency measures planning exercise than a climate change workshop (Fisher, 2010). Longer term, subtler changes (e.g. impact of drought on landscaping practices, impact of changing heating and cooling needs on budgets) were not addressed. The final plan proposed future workshops utilizing scenarios that "include scenarios that feature smaller climate changes over a longer period of time" (Fisher, 2010, p. AE-6) to address these perceived deficiencies.

The relationship of risk to campus vulnerabilities presented in the scenarios was not made clear enough, possibly as a result of the way the scenarios presented the risks as actual impact events. As a result:

> Participants were unsure as to whether they were rating the probability a vulnerability posed a risk to the university, or whether they were assigning levels of risk to each vulnerability (Fisher, 2010, p. AE-6).

Other recommendations for modifications included more inclusion of socio-economic factors in scenarios and testing adaption options against these scenarios.

Despite these shortcomings, the Dalhousie University found scenario planning and analysis to be an effective way to specifically target campus vulnerabilities and engage stakeholders in a discussion of adaptation options. The findings were used to create adaptation strategies and targets for the Dalhousie Climate Change Plan. Key adaptation goals, objectives, and strategies are outlined in the plan and are highlighted in Table III.

The Dalhousie Climate Change Plan integrates mitigation and adaptation strategies under six key action areas: campus energy systems, green buildings, sustainable transport, knowledge and behavior, natural environment, and carbon offsets and sinks. This integration of strategies is important as it helps to focus on priority actions that meet mitigation and adaptation goals. A clear example of this includes the adoption of renewable energy systems. Building-level renewable energy production reduces GHGs,

Goal	Objectives	Vulnerabilities	Impacts	Strategies
Adapt to a changing climate	Increase energy security	Energy	Finances	Energy master planning
	Outline EMO and communications plan	Transportation	Classes	Bury power lines
	Improve resilience of natural and built systems to severe weather	Built environment	Food	Implement priority utility projects including renewable energy
			Transportation	Utilize building design guidelines and audits
			Housing	Emergency generators for key facilities
			Administration	Use alternate building materials
			Energy	Implement TDM measures
			Health services	Incorporate adaption issues in emergency measures and communications plan
				Create and update flood maps
				Develop/utilize "green infrastructure"

Table III.
Dalhousie University climate change adaptation plan highlights

is an energy security strategy for fluctuating global fuel prices and availability, and reduces energy infrastructure risks such as damage to transmission services from severe weather.

7. Conclusion

Higher education institutions have a significant contribution to play to reduce GHGs and air pollutants, to be prepared for climate impacts, and to increase knowledge on climate change issues. The integration of climate change mitigation and adaptation in planning is important to realize priority actions.

In order to develop successful adaptation strategies an understanding of the concept of vulnerability, methods for conducting vulnerability assessments and options are required. Although both the grey and peer-reviewed literature were informative regarding concept meanings, framework characterizations, and examples from governments, little was found regarding higher education adaptation planning.

A climate change adaption planning process was developed for universities using Dalhousie University as a case study. The six-step planning process was implemented and findings were used to identify vulnerabilities and create adaptation goals, objectives, and strategies for the Dalhousie University Climate Change Plan. The planning process included the creation and use of an adaption survey and workshop that elicited the input of university and community participants. Scenarios developed for the workshop creatively presented modeling data. Six campus news stories were written using climate modeling information. Students narrated the stories and relevant imagery was tagged to the audio files to make mini-movies for the workshop.

The six-step planning process is method that can be used by other universities, colleges, and organizations. Detailed information on planning process steps, such as the format of the adaptation workshop and survey questions and results, are provided on the Dalhousie University Office of Sustainability web site. Ultimately more research will be required to determine a specific set of adaptation actions to reduce campus vulnerability to climate change.

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About the authors

Rochelle Owen has worked in the environment and sustainability field for over 21 years at non-profit, government, and academic institutions. She currently works as the Director of the Office of Sustainability at Dalhousie University. She uses facilitation, community development, program management, and analytical skills to design programs and involve people in sustainability issues. She holds a BSc in Community Health Education and a Masters in Environmental Studies. Rochelle Owen is the corresponding author and can be contacted at: rjowen@dal.ca

Erica Fisher is relatively new to the field, after sustainability sparked her interest during her BSc studies in 2008. As of 2011 she had completed a Master's in Resource and Environmental Management and interned as the Climate Change Co-Ordinator at Dalhousie University's Office of Sustainability. She is actively seeking opportunities to continue exploring her passions for sustainability, the urban environment and climate change.

Kyle McKenzie has been working in the field of climate change science, impacts, and adaptation for ten years, both at Dalhousie University and with the federal and provincial governments. He possesses a Bachelor's degree in Science, a Master's degree in Planning, and is currently undertaking his doctoral work in climate change adaptation.

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