the adaptation primers*

PRIMER TWO
PREPARING FOR CHANGE

Colleen S.L. Mercer Clarke and Alexander J. Clarke

2018

*prim•er (Pronunciation: /ˈprɪmər/; rhymes with "trimmer"):

A small book containing basic facts about a subject, used especially when you are beginning to learn about that subject.
Source: Cambridge Dictionary Online at http://dictionary.cambridge.org/dictionary/english/primer

CITATION

The preferred citation for the report is:
Mercer Clarke, C.S.L. and A.J. Clarke. 2016. The adaptation primers. Four Volumes. Canadian Society of Landscape Architects, and the Interdisciplinary Centre for Climate Change, University of Waterloo, Ottawa, Canada.

PDF copies of the report are available from the Canadian Society of Landscape Architects website at: http://www.csla-aapc.ca/climate-change/climate-change

COPYRIGHT

GOVERNMENT SOURCES

To facilitate locating material by nation, citations may be written as (by example) GOV/CAN/ECCC where the document is the product of the federal department Environment and Climate Change Canada. Documents produced by state, provincial and/or territorial governments may be cited as GOV/CAN/BC, where the document is (by example) the product of the Government of British Columbia.

WEB RESOURCES

At the time this text was prepared, the URLs for all websites provided were active. As time progresses, these URLs may cease to function, or the content of the sites may change. If this happens you may be able to locate the new site by searching under the name of the organization, or the title of the specific report referenced.

SUPPORT

Many people contributed to the development of material that has been summarized in this text, but we are especially appreciative of the Canadian scientists and government staff who have freely provided access to their research, tools and knowledge. The authors are also grateful for the advice and insights and support of Dr. Daniel Scott, University of Waterloo, and Mr. John D. Clarke, P. Eng.; Environment Canada (retd.).

The Canadian Society of Landscape Architects, through its Committee on Climate Adaptation, provided valuable insights on the final configuration and content of the report. The Society provides the web publication site for the documents.

*T*he research and writing of this report was assisted by funding from the ParCA initiative (School of Planning and Interdisciplinary Centre on Climate Change, University of Waterloo), through support provided from the International Development Research Centre (IDRC/CRDI) and the Social Sciences and Humanities Research Council (SSHRC/CRSH) of Canada.

CSLA | AAPC
Canadian Society of Landscape Architects
Association des architectes paysagistes du Canada

ParCA
Partnership for Canada-Caribbean Community Climate Change Adaptation

UNIVERSITY OF WATERLOO

TABLE OF CONTENTS

6 SEEKING A BETTER FUTURE

PREFACE

There is scientific certainty that due to global emissions of greenhouse gases our planet is already changing and will continue to change - in some cases dramatically. How global warming will affect the climate and weather patterns across Canada is complicated by the vast landscapes that comprise our nation, and the complex array of direct and indirect effects that are already anticipated. Our uncertain future should compel professionals and decision-makers to be better informed and more capable of making effective and insightful decisions.

Our hope for a stable and sustainable future action requires action be taken today. Whether the goal is to reduce the emissions that are warming the planet, or to prepare society for anticipated changes, efforts towards mitigation and adaptation must begin now. Everyone is responsible, everyone needs to act.

The **PRIMERs** are provided in a four-volume set. PRIMER ONE summarizes the science on climate weather and change. PRIMER TWO provides information on how individuals, communities and organizations can begin now to prepare for anticipated changes. PRIMER THREE presents planning and design tools, existing and emerging, that can help in the creation of resilient and prosperous communities and sustainable ecosystems. PRIMER FOUR summarizes approaches and tools focused on one of the fastest emerging challenges – rising water levels.

The Primers are intended to augment your basic understanding of the science on global warming and climate change, to provide improved access to information on anticipated impacts to Canadian landscapes, and to promote improved understanding of the options available to society through adaptive planning for change. Should you wish to expand your understanding on the topics discussed, access the materials referenced in the *Additional Readings* and *Resources on the Web*, and reach out to do your own search for newer information. Climate adaptation is a rapidly evolving knowledge area.

The Primers rely on two categories of information: reports and papers that have been freely distributed on the internet; and a selection of books and peer-reviewed papers. Many of the reports and books referenced are available from public or university libraries. Should the URLs provided for material available on the internet become inactive, it could mean only that the material has been moved, not that it is outdated or no longer relevant. We encourage you to search by author and/or title to find the document.

Peer reviewed papers are included here because they are an important source of information on climate change science, mitigation and adaptation, and the first access point for new knowledge. Some journal papers are provided freely on the Internet. Unfortunately, digital access to other journals requires paid subscriptions, or individual papers can be purchased on-line. Most university libraries in Canada provide memberships to the public for a nominal annual fee, but not all may include access to online journals. However, in addition to borrowing texts, hard and/or electronic copies of many journals can be viewed at the library. Readers can also become members of local, regional, or national communities of practice, where enrollment and access to many valuable sources of information are freely provided.

PRIMER ONE:
CLIMATE, WEATHER AND CHANGE
Chapters One and Two provide users with a summary of the current science on global warming, and the current and projected future changes in weather and climate throughout Canada. Chapter Three summarizes current thinking on the effects anticipated environmental change will have on ecosystems, on society and on local as well as regional economics.

PRIMER TWO:
PREPARING FOR CHANGE
Chapter Four focusses on managing risk and understanding the role played in decision-making by uncertainty. Chapter Five outlines the need to change what we do, to mitigate and to adapt. Chapter Six provides direction for those seeking a better future, incorporating existing instruments and tools with emerging principles and processes for guiding change.

PRIMER THREE:
CREATING RESILIENT COMMUNITIES
Chapter Seven summarizes opportunities to create resilient communities that integrate with their natural environment and promote well being and sustainability for humans and ecosystems.

PRIMER FOUR:
FACING RISING WATERS
Chapter Eight examines preventative and protective measures to rising water, whether it is fresh water (overland flooding) or the result of rising sea levels and/or storm surges.

4 MANAGING RISK AND UNCERTAINTY

4.1 UNDERSTANDING RISK

RISK: The probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk is also influenced by how it is perceived.

(Adapted from Black et al. 2010, p 28; Field et al. 2014, p39-40; IPCC 2014, p5).

Understanding the risks associated with a changing climate is one of the more complicated elements of planning for adaptation (Figure 4-1). Risk is the combination of a range of factors that include the hazard itself, the severity of impacts that could result, the exposure, vulnerability and sensitivity of the asset, and the value that asset has to the community, the individual and the environment. Risks associated with climate change alter over time, and as new and potentially unanticipated impacts manifest.

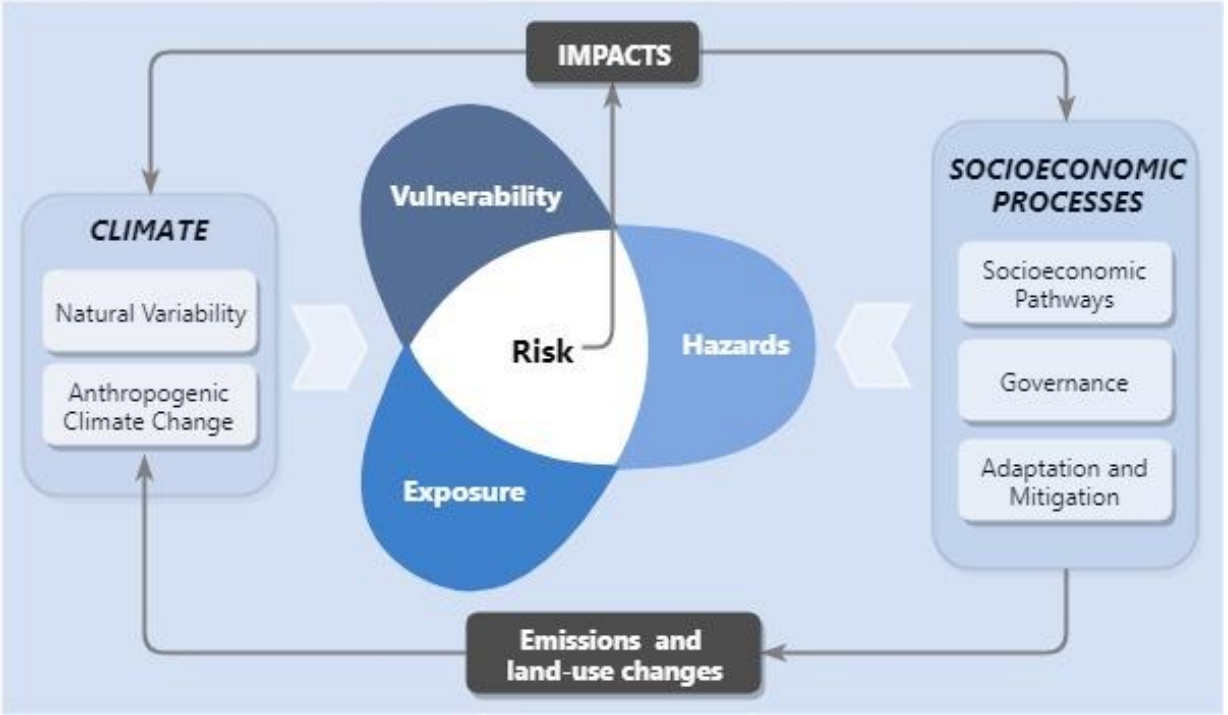


FIGURE 4-1: RISK associated with climate-related impacts is a product of the interaction of the hazards, vulnerability and exposure of human and natural systems. Changes in both the climate system (left) and in related socioeconomic processes (right) are drivers of hazards, exposure, and vulnerability. (*Adapted from: Field et al. 2014, Figure TS.1, p.37).*

The IPCC (2014 Summary for Policy makers (IAV)) has identified five categories of risk important to people, to economies and/or to ecosystems:

1. The risk of global aggregate impacts resulting from additional warming of the planet (i.e., 1–2°C) resulting in changes to biodiversity and to the global economy. Warming above this level is anticipated to result in extensive impacts to biodiversity with associated losses in ecosystem goods and services. Aggregate economic damage is anticipated to accelerate as temperatures increase.

2. The risk of damage from increasingly frequent and/or severe extreme weather events (e.g., extreme heat, precipitation, drought, inland and coastal flooding).

3. The risk of damage to unique and threatened systems (e.g., communities, cultures, ecosystems) whose sustainability may be further compromised by pressures resulting from a changing climate. Vulnerable components of human society may be increasingly stressed by changes in well-being associated with periods of extreme heat or cold, with damages to infrastructure and with changes to economic conditions. Species and ecosystems that have only limited capacity to absorb impacts or to adapt to changing environmental parameters, will be at increasingly higher risk, especially if temperatures continue to warm above 2°.

4. As the planet warms, some physical components of the environment, as well as some ecosystems may be at risk of abrupt and irreversible change. The risks of such large-scale singular events intensify as alterations to systems approach thresholds and tipping points.

5. The risk of uneven distribution of impacts in populations with decreased opportunities for migration and/or in those dependent on diminished or more locally expensive supplies for food and water.

Responding to climate-related risks will necessitate that we make astute decisions in an ever-changing changing world. Uncertainty over the scope, severity and timing of impacts will continue, requiring iterative processes to scope and analyze the kinds and level of risk, as well as a continuous re-evaluation of responses (Figure 4-2). While avoidance of situations that create risk will be the ultimate goal, the reality is that society will need to become increasingly comfortable with the prospect of managing rather than resolving risk.

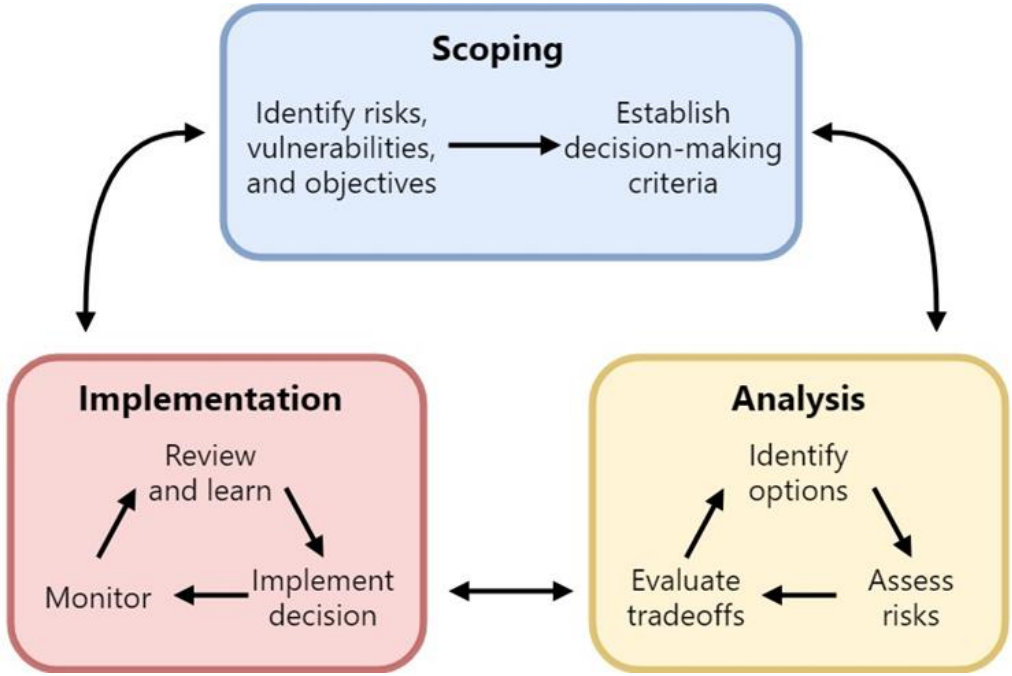


FIGURE 4-2: The IPCC recognizes climate-change adaptation as an iterative risk management process with multiple feedbacks. The process and its products are shaped by the people who participate and the values and knowledge base they rely upon *(Adapted from IPCC 2014, p9).*

4.1.1 MANAGING RISK

Risk management is a multi-step, iterative process that assesses risk, promotes measures to reduce vulnerabilities to risk, and monitors and evaluates the effectiveness of those actions. (Figure 4-3). Residual risks remain when there is no physical, practical and/or fiscally acceptable mechanism to avoid or reduce an effect of climate change (e.g., loss of historic sites to sea-level rise).

Risk assessment begins with the collection of data on anticipated hazards. Analysis of the available data enables early identification of anticipated effects and provides the groundwork for estimating the potential for damage or harm to individuals, populations, property and the environment. Risk estimation uses models and alternative scenarios to project anticipated future conditions and to improve understanding of the probability of occurrence of one or more risks. Estimates of risk are at their most effective when they allow for changes to local conditions over time. Risk evaluation relies on this information to evaluate risks against the potential costs, and benefits to ecosystems and society.

Risk assessment can be guided by these basic principles (King et al. 2015):

RISK MANAGEMENT: The systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating, controlling, and communicating about risk issues.

RISK ANALYSIS: The use of information to identify hazards and to estimate the chance for, and the severity of, injury or loss to individuals, populations, property, the environment and other assets of value.

RISK ESTIMATION: Examination of the probability and consequence of alternative risk scenarios, allowing for changes in parameters over time.

RISK EVALUATION: An examination of risks in the context of costs and benefits, and the acceptability of the risk as determined by the needs, issues, and concerns of stakeholders.

RISK ASSESSMENT: The overall process of risk analysis, risk estimation and risk evaluation.

RESIDUAL RISK: The risk that remains after all adaptation measures and control strategies have been applied.

(Adapted from APEGGA 2006, p4; Black et al. 2010, p 28)

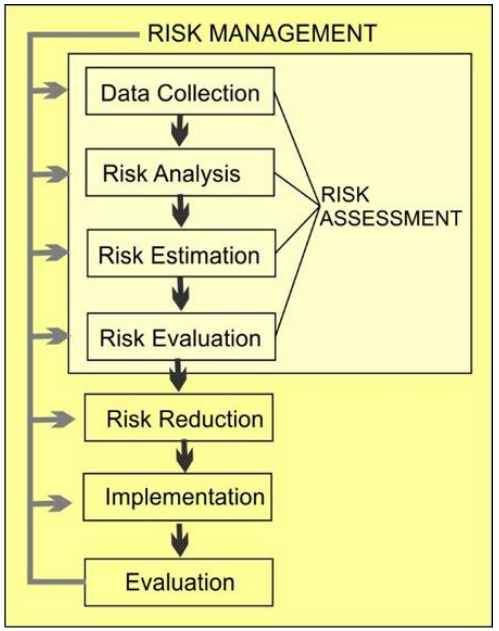


FIGURE 4-3: Illustration of a risk management process

1. Link risks to objectives. Objectives can be general (e.g., human prosperity and security), or specific (e.g., keeping residential properties dry). They identify risks to be avoided, working also to estimate probability of occurrence.

2. Identify the largest risks first. The more a risk could affect the objectives, the more relevance it will have for decision-making. Larger risks are those which are most likely to occur, those with the greatest impact, or those which fall somewhere in between. Risks should include both short-term events and long-term changes.

3. Consider all probabilities. Low probability high impact risks (e.g., flooding from a 100-year storm event) should not be ignored, or down-graded, at a time when established best practice for return periods of severe weather will increasingly become irrelevant. When probability cannot be meaningfully quantified, consider the 'plausible worst case' scenario. The relevant threshold for plausibility will most likely be a matter of judgement, significantly affected by threats to human health and well-being.

4. Use the best available information, whether it consists of current science or is based on expert judgment. Even where deep uncertainty exists, risk estimates based on available information, are better than no estimate at all.

5. Include as many factors as feasible. Complex systems and issues can defy prediction (e.g., human behaviour), and resist simplification. Risks must be assessed across changing spatial dimensions and over a range of time periods. Development of a range of plausible scenarios will help to conceptualize possible future states and proactive responses.

6. Document where you use value judgments. Many conclusions in risk management are inherently subjective whether dealing with what constitutes a risk (i.e. what it is that we might wish to avoid) or deciding how much we care about it. Describing the values and opinions used ensures that others can apply different values as appropriate (Table 4-1). Assessment of the likelihood of a risk occurring should strive to be objective, based on the best available information/science.

TABLE 4-1: Example of a climate change impact assessment matrix *(adapted from GOV/CAN/NS 2011).*

HAZARD	SEVERITY			FREQUENCY			AREA AFFECTED		
	Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small
Sea-level Rise		X						X	
Storm Surge		X			X		X		
Cloudbursts	X			X				X	
Inland Flooding	X				X		X		
Landslides			X			X			X
Wind		X			X				X
Extreme Heat		X			X			X	
Extreme Cold		X			X			X	
Drought			X			X		X	
Forest Fires			X			X		X	

Information generated by risk assessment processes is invaluable to the determination of the most effective measures to avoid risks, and to reduce risks. When examining hazards, evaluation of impacts must take a broad and holistic approach to identify not just the primary issues of concern, but to ensure that indirect as well as direct risks are identified. Similarly, when considering measures to avoid or reduce risk in one area, it is important to assess the potential that such actions could change local conditions and/or increase risks to other assets. Managing risk must also be framed to address multiple hazards and changing conditions over time.

Risk evaluation is shaped by knowledge, especially critical information on the potential risk of damage to assets and individuals. It is also greatly affected by how much risk can be avoided altogether through proactive measures (e.g., moving at-threat structures out of potential flood-up areas).

Some measures must be given priority over other actions, primarily due to the potential for impact to important assets and to human health and safety (Figure 4-4). Other first priorities could include actions often referred to as low-hanging fruit, and include situations where most participants can agree, costs to implement are low, and benefits are readily seen. In general, high priority, and low-hanging fruit responses can be the easiest on which to gain agreement and to act, but risk management processes can be dominated by more thorny issues that reflect conflicting perspectives, differing values and/or opposing views as to priorities and potential actions.

IDENTIFYING RISKS *(adapted from GOV/CAN/NS 2011)*

- What climate change and/or severe weather effects have you already experienced?
- What kinds of events caused these issues (e.g., storms, high tides, heat or cold)?
- What kinds of measures (if any) were undertaken to respond to these issues?
- How well prepared are you for such events, especially if they become more frequent or more severe?
- Do you have the capacity/resources to withstand the next event, if it occurs soon?
- How often have these events occurred (e.g., rarely, occasionally, frequently)?
- Did the event affect a significant area, population or necessary service?
- Was the impact large or small?
- Can you describe and record the range of issues that occurred because of this event?
- Will these types of events and associated hazards continue? Become more problematic?
- What contributing factors may result in these events becoming more of a problem over time (e.g., new development in low lying areas, aging infrastructure, vulnerable population)?
- What other sorts of climate related issues do you anticipate will occur in the future? Are these new effects?
- Do you anticipate the development of new opportunities as the climate changes?
- What information do you need to plan effectively for the future?
- Do you have access to this information?
- Do you have the resources to create the needed information?

Risk management derives the greatest benefits and results in lower costs when it is integrated into other planning and development policies, where it focuses on delivering sustainability in design and in practice. Integration will ensure that adaptation measures are acceptable across the broadest array of assets and uses and may stimulate potential benefits as knock-on effects of change (e.g., improvements to waterfront protection from sea-level rise could be a starting point for rejuvenation of aging infrastructure and re-vitalization of a space as a public use area).

And finally, risk management processes must accept that even in those situations where significant efforts and funds are expended to reduce risks, there will be situations where risk cannot be avoided, and where disaster readiness and response remain as an important component of risk management measures. This is especially true of risks associated with climate change, as future conditions are an evolving reality, and some risks to assets and to individuals cannot be entirely avoided. Ensuring that systems are as ready for severe events as is practical, and that communities and individuals are informed and prepared for disaster conditions will be key to damage reduction and to protection of life and well-being.

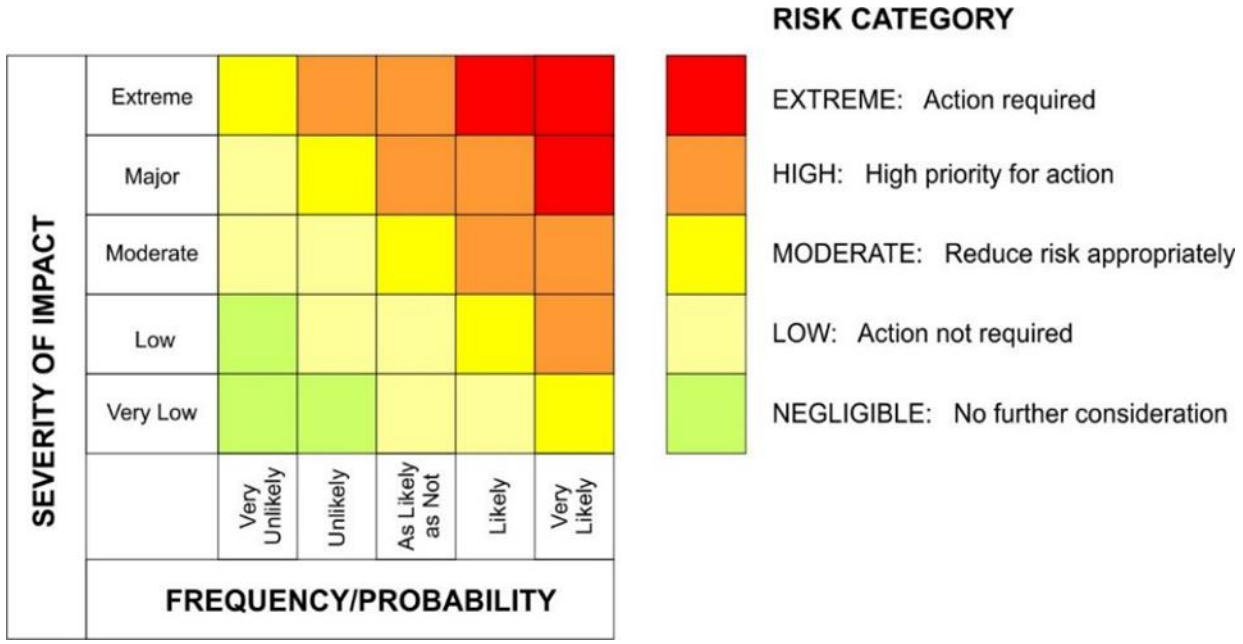


FIGURE 4-4: Risk evaluation categories based in severity of impact and frequency or probability *(adapted from Black et al. 2010).*

4.1.2 VALUES AND JUDGEMENTS

Early involvement of stakeholders is an important criterion for success in risk assessment and risk management. Ready access to current science and emerging information will maximize the opportunities for stakeholders to become informed on the threats and opportunities associated with the changing climate. While an increasing array of tools is being developed specifically to quantifiably express risk, and to determine risk management priorities, much decision-making ultimately comes down to value judgements. Personal perspectives can affect a range of decision-making, but the most contentious and often the most important value judgements include (King et al. 2015):

- value for human life;
- aversion to inequality in society;
- the impacts to future generations; and
- tolerance for risk in any form.

Ultimately, most risk management decision-making is based not on what is practically possible, but on what can be accepted as appropriate and just, given the circumstances. Human tolerance for risk is largely a product of an individual's, a group's or a society's willingness to live with certain risks, in order to secure benefits, as long as they believe the risks to have been based on good science, and the benefits and potential costs have been well defined and communicated. When assigning degrees of severity of risk and impact, more objective criteria (e.g., financial costs associated with damages) can be used, but human perspectives and values will still play a significant role in determining the level of tolerance for the unavoidable risk (Table 4-2, Figure 4-5).

STAKEHOLDERS/ACTORS: Any person, group, or organization that can affect, be affected by, or believe that they might be affected by a decision or activity related to the risk assessment (e.g., property owners, residents, decision makers, government regulators, senior professionals, project managers, technical experts, regulatory agencies, special interest groups, and the public at large. (*Adapted from APEGGA 2006, p10)*

TOLERABLE LEVEL OF RISK: The tolerable level of risk is drawn from a range of values and standards including government regulations, industry standards, best practices by industry, and a qualitative assessment by stakeholders of what is fair and reasonable. Toleration does not necessarily mean that the risk is negligible or acceptable. Toleration is a willingness to live with risk to secure benefits (e.g., continuing to live near the shore) and in the confidence that the risk is well defined, monitored and managed. *(Adapted from APEGGA 2006, p4).*

TABLE 4-2: Sample table to assess level of risk of anticipated impacts of climate change

HAZARD	ANTICIPATED IMPACTS	LOCATION	SEVERITY			FREQUENCY			AREA AFFECTED			LEVEL OF TOLERANCE			RISK CATEGORY
			Severe	Moderate	Minor	often	Sometimes	Rarely	Large	Medium	Small	Large	Medium	Small	EXTREME / HIGH / MODERATE / LOW
Sea-level Rise	Beach loss, Waterfront area reduced	Along waterfront		X			X						X		
Storm Surge	Flood/wave damage	Along waterfront		X		X				X				X	
Cloudbursts	Stormwater drainage system overload	Older parts of city	X				X		X				X		
Inland Flooding	Basement flooding, infrastructure	River bank areas	X			X				X				X	
Landslides	Hillside collapse	Soccer fields			X			X			X	X			
Wind	Tree and roof damage, falling glass	Whole City		X				X		X				X	
Extreme Heat	Health issues for vulnerable citizens	Residential towers		X			X			X			X		
Extreme Cold	Health issues, frozen pipes, transportation	Throughout city		X			X			X				X	
Drought	Damage to street trees, landscapes	Inner city, suburbs			X		X				X	X			
Forest Fires	Loss of canopy, damage to structures	Greenspace, suburbs			X		X				X	X			

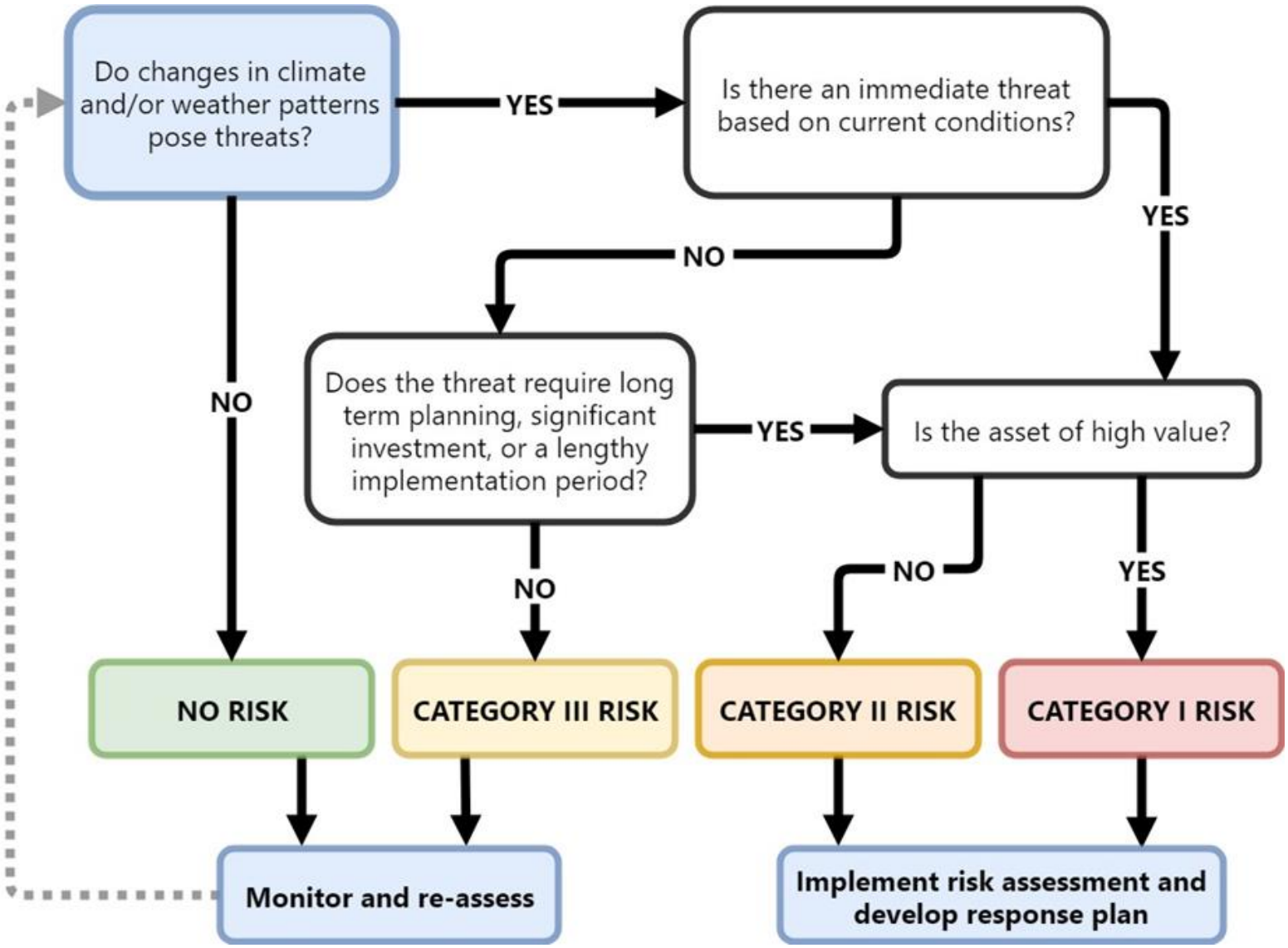


FIGURE 4-5: Risk management decision tree (*Adapted from Pew 2008*).

4.1.3 COMMUNICATING WITH CERTAINTY

For some time now, media reporting on climate change has often focussed on the degree of uncertainty that seemed to plague scientist's conclusions on the causes and effects of global warming While journalists, politicians, economists and others may recite their impressions that there is confusion, disagreement or discord amongst climate scientists, they would be wrong. Recently it has been reported that many of the supposed independent reviews on climate science, that fueled the dialogue about uncertainty, were funded by companies from the oil and gas sector, some of whom are alleged to have been informed decades ago by their own internal research staff of the dangers posed to the planet by fossil fuels combustion. There is no uncertainty over whether the planet is warming, there are only degrees of certainty for scientists working on the scope and timing of anticipated impacts to weather and to climate. Certainty is derived from the confidence scientists have in the validity of their conclusions. Confidence requires reliable data, objective and replicable evaluation of the evidence, and the support of other credible experts in the field. Levels of confidence are expressed qualitatively (Table 4-3).

When the IPCC (Field et al. 2014) presents its key findings, the degrees of certainty it reports are based on:

- confidence in the validity of a finding, based on the type, amount, quality, and consistency of the evidence (e.g., data, mechanistic understanding, theory, models, expert judgment) and the degree of agreement among researchers; and
- measures of uncertainty in a finding, expressed probabilistically (based on statistical analysis of observations or model results, or both, and expert judgment).

When the IPCC reports that there is High Confidence in a conclusion, it means that there is a significant body of data, that many independent studies have produced the same results, and that there is a high degree of consensus among researchers (Figure 4-6).

In some circumstances the discussion around certainty has fueled somewhat wishful thinking on the immediacy or severity of impacts from climate change. When issues are discussed within a context where there is certainty regarding the impact, but an as yet undetermined time frame in which the impact will manifest, there is greater potential for pragmatic assessment of adaptation issues and options (Ballard and Lewandowsky 2015).

> The degree of **certainty** is based on the type, amount, quality, and **consistency of evidence** (e.g., data, information, theory, models, expert judgment) and the **degree of agreement** amongst experts. (*IPCC 2014)*

TABLE 4-3: Basis for confidence levels as determined by the body of evidence and the consensus amongst experts *(Burkett and Davidson 2012).*

CONFIDENCE LEVEL	BASIS FOR THE DETERMINATION
HIGH	There is strong evidence based on established theory, multiple sources, consistent results, reliable, documented methodologies acceptable to science, and a high consensus amongst researchers.
MODERATE	There is moderate evidence based on multiple sources, with some consistency in approach, methods and findings and a medium level of consensus on conclusions.
FAIR	There is evidence derived from few sources, with limited consistency across the studies, incomplete models, and/or based on emerging but not yet proven methodologies, possibly resulting in competing schools of thought.
LOW	Inconclusive evidence, derived from limited sources, or dependent on extrapolations, inconsistent conclusions, poor documentation and/or untested or questionable methodologies that demonstrate disagreement among experts, or a lack of opinions provided by the scientific community.

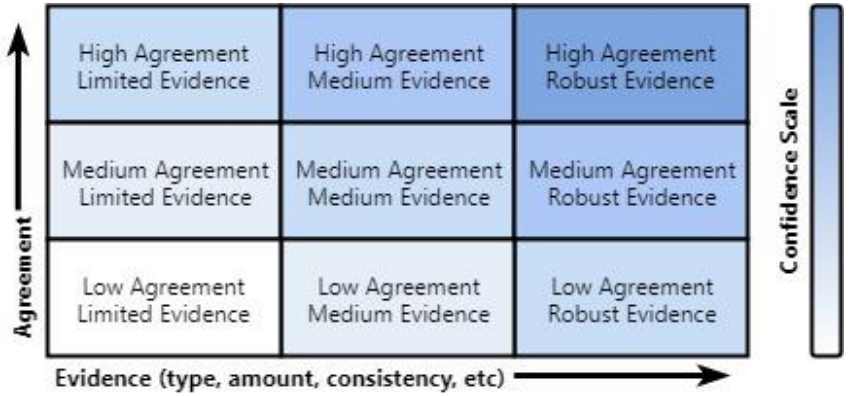


FIGURE 4-6: The relationship of confidence to evidence and agreement statements. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence *(Adapted from Field et al. 2014, Figure 1, p 41.*

Likelihood or probability is the chance that a well-defined outcome has occurred or will occur in the future, and is based on statistics of past events, or models that predict the potential for future occurrence. There are a range of scales in use, most of which mirror to some degree the IPCC mathematical scale (Table 4-4). Likelihood or probability are generally only used to express the frequency of occurrence of findings that have been afforded a high or very high level of confidence

TABLE 4-4: IPCC standards for likelihood or probability of outcomes *(Field et al. 2014, p41)*

TERM	LIKELIHOOD OF THE OUTCOME
Virtually certain	99–100% probability
Extremely likely	95–100% probability
Very likely	90–100% probability
Likely	66–100% probability
More likely than not	>50–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Extremely unlikely	0–5% probability
Exceptionally unlikely	0–1% probability

DESIGN STORMS

Likelihood that something will happen has been an effective tool in planning and design for decades. Design storms, which are statistical representations of precipitation and wind events that reflect anticipated conditions in a specific area, are associated with anticipated return periods (e.g., the likelihood that a 100-year storm will happen in any year). In Canada, design storms have been used for years to assist in establishing a basis for standards of construction for a wide array of water and transportation infrastructure and for buildings.

As conditions change and severe storm events become more frequent, the return period for stronger storms is decreasing. What used to be a 100-year storm event may now have occurred twice within a decade. Science has had difficulties in responding to these changing realities because data on the frequency of severe storm events may have changed only over the past decade or so – too short a time frame to be statistically valid. As a result, much information on storms remains anecdotal, and accepted best practice for design storm has not yet been altered for most of the country.

4.1.4 THE RIGHT TO KNOW

While property owners and the public have the right to know of threats or hazards that affect their assets, their well-being, or their safety, it is less clear as to when decision-makers have the responsibility to share information on anticipated changes to environmental conditions (Gibbs and Hill 2011). For many of us, the risks attached to a property or to human use of an area or asset have historically been based on when the hazardous event could be expected to occur again. By example, having experienced a 100-year storm, property owners would likely see investment in damage repair as worthwhile, anticipating that it is relatively unlikely that those conditions will re-occur soon. Their confidence is based on the years of data used to determine the return period for weather events of such severity. But in some areas hindsight may no longer be a viable option for anticipating risk of damage, as water levels rise, and weather intensifies.

If areas are now projected to become more prone to overland flooding (e.g., because of cloudburst precipitation, storm surges, extreme high tides), when should property owners, residents, users, insurers, and financers be informed of the anticipated changes to threat and to risk? For many areas in Canada, detailed information on changes in sea-level rise, or on the potential for inland flooding is either not yet available or has been based on anticipatory models of a projected future condition. Decision-makers can be challenged by anticipated conflicts arising from the devaluation of property situated in newly designated hazard areas, and by the right of insurers and financers to know all risks and liabilities associated with a property

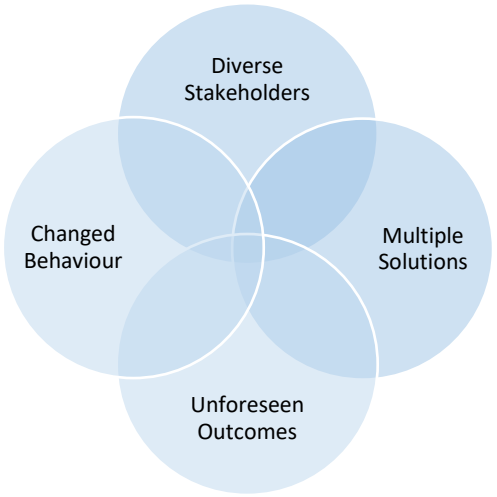
4.2 WICKED PROBLEMS AND CLUMSY SOLUTIONS

Before you can craft a solution, you must know the scope of the problem. Knowing your contribution to ongoing changes in the climate and understanding the effects of those changes can be complicated by geographic factors, operational conditions and by the timing of climate change impacts on your area. The science on climate change is improving daily, but there are ongoing issues in mobilizing that knowledge so that it can be timely and useful to planning and decision-making. In some circumstances the changing climate will present problems. In others it will manifest as new opportunities.

Increasingly climate change is being described as a wicked problem - where the scope and magnitude of impacts can be difficult to predict; where knowledge is incomplete, where there are multiple perspectives, large costs, and knock-on effects to inter-linked components of society and the environment. Wicked problems are not easy to solve because they resist simplification, because they do not fall easily into established frameworks for problem-solving, because there is often no accepted 'right' solution, and because each problem associated with climate change is unique to local circumstances and local time frames. Solving wicked problems is best tackled by inter-disciplinary teams, whose members have a willingness to learn by doing, to adapt to changing circumstances, and to persevere over time.

The best approach for dealing with wicked problems accepts that there are few situations where there is only one solution. Traditional approaches to problem-solving are often based on the identification of one preferred method- which becomes the right method and discarding all other proposals – which become the wrong methods. Wicked problems are best resolved by taking a clumsy approach (Verweij et al. 2006). Clumsiness in problem-solving accepts that there are often contradictory opinions, values and perspectives in both describing the problem and in finding the best pathways towards its resolution. Unlike much of current thought which requires society to pick only one option (opinion, perspective, methodology) and discard all others, clumsiness allows for disparate views and conclusions, the retention of alternatives as plausible options should the preferred solution prove ineffective, and a continuation of the discourse as new knowledge appears and experience changes perspectives.

Clumsiness as an approach to problem solving works well within an adaptive management framework (Figure 4-7)– often described as a looped process that depends on learning from experience as a significant component for forward progress towards a defined or emerging goal. Adaptive management doesn't work in every situation and can be especially frustrating when rapid changes to process are not possible. However, because it functions even when there are information shortfalls and uncertainty, it offers an alternative to linear management systems, and can be effective in fostering resilience, and in building the flexibility to cope with change over time. Planning and design for a changing climate needs to be fluid and opportunistic, ready to seize on new opportunities created as much by an expanding body of knowledge, as by new realities within local and regional environments. Ingenuity and innovation must replace best practice options, relying on an evolving understanding of vulnerability, exposure and risk to aid the development of effective strategies that can adapt over time to continuously changing conditions.



WICKED PROBLEMS arise from tricky, thorny issues that can be difficult to isolate from larger issues and demand ongoing efforts to resolve, partly because it is difficult to determine when efforts to resolve the issues have been successful.

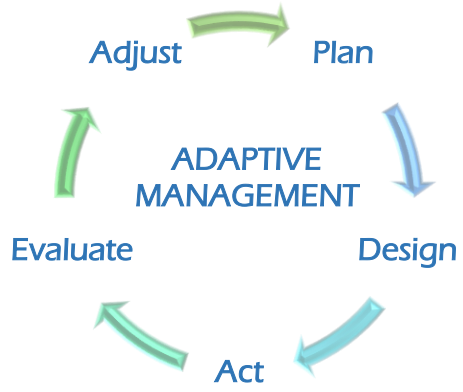


FIGURE 4-7: Generalization of the steps in an adaptive management approach to problem solving.

4.3 INFORMING DECISION-MAKING

Gaining access to the best, most current, most relevant knowledge on changing climate conditions and the scope and timing of effects on local areas can be a challenging activity. Information on climate change is ramping up, but not all of it is good science. Even within the professions, individuals may, or may not yet be, well-informed on the most current predictive models for effects such as sea-level rise, cloud bursts, and/or changing extremes of heat and cold. Much of the work to alleviate the effects of a changing environment must deal with an evolving case of information, and care must be taken to ensure that the information is credible not merely popular. In a recent survey of professionals in Canada, a significant proportion identified the media as their most prominent source for information on climate change. The media, and especially the internet, can be amazingly efficient methods for knowledge dissemination. However, as much information could be derived from sources with no credible association to science, it is important that users take care in assessing the credentials of sites and of authors.

Information should include:

- The most current and accurate spatial information on topography, land cover, structures and services. Information on elevation is critical to advance planning for issues ranging from flooding to emergency response and evacuation routes.
- Historic information on key parameters (e.g., temperature, precipitation) and on seasonal and yearly climate patterns in the local areas. In Canada, this data is freely available from Environment Canada, and can be keyed to specific local areas. Historic data will assist in building understanding of how changing conditions will affect the operating normals of ecosystems, habitats and species as well as human systems such as water supply management, urban forests, and transportation linkages.
- Current data on weather, as well as global projections for change, used to develop a range of possible scenarios over timelines projected for 10 years, 20 years, 50 years and 100 years keeping in mind that:
- Temperature predictions are more certain than precipitation predictions, which can be influenced by extreme storm events;
- Current models for changes in climate (e.g. less than five years old) are more likely to reflect current science and data;
- Projections for future conditions will have a range of degrees of confidence (e.g., more likely than not, unlikely), and could be significantly affected by exposure to locally confounding factors (i.e., parameters that can affect local weather, and local environmental conditions such as exposure to active wave energy).

WHAT MAKES A SOURCE CREDIBLE?

Are the authors experts in the field? Most decisions should be guided by science-based information provided by persons with advanced degrees in related areas of study (e.g., atmospheric science, chemistry, hydrology, ocean engineering, oceanography, marine, aquatic, terrestrial ecology, fisheries, forestry, agriculture).

Has the work been conducted by an established organization? Is this a government study, the work of an established academic team, a collaboration of scientists, government and/or community organizations? Some studies available on-line may selectively use information to promote an unsubstantiated point of view. Even some on-line journals are more 'vanity' publications (i.e., authors pay to have their work published) than collections of peer-reviewed science.

Does the information provided in the study make sense to your situation? While there is much to be gained from the knowledge and experiences of others, care must be taken in applying knowledge gained in other environments, regions and countries.

How old is the information? Outdated data on weather and other environmental conditions must be viewed as historic artifacts, as conditions throughout Canada may be changing rapidly. This is especially important in the derivation of statistically based codes for practice such as the return periods for extreme weather or anticipate maximum precipitation by season or by month. As the science on climate change is quickly evolving, care should be taken in using information provided in reports more than five years old. Reports that are more than ten years old should be viewed as historical rather than current.

Changes in climate variables can have direct and trickle-down effects on an array of environmental and social components. Tracking data on changes in climate, as well as on resulting effects, and/or the efficacy of response mechanisms, will quickly become numbingly complex. Decisions may be made and/or changes based on changing information and the need for future decision-makers to understand the basis for earlier efforts will become increasingly important.

To keep track of the basis for decision-making, consider the benefit in developing and updating a table on data and information sources (Table 4-5). This will facilitate tracking the information used for planning and design decisions, and prompt decision-makers to re-examine the information when up-dating is deemed beneficial.

Finding, collecting and creating needed information is an important and critical part of preparing for a changing climate and an altered environment.

TABLE 4-5: Sample table outlining basis for decision-making

CLIMATE VARIABLE	INFORMATION PROVIDED	ANTICIPATED CHANGE	SPECIFIC CHANGE PROJECTED	RELEVANT CONCLUSION	SOURCE	CONFIDENCE	DATE AND USE OF INFORMATION
Air Temperature	Data covering the period 2000-2014, as compared to climate normals for the previous 75 years	Increase	Projected increases in mean annual temperature ranging between 0.7-3.5 °C	Seasonal temperatures will be warmer in summer, small increases in winter temperatures.	Smith et al. 2014, information derived from IPCC ARP5 reports	High confidence in data and in projections based on a range of emissions scenarios.	March 2015, Municipal Planning Policy Review

4.3.1 BUILDING CAPACITY

Given the nature of the changes that are upon us, it is unlikely that all organizations or individuals will have access to the breadth and scope of expertise in climate change science, mitigation and adaptation that is needed to holistically aid in decision-making. Following from the Paris (December 2015) meetings on greenhouse gas emissions, Canada's commitments to curbing emissions will require significant change in social, industrial, commercial and political systems. Interdisciplinary approaches will be needed to understand all the ramifications of anticipated environmental change, and to aid in effective planning and managing to reduce our contributions to greenhouse gas emissions, and to prepare for alterations to our environment.

Within Canada, planning and design professions are aware of the value in using a multi-disciplinary team approach (e.g., planning, architecture, landscape architecture, engineering, geo-science, ecology) to solving complex challenges. Unlike more traditional approaches to problem-solving, climate change will require not only collaboration across disciplines, but will require each of the professions to learn and to apply gained knowledge to alter their approach and practice. There will be fewer opportunities to rely on 'best practice' techniques learned from experience, and a great deal of pressure to be open to new approaches, to risk new methodologies and to adapt on the fly. Climate change will also need greater collaboration among related professions (e.g., finance, insurance, economics, law, sociology, health) if retrofitting, rebuilding and designing new builds to achieve the highest benefits to todays society and the lowest costs to future generations.

The **Code of Ethics of Engineers Canada**, like that of most of the planning and design professions in Canada (e.g. planners, landscape architects, architects) requires that all members:

'shall hold paramount the safety, health and welfare of the public, the protection of the environment and promote health and safety within the workplace'.

Professions in Canada are already moving to inform members, to adjust standards and to advance knowledge through partnerships with universities, industry, governments and communities. These affiliations must cross established barriers, and require tolerance and collaboration among disciplines and individuals, many of whom have had little experience with each other's perspectives or needs. The learning curve will be high for some, but there is an appetite within most sectors of Canada to get on with this job. The potential benefits of ingenuity and innovation will surpass preparation for the impacts of change, to embrace the creation of new and prosperous human communities surviving in sustainable landscapes. The professions, academic and government research, all levels of government, non-government organizations and the private sector have in recent years built collaborative partnerships to improve local knowledge and to share emerging information and developing tools (Table 4-6). This two-way transference of needed expertise and experience, bolsters capacity within communities and organizations, and ensures that research is more engaged in providing timely information and in advancing needed technology.

TABLE 4-6: Recent collaborative partnerships on planning for adaptation in coastal Canada

PARTNERSHIP	DURATION	OUTCOMES
CoastalCURA: A community-university research alliance	2006-2012	Saint Mary's University, University of New Brunswick, Acadia First Nation, Bear River First Nation, Fundy Fixed Gear Council, Fundy North Fishermen's Association, Mi'kMaq Confederacy of Prince Edward Island, Bay of Fundy Marine Resource Centre
ParCA: Partnership for Canada-Caribbean Community Climate Change Adaptation	2011-2016	University of Waterloo, University of Prince Edward Island, St. Mary's University, University of the West Indies, Laurentian University. Jamaica, Tobago, Nova Scotia, Prince Edward Island
C-CHANGE: Managing Adaptation to Environmental Change in Coastal Communities: Canada and the Caribbean,	2009-2015	University of Ottawa, University of British Columbia, University of New Brunswick, Memorial University of Newfoundland and Labrador, University of West Indies. Iqaluit NU, Gibsons BC, Charlottetown PE, Isle Madame NS; Grande Riviere Trinidad and Tobago: Bequia; Georgetown, Guyana; San Pedro, Belize.
CCaR: Coastal Cities at Risk	2011-2016	Simon Fraser University, Institute for Catastrophic Loss Reduction, Environment Canada: Vancouver, Bangkok, Manilla, Lagos

4.4 VULNERABILITY TO CHANGE

One of the first steps in planning for climate change is to describe the degree of exposure to potential hazards, to identify how assets, individuals and society might be vulnerable to those hazards, and to assess the risk of damaging events. There are many perspectives on the meaning of the terms vulnerability, exposure, sensitivity, and risk, which can lead to confusion when discussing how a society, an industry or an individual may be harmed by changes in climate, in weather and in linked and altered environmental conditions. Similarly, confusion can be created when explaining how the impacts of climate change may not always result in negative change, but may create new opportunities for species, ecosystems and society. It can be relatively simple to comprehend how unique local conditions in the physical environment and in society will affect not only the hazards created by climate change but will also contribute to the breadth and scope of exposure. People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized can be especially vulnerable to change, and may be further marginalized by some proposals for mitigation and/or adaptation (Figure 4-8). Heightened vulnerability is rarely the result of a single factor but is often caused by multiple conditions such as the location of impoverished populations in areas more prone to flooding, or the inability of elders to effectively cope with periods of extreme heat. Overall, vulnerability should be seen as resulting from the combination of exposure to hazards, the sensitivity of the affected element of the environment and/or society to change, and the capacity of those affected to cope with change.

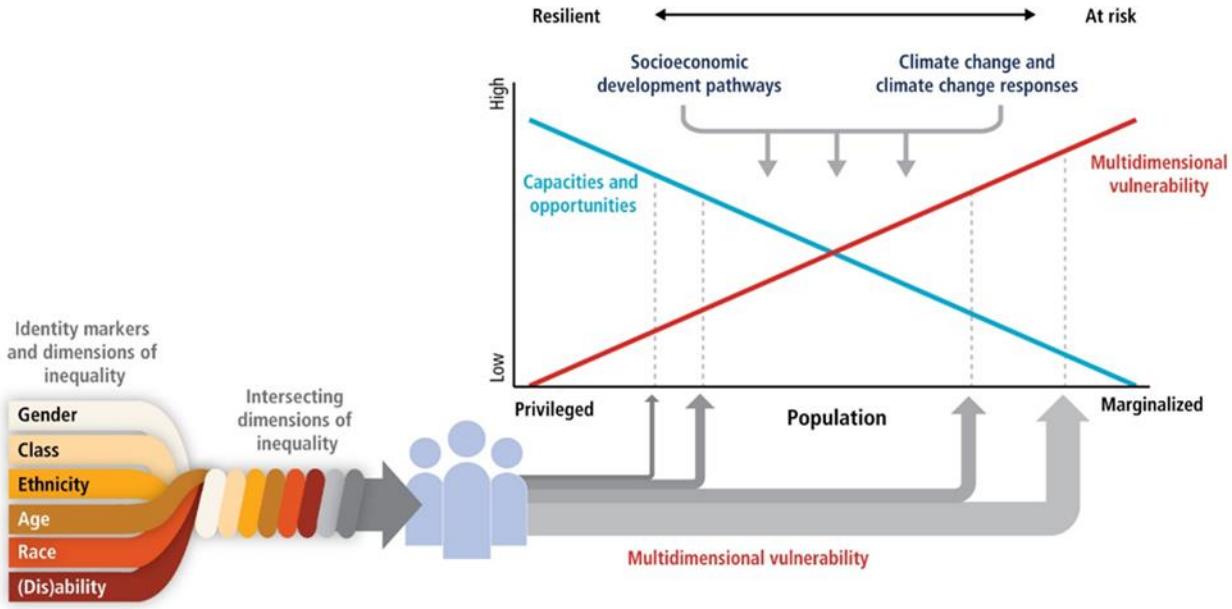


FIGURE 4-8: As portrayed by the IPCC, multidimensional vulnerability in society is the result of intersecting dimensions of inequality. Vulnerability increases when people's capacities and opportunities to adapt and to adjust are diminished *(Field et al. 2014, Box TS.4, Figure 1, P 49).*

HAZARD: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

EXPOSURE: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

VULNERABILITY: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

IMPACTS: The effects on natural and/or human systems. (e.g., lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure) due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system.

SENSITIVITY: The degree to which a system is affected either adversely or beneficially by climate variability or change.

(Adapted from Field et al. 2014, p39-40; IPCC 2007, p726; IPCC 2014, p5).

4.4.1 ADAPTIVE CAPACITY

The capacity to cope with hazards determines the sensitivity of the system and the individual to impact and affects whether the impact results in positive or negative change. Understanding the adaptive capacity of a community, a segment of society, or an individual is a necessary element in the design and implementation of effective adaptation strategies. Adaptive capacity is also a determining factor in the interest and ability of sectors and organizations to take advantage of the opportunities which may present themselves as the climate changes (e.g., longer growing seasons for crop species, improved tourism assets, deeper port waters).

Thresholds (e. g., flood levels, high and low temperature extremes, concentrations of salt in drinking water) represent that point after which some significant change in local conditions will occur. With a changing climate, it is extremely important to understand that thresholds will alter significantly over time. Mean sea levels will continue to rise, making low-lying assets increasingly vulnerable to flooding and to storm damage. Higher and lower temperatures will affect growing conditions for crops, increase the potential for nitrification in nearshore marine waters, and create dangerous living conditions for the very young, infirm and older members of human society. In planning for change, it will be important to know, and to track important thresholds. As conditions change, even before thresholds are exceeded, systems and individuals may be increasingly altered and then catastrophically transformed into a different state – one that may be permanent - once tipping points are reached (Figure 4-9).

Tipping points and other limits can be a factor in the adaptive capacity of human society. Opportunities and resources to adapt may in fact be limited for some, affecting their perception of tolerable risk (Dow et al., 2013).

ADAPTIVE CAPACITY: The ability or potential of a system to respond successfully to climate variability and change, including adjustments in both behaviour and in resources and technologies.

THRESHOLD: The stage of an ecological, social, economic or other system or process at which sudden or rapid change occurs.

TIPPING POINT: The point after which recovery is unlikely and the system is transformed to an altered state.

TRANSFORMATION: A change in the fundamental attributes of natural and human systems that may reflect a neutral change, a positive change or a negative change to an altered state. A transformation could also reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction.

(Adapted from Field et al. 2014, p39-40; IPCC 2007, p726; IPCC 2014, p5)

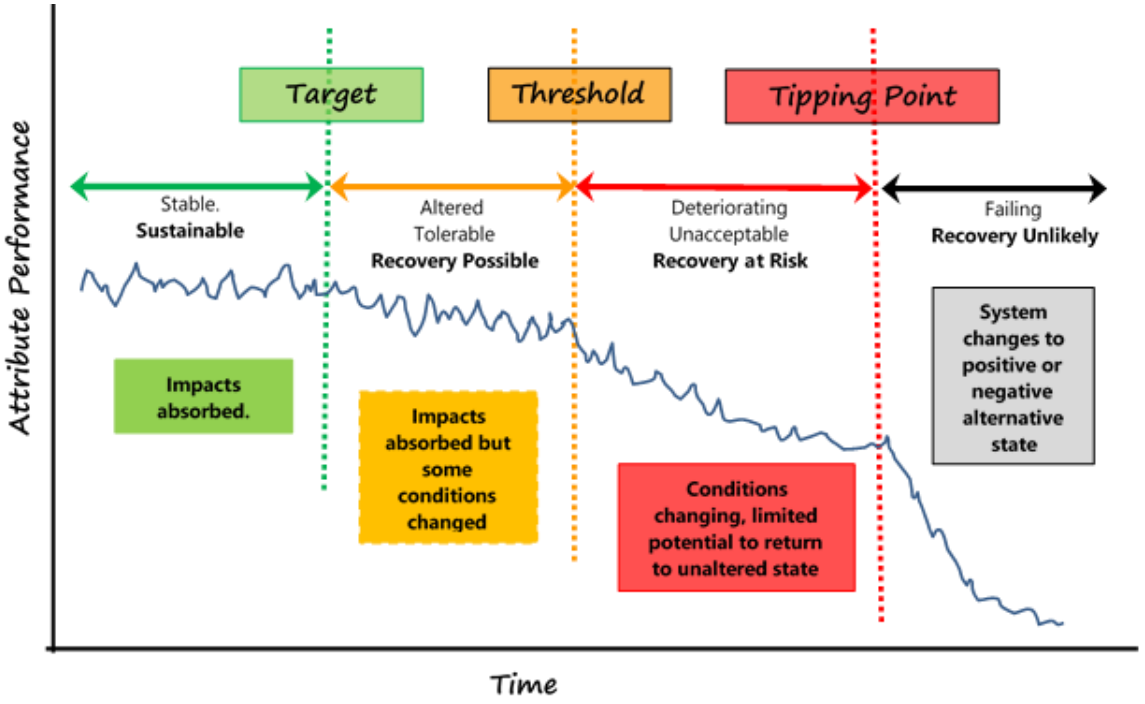


FIGURE 4-9: Representation of the progress of anticipated changes in environmental and societal attributes as a response to changes in climate *(Adapted from Mercer Clarke 2011).*

REFERENCES

APEGGA. 2006. Guideline for management of risk in professional practice. Association of Professional Engineers, Geologists and Geophysicists of Alberta, Edmonton AB. 47 pp.

Ballard, T., and S. Lewandowsky. 2015. When. not if: the inescapability of an uncertain climate future. Philosophical Transactions of the Royal Society A 373:

Black, R. A., J. P. Bruce, and I. D. M. Egener. 2010. Adapting to climate change: A risk-based guide for local governments: Volume 1. A report prepared by Summit Enterprises International Inc. 34 pp.

Burkett, V. R., and M. A. E. Davidson. 2012. Coastal impacts, adaptation and vulnerability: A technical input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment, National Oceanic and Atmospheric Administration, Washington DC.

Dow, K., F. Berkhout, B. L. Preston, R. J. T. Klein, G. Midgly, and M. R. Shaw. 2013. Limits to adaptation. Nature Climate Change 3:305-307.

Field, C.B., V.R. Barros, K.J. Mach, M.D. Mastrandrea, M. van Aalst, W.N. Adger, D.J. Arent, J. Barnett, R. Betts, T.E. Bilir, J. Birkmann, J. Carmin, D.D. Chadee, A.J. Challinor, M. Chatterjee, W. Cramer, D.J. Davidson, Y.O. Estrada, J.-P. Gattuso, Y. Hijioka, O. Hoegh-Guldberg, H.Q. Huang, G.E. Insarov, R.N. Jones, R.S. Kovats, P. Romero-Lankao, J.N. Larsen, I.J. Losada, J.A. Marengo, R.F. McLean, L.O. Mearns, R. Mechler, J.F. Morton, I. Niang, T. Oki, J.M. Olwoch, M. Opondo, E.S. Poloczanska, H.-O. Pörtner, M.H. Redsteer, A. Reisinger, A. Revi, D.N. Schmidt, M.R. Shaw, W. Solecki, D.A. Stone, J.M.R. Stone, K.M. Strzepek, A.G. Suarez, P. Tschakert, R. Valentini, S. Vicuña, A. Villamizar, K.E. Vincent, R. Warren, L.L. White, T.J. Wilbanks, P.P. Wong, and G.W. Yohe, 2014: Technical summary. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 35-94.

Gibbs, M., and T. Hill. 2011. Coastal climate change risk - Legal and policy responses in Australia. Government of Australia, Department of Climate Change and Energy Efficiency. 93 pp.

GOV/CAN/ECCC. 2018. National inventory report 1990-2016: Greenhouse gas sources and sinks in Canada. Environment and Climate Change Canada. Ottawa. 16 pp.

GOV/CAN/NS. 2011. The municipal climate change action plan guidebook. Canada -Nova Scotia Infrastructure Secretariat, Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds, Halifax NS. 36 pp.

IPCC. 2007. Fourth assessment report: Working Group II Report: Impacts, adaptation and vulnerability Intergovernmental Panel on Climate Change, , M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, (Eds.),Cambridge University Press, Cambridge UK. 987 pp. Glossary, pp. 869-883.

IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

King, D., D. Schrag, Z. Dadi, Q. Ye, and A. Ghosh. 2015. Climate change: A risk assessment. A report commissioned by the United Kingdom Foreign and Commonwealth Office, London UK. 79 pp.

Mercer Clarke, C. S. L. 2011. A proposed framework for assessing and reporting on the status and trends in oceans and coastal health in Canada. Research conducted as a Post Doctoral Fellow at the Oceans Science Centre, Memorial University of Newfoundland, St. John's NL. 150 pp.

PEW. 2008. Adapting to climate change: A business approach. A report prepared for the Pew Center on Global Climate Change, Arlington VA. 40 pp.

Verweij, M., M. Douglas, R. Ellis, C. Engel, F. Hendriks, S. Lohmann, S. Ney, S. Rayner, and M. Thompson. 2006. Clumsy solutions for a complex world: the case of climate change. Public Administration 84:817-843.

ADDITIONAL READING

UNDERSTANDING AND MANAGING RISK

Allen, C. R., J. J. Fontaine, K. L. Pope, and A. S. Garmestani. 2011. Adaptive management for a turbulent future. Journal of environmental management 92:133

City of Vancouver. 2014. Coastal flood risk assessment A report prepared by Northwest Hydraulic Consultants Vancouver BC. 143 pp.

EAC. 2008. Exploring issues, engaging partners: risk management, climate change and coastal planning. Ecology Action Centre, Coastal Issues Committee, Halifax NS. 25 pp.

Gibbs, M., and T. Hill. 2011. Coastal climate change risk - Legal and policy responses in Australia. Government of Australia, Department of Climate Change and Energy Efficiency. 93 pp.

GOV/AUSTRAL/NSW. 2010. Coastal risk management guide: Incorporating sea level rise benchmarks in coastal risk assessments. Government of New South Wales, Department of Environment, Climate Change and Water, Sydney South. 12 pp.

GOV/CAN/BC. 2018. Managing climate change risks: An independent audit. Office of the Auditor General of British Columbia Victoria BC. 118 pp.

GOV/CAN/ON. 2001. Understanding natural hazards; Great Lakes – St. Lawrence River system and large inland lakes, river and stream systems and hazardous sites: An introductory guide for public health and safety policies. 3.1, Provincial Policy Statement. Government of Ontario, Toronto

GOV/USA/NAS. 2013. Environmental decisions in the face of uncertainty. National Research Council, Committee on Decision Making Under Uncertainty; Board on Population Health and Public Health Practice; Institute of Medicine, Washington DC. 281 pp.

GOV/USA/NAS. 2016. Characterizing risk in climate change assessments: Proceedings of a workshop. National Academies of Sciences, Engineering and Medicine. National Academies Press Washington DC. 101 pp.

GOV/USA/NRC. 2002. Abrupt climate change: Inevitable surprises. National Research Council, Committee on Abrupt Climate Change, Ocean Studies Board, Polar Research Board, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, Washington DC. 244 pp.

GOV/USA/NRC. 2011. Adapting to the impacts of climate change. National Research Council. 293 pp.

GOV/USA/NRC. 2014. Reducing coastal risk on the East and Gulf coasts. National Research Council, Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning: Coastal Risk Reduction; Water Science and Technology Board; Ocean Studies Board; Division on Earth and Life Studies, Washington DC. 209 pp.

Hendricks, D. P. 2002. Silence is golden: The case for mandatory disclosure of coastal hazards and land-use restrictions by residential sellers in North Carolina. NC Cent. LJ 25:96.

Higgins, M. 2008. Legal and policy impacts of sea level rise to beaches and coastal property. Sea Grant Law and Policy Journal 1:43-64.

ICES. 2013. Marine and coastal ecosystem-based risk management handbook. International Council for the Exploration of the Sea, Geesthacht, Germany. 64 pp.

IDMC. 2015. Disaster-related displacement risk: Measuring the risk and addressing its drivers. International Displacement Monitoring Centre, Geneva. 48 pp.

IOC. 2009. Hazard awareness and risk mitigation in Integrated coastal area management. Intergovernmental Oceanographic Commission, UNESCO Headquarters, Paris. 143 pp.

Jha, A. K., B. R., and J. Lamond. 2012. Cities and flooding: A guide to integrated urban flood risk management for the 21st century. The World Bank, Washington DC. 638 pp.

King, D., D. Schrag, Z. Dadi, Q. Ye, and A. Ghosh. 2015. Climate change: A risk assessment. A report commissioned by the United Kingdom Foreign and Commonwealth Office, London UK. 79 pp.

Kovacs, P., and H. Kunreuther. 2001. Managing catastrophic risk: Lessons from Canada. ICLR/IBC Earthquake Conference, Simon Fraser University, Vancouver BC.

Lane, D. E., and R. L. Stephenson. 1998. A framework for risk analysis in fisheries decision-making. ICES Journal of Marine Science: Journal du Conseil 55:1-13.

Lieske, D. J., T. Wade, and L. A. Roness. 2014. Climate change awareness and strategies for communicating the risk of coastal flooding: A Canadian Maritime case example. Estuarine, Coastal and Shelf Science 140:83-94.

Maani, K. 2013. Decision-making for climate change adaptation: A systems thinking approach. University of Queensland, National Climate Change Adaptation Research Facility, Gold Coast. 66 pp.

McFadden, L., E. Penning-Rowsell, and S. Tapsell. 2009. Strategic coastal flood-risk management in practice: Actors' perspectives on the integration of flood risk management in London and the Thames Estuary. Ocean and Coastal Management 52:636-645.

Noble, D., J. Bruce, and M. Egener. 2005. An overview of the risk management approach to adaptation to climate change in Canada. A report prepared by Global Change Strategies International for Natural Resources Canada, Climate Change Impacts and Adaptation Directorate Ottawa. 29 pp.

NYCPCC. 2009. Climate risk information. New York City Panel on Climate Change, New York NY. 74 pp.

Peck, A. M., E. A. Bowering, and S. P. Simonovic. 2013. A flood risk assessment to municipal infrastructure due to changing climate part II: case study. Urban Water Journal:1-13.

Purdy, M., and L. Smythe. 2010. From obscurity to action: Why Canada must tackle the security dimensions of climate change. International Journal:411-433.

SFU/ACT. 2014. Conference proceedings report: Not waiting for Noah: New approaches to assessing flood risk. Simon Frazer University, Adaptation to Climate Change Team (ACT), Vancouver BC. 32 pp.

SFU/ACT. 2016. Climate risk: getting to action. Professional's perspectives on climate change challenges. Adaptation to Climate Change Team, Simon Fraser University. 44 pp.

Silton, A. C., and J. Grannis. 2010. Virginia Case Study: Stemming the tide: How local governments can manage rising flood risks. University of Virginia, Georgetown Climate Center, Georgetown State-Federal Climate Resource Center, Georgetown, VA. 24 pp.

Silver, A., and C. Conrad. 2010. Public perception of and response to severe weather warnings in Nova Scotia, Canada. Meteorological Applications 17:173-179.

Stults, M., and Meerow, S. 2017. Professional societies and climate change: an analysis of how urban-focused professional societies are integrating climate change into their member engagement activities. The Kresge Foundation. 38 pp.

Theron, A. K., and M. Rossouw. 2008. Analysis of potential coastal zone climate change impacts and possible response options in the southern African region.

Trück, S., S. Mathew, A. Henderson-Sellers, R. Taplin, T. Keighley, and W. Chin. 2013. Climate adaptation decision support tool for local governments: CATLoG. Developing an Excel spreadsheet tool for local governments to compare and prioritise investment in climate change adaptation. MacQuarrie University, National Climate Change Adaptation Research Facility, Gold Coast. 39 pp.

Varnell, L. M., and J. C. Scott Hardaway. 2005. A risk assessment approach to management of estuarine dune fields. Ocean & Coastal Management 48:767-781.

WEF. 2013. Insight Report: Global risks 2013: Eighth Edition. REF: 3012111: 978-92-95044-50-0, World Economic Forum, An Initiative of the Risk Response Network, Geneva. 80 pp.

Woodroffe, C., P. Cowell, D. Callaghan, R. Ranasinghe, R. Jongejan, D. Wainwright, S. Barry, K. Rogers, and A. Dougherty. 2012. Approaches to risk assessment on Australian coasts: A model framework for assessing risk and adaptation to climate change on Australian coasts. National Climate Change Adaptation Research Facility, Gold Coast. 205 pp.

WICKED PROBLEMS AND CLUMSY SOLUTIONS

Brown, S., R. J. Nicholls, S. Hanson, G. Brundrit, J. A. Dearing, M. E. Dickson, S. L. Gallop, S. Gao, I. D. Haigh, and J. Hinkel. 2014. Shifting perspectives on coastal impacts and adaptation. Nature Climate Change 4:752-755.

Buchanan, R. 1992. Wicked problems in design thinking. Design issues 8:5-21.

IPCC. 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

Jentoft, S., and R. Chuenpagdee. 2009. Fisheries and coastal governance as a wicked problem. Marine Policy 33:553-560.

Pahl-Wostl, C. 2007. The implications of complexity for integrated resources management. 1364-8152. 561-569 pp.

Rittel, H. W. J., and M. M. Webber. 1984. Planning problems are wicked problems. In N. Cross, editor. Developments in design methodology. Pages 135-144. John Wiley & Sons, New York.

Thompson, M. 2003. Cultural theory, climate change and clumsiness. Economic and Political Weekly.

Verweij, M., M. Douglas, R. Ellis, C. Engel, F. Hendriks, S. Lohmann, S. Ney, S. Rayner, and M. Thompson. 2006. Clumsy solutions for a complex world: the case of climate change. Public Administration 84:817-843.

Verweij, M., M. Douglas, R. Ellis, C. Engel, F. Hendriks, S. Lohmann, S. Ney, S. Rayner, and M. Thompson. 2006. The case for clumsiness. Pages 1-34 in M. Verweij and M. Thompson, editors. Clumsy Solutions for a Complex World. Singapore Management University, School of Economics and Social Sciences.

Verweij, M., and M. Thompson (Eds). 2006. Clumsy solutions for complex world: Governance, politics, and plural perceptions. Macmillan, New York.

INFORMING DECISION-MAKING

Elemental Sustainability Consulting Ltd. 2012. The Municipal Climate Change Action Plan Assistant: Learning from others: Developing climate change capacity at the municipal level in Nova Scotia Report: Appendix 5 Municipal Learnings Project. A report prepared for Service Nova Scotia and Municipal Relations, Canada-Nova Scotia Infrastructure Secretariat Halifax NS.

Gage, A. 2011. Professionals and climate change: How professional associations can get serious about global warming. West Coast Environmental Law, Vancouver BC. 29 pp.

GOV/CAN/BC. 2014. A primer for understanding concepts, principles and language use across disciplines: Developing effective dialogue between practitioners of climate change vulnerability-risk assessments. B.C. Ministry of Transportation and Infrastructure, Nodelcorp Consulting Inc., and the Pacific Climate Impacts Consortium, Victoria. 33 pp.

GOV/USA/NAS. 2014. The climate change educational partnership: Climate change, engineered systems, and society: A report of three workshops. National Academy of Engineering, Washington DC. 104 pp.

Grorud-Colvert, K., S. E. Lester, S. Airamé, E. Neeley, and S. D. Gaines. 2010. Communicating marine reserve science to diverse audiences. Proceedings of the National Academy of Sciences 107:18306-18311.

Hess, C., and E. Ostrom. 2005. Understanding knowledge as a commons: From theory to practice. The MIT Press, Cambridge. 355 pp.

Keys, N., D. C. Thomsen, and T. F. Smith. 2014. Adaptive capacity and climate change: the role of community opinion leaders. Local Environment:1-19.

Ng'ang'a, S. M., M. Hutchison, K. Vodden, J. Pepper, M. Berry, S. NIchols, M. Sutherland, R. White, and B. Nkwae. 2005. A handbook on issues surrounding linking science and local knowledge in coastal areas. Fisheries and Oceans Canada. Technical Report No. 243.

Porter, J. J., D. Demeritt, and S. Dessai. 2014. The right stuff? Informing adaptation to climate change in British local government. Sustainability Research Institute, School of Earth and Environment, The University of Leeds, Leeds UK.

Smit, B., and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16:282-292.

Tribbia, J., and S. C. Moser. 2008. More than information: what coastal managers need to plan for climate change. environmental science & policy 11:315-328.

Wall, E., and K. Marzall. 2006. Adaptive capacity for climate change in Canadian rural communities. Local Environment 11:373-397.

VULNERABILITY TO CHANGE

Adger, W.N. 2006. Vulnerability. Global Environmental Change, 16, 268–281.

Alexander, C., and C. McDonald. 2014. Natural catastrophes: A Canadian perspective. A special report prepared by the Chief Economist for TD Economics, TD Bank Group. 5 pp.

Bennett, N. J., J. Blythe, S. Tyler, and N. C. Ban. 2015. Communities and change in the anthropocene: understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. Regional Environmental Change:1-20.

Bogardi, J., and J. Birkmann. 2004. Vulnerability assessment: The first step towards sustainable risk reduction. Pages 75-82 In D. Malzahn and T. Plapp, editors. Disaster and society – From hazard assessment to risk reduction. Logos Verlag Berlin, Berlin.

Boughton, D. A., E. R. Smith, and R. V. O'Neill. 1999. Regional vulnerability: a conceptual framework. Ecosystem Health 5:312-322.

Burkett, V. R., and M. A. E. Davidson. 2012. Coastal impacts, adaptation and vulnerability: Technical input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment, NOAA, Washington DC. 150 pp.

Chu, C. 2015. Climate change vulnerability assessment for inland aquatic ecosystems in the Great Lakes Basin, Ontario. Aquatic Research and Monitoring Section, Science and Research Branch, Ontario Ministry of Natural Resources and Forestry, Toronto ON. 48 pp.

Ciurean, R. L., D. Schröter, and T. Glade. 2013. Conceptual frameworks of vulnerability assessments for natural disasters reduction. INTECH Open Access Publisher.

Clark, G. E., S. C. Moser, S. J. Ratick, K. Dow, W. B. Meyer, S. Emani, W. Jin, J. X. Kasperson, R. E. Kasperson, and H. E. Schwarz. 1998. Assessing the vulnerability of coastal communities to extreme storms: The case of Revere, MA., USA. Mitigation and Adaptation Strategies for Global Change 3:59-82.

CPAWS/WWF. 2012. climate change impacts and vulnerabilities in Canada's Pacific Marine Ecosystems. Canadian Parks and Wilderness Society and World Wildlife Fund Canada, Vancouver BC. 157 pp.

Denny, M. W., L. J. Hunt, L. P. Miller, and C. D. Harley. 2009. On the prediction of extreme ecological events. Ecological Monographs 79:397-421.

Dolan, A., and I. Walker. 2006. Understanding vulnerability of coastal communities to climate change related risks. Journal of Coastal Research SI39 (Proceedings of the 8th International Coastal Symposium), Itajaí, SC -Brazil:1316-1323.

Dyer, K. R. 1995. Response of estuaries to climate change. Pages 85-110 In D. Eisma, editor. Climate change: impact on coastal habitation. Lewis Publishers, Boca Raton.

Engineers Canada. 2011. PIEVC engineering protocol for infrastructure vulnerability assessment and adaptation to a changing climate: Revision 10 BETA. Canadian Council of Professional Engineers, Ottawa. 93 pp.

Forbes, D. L., T. Bell, T. S. James, and K. M. Simon. 2014. Reconnaissance assessment of landscape hazards and potential impacts of landscape hazards and potential impacts of futures climate change in Arivat, southern Nunavut. Pages 183-192 Summary of Activities 2013. Canada-Nunavut Geoscience Office.

Ford, J. D., and B. Smit. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. Arctic:389-400.

Ford, J. D., B. Smit, and J. Wandel. 2006. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. Global Environmental Change:145-160.

Garster, J. G., M. W. Huber, and K.D. White. 2015. US Army Corps of Engineers screening-level assessment of projects with respect to sea level change civil works Technical Report, CWTS 2015-16, US Army Corps of Engineers, Washington DC.

Gauthier, S., P. Bernier, P. J. Burton, J. Edwards, K. Isaac, N. Isabel, K. Jayen, H. Le Goff, and E. A. Nelson. 2014. Climate change vulnerability and adaptation in the managed Canadian boreal forest 1. Environmental Reviews 22:1-30.

Godschalk, D. R., R. Norton, C. Richardson, and D. Salvesen. 2000. Avoiding coastal hazard areas: best state mitigation practices. Environmental Geosciences 7:13-22.

GOV/CAN/C-CIARN. 2004. Reducing the vulnerability of coastal trails & boardwalks to storm surge, flooding, erosion and sea ice. C-CIARN Coastal Zone Report 04-3, Government of Canada, Canadian Climate Impacts and Adaptation Research Network, Coastal Zone Sector Coordinating Offices, Ottawa. 35 pp.

GOV/CAN/CCME. 2013. Tools for climate change vulnerability assessments for watersheds. A report prepared by ESSA Technologies Ltd. for the Canadian Council of Ministers of the Environment, Winnipeg MN. 135 pp.

GOV/CAN/NS. 2005. Adapting to a changing climate in Nova Scotia: Vulnerability assessment and adaptation options. A report submitted to the Government of Nova Scotia, Halifax NS. 105 pp.

GOV/CAN/PEI. 2003. Consequence analysis of storm surge in the Charlottetown, Prince Edward Island area. D82-83/2003E-PDF, Government of Canada, Office of Critical Infrastructure Protection and Emergency Preparedness, Science Applications International Corporation (SAIC Canada), Ottawa ON. 34 pp.

GOV/AUSTRAL/NSW. 2008. High resolution terrain mapping of the NSW Central and Hunter coasts for assessments of potential climate change impacts: Final project report. Government of Australia, State of New South Wales Department of Planning, Climate Change Impacts and Adaptation Research Project, Sydney Australia. 183 pp.

GOV/NZ. 2008. Coastal hazards and climate change: A guidance manual for local government in New Zealand: 2nd Edition. Government of New Zealand, Ministry for the Environment, Wellington, New Zealand. 139 pp.

GOV/USA/CAL. 2012. California adaptation planning guide: Defining local and regional impacts. A report prepared by the California Emergency Management Agency and the California Natural Resources Agency. 81 pp.

GOV/USA/EPA. 2009. Coastal sensitivity to sea level rise: A focus on the Mid-Atlantic Region. Final Report, Synthesis and Assessment Product 4.1, United States Environmental Protection Agency, Climate Change Science Program, Subcommittee on Global Change Research, Washington DC. 320 pp.

GOV/USA/FLA. 2005. Protecting Florida's Communities: Land use planning strategies and best development practices for minimizing vulnerability to flooding and coastal storms. US State of Florida Department of Community Affairs; Division of Community Planning and Division of Emergency Management, Tallahassee FL. 217 pp.

GOV/USA/MD. 2008. Chapter 5: Comprehensive strategy for reducing Maryland's vulnerability to climate change: Phase I: Sea-level rise and coastal storms. Report of the Maryland Commission on Climate. Pages 1-40.

GOV/USA/NRC. 2008. New directions in climate change vulnerability, impacts, and adaptation assessment: Summary of a Workshop. National Research Council, Washington DC. 44 pp.

GOV/USA/NRC. 2013. Abrupt impacts of climate change: Anticipating surprises. National Research Council, Committee on Understanding and Monitoring Abrupt Climate Change and Its Impacts; Board on Atmospheric Sciences and Climate; Division on Earth and Life Studies, Washington DC. 223 pp.

GOV/USA/NWF. 2008. Increasing vulnerability to hurricanes: Global warming's wake-up call for the U.S. Gulf and Atlantic Coasts. United States National Wildlife Federation, Washington DC. 8 pp.

Hatcher, S., and D. L. Forbes. 2015. Exposure to coastal hazards in a rapidly expanding northern urban centre, Iqaluit, Nunavut. Arctic 68:453-471.

IISD. 2013. Climate change adaptation and Canadian infrastructure: A review of the literature. International Institute for Sustainable Development, Winnipeg MN. 40 pp.

Ionescu, C., R. J. Klein, J. Hinkel, K. K. Kumar, and R. Klein. 2009. Towards a formal framework of vulnerability to climate change. Environmental modeling & assessment 14:1-16.

Judge, E. K., M. F. Overton, and J. S. Fisher. 2003. Vulnerability indicators for coastal dunes. Journal of Waterway, Port, Coastal and Ocean Engineering.

Leonard, L. J., G. C. Rogers, and S. Mazzotti. 2014. Tsunami hazard assessment of Canada. Natural Hazards 70:237-274.

Manuel, P., E. Rapaport, J. Keefe, and T. Krawchenko. 2015. Coastal climate change and aging communities in Atlantic Canada: A methodological overview of community asset and social vulnerability mapping. The Canadian Geographer. 59: 433-446.

Marzeion, B., and A. Levermann. 2014. Loss of cultural world heritage and currently inhabited places to sea-level rise. Environmental Research Letters 9:034001.

McBean, G., and D. Henstra. 2003. Climate change, natural hazards and cities. A paper prepared for Natural Resources Canada by the Institute for Catastrophic Loss Reduction, London ON.

McFadden, L. 2007. Vulnerability analysis in environmental management: widening and deepening its approach. Environmental Conservation 34:195-204.

McLaughlin, S., J. McKenna, and J. A. G. Cooper. 2002. Socio-economic data in coastal vulnerability indices: constraints and opportunities. J. Coast. Res 36:487–497.

Mendler de Suarez, J., B. Cicin-Sain, K. Wowk, R. Payet, and O. Hoegh-Guldberg. 2014. Ensuring survival: Oceans, climate and security. Ocean and Coastal Management 90:27-37.

Nelitz, M., S. Boardley, and R. Smith. 2013. Tools for climate change vulnerability assessments for watersheds. A report prepared by ESSA Technologies Ltd. for the Canadian Council of Ministers of the Environment (CCME). 125 pp.

Nicholls, R. J., S. Hanson, C. Herweijer, N. Patmore, S. Hallegatte, J. Corfee-Morlot, J. Château, and R. Muir-Wood. 2008. Ranking port cities with high exposure and vulnerability to climate extremes: Exposure estimates. OECD Publishing.

Romero-Lankao, P., J.B. Smith, D.J. Davidson, N.S. Diffenbaugh, P.L. Kinney, P. Kirshen, P. Kovacs, and L. Villers Ruiz. 2014. North America. In: Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1439-1498.

Rosendahl Appelquist, L. 2012. Generic framework for meso-scale assessment of climate change hazards in coastal environments. Journal of Coastal Conservation:1-16.

Rosendahl Appelquist, L., and K. Halsnæs. 2015. The Coastal Hazard Wheel system for coastal multi-hazard assessment and management in a changing climate. Journal of Coastal Conservation:157-1791-1716.

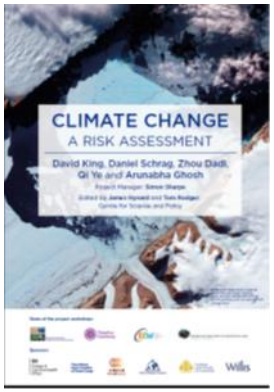
Smit, B., and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16:282-292.

Smith, I. R., and D. L. Forbes. 2014. Reconnaissance assessment of landscape hazards and potential impacts of future climate change in Cambridge Bay, western Nunavut Pages 159-170 Summary of Activities 2013. Canada-Nunavut Geoscience Office.

Stults, M., and S. Meerow. 2017. Professional societies and climate change: An analysis of how urban-focussed professional societies are integrating climate change into their member engagement activities. The Kresge Foundation. 38 pp.

Vafeidis, A. T., R. J. Nicholls, L. McFadden, R. S. J. Tol, J. Hinkel, T. Spencer, P. S. Grashoff, G. Boot, and R. J. T. Klein. 2008. A New Global Coastal Database for Impact and Vulnerability Analysis to Sea-Level Rise. Journal of Coastal Research: 917-924.

KEY REPORTS



King, D., D. Schrag, Z. Dadi, Q. Ye, and A. Ghosh. 2015. Climate change: A risk assessment. A report commissioned by the United Kingdom Foreign and Commonwealth Office, London UK. 79 pp.

Available at:

http://www.csap.cam.ac.uk/media/uploads/files/1/climate-change--a-risk-assessment-v11.pdf

5 MITIGATION AND ADAPTATION

5.1 THE NEED TO CHANGE WHAT WE DO

As we look to our future, the scope, intensity and rate of changes to the global climate will depend on emission levels of carbon dioxide and other global greenhouse gases. Currently, more conservative models of future change rely upon a slowing, or elimination of new emissions (Figure 5-1). Less optimistic models are based on potentially more realistic changes in human contributions, anticipating that while emission levels may decrease from current loadings, they will continue. Current concentrations of carbon dioxide (CO_2) in the atmosphere have already passed the 400-ppm threshold (as compared to pre-industrial era concentrations that have been estimated at 280 ppm). Concentrations of carbon this high have not occurred for at least 800,000 years. There are considerable concerns amongst scientists that CO_2 concentrations in excess of 450 ppm may create a world much different than we have today.

Average air temperatures across the globe have increased by almost one degree Celsius from pre-industrial averages. Given the levels of greenhouse gases ALREADY in the atmosphere, the planet will warm at least another 1.5 °C, even if we stopped all emissions immediately. Warming in excess of 2 °C is anticipated to result in dramatic changes to environments and to society. Added to these concerns is an increasing understanding that global warming is not a linear process. One effect leads to another. Rising temperatures in the Arctic and thawing permafrost will increase the volume of methane contributed to the atmosphere, accelerating warming.

"...we have the means to limit climate change and its risks, with many solutions that allow for continued economic and human development. However, stabilizing temperature increase to below 2°C relative to pre-industrial levels will require an urgent and fundamental departure from business as usual. Moreover, the longer we wait to act, the more it will cost and the greater the technological, economic, social and institutional challenges we will face." *(IPCC 2014a Synthesis Report, p v).*

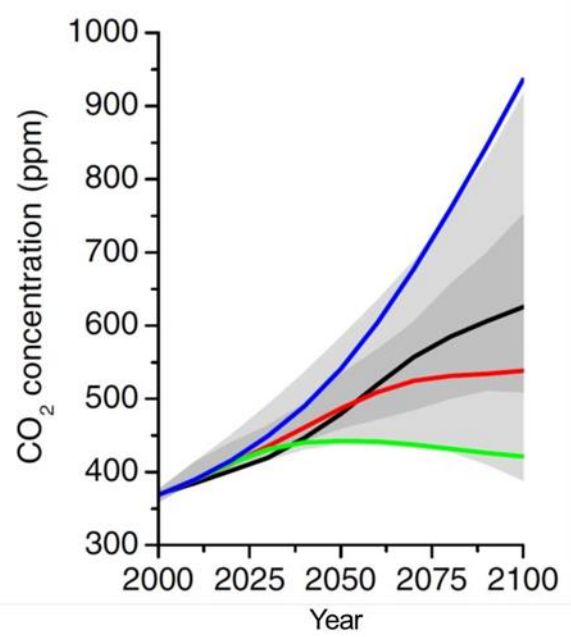


FIGURE 5-1: Four scenarios for atmospheric concentrations of CO_2 (measured in parts per million or ppm) projected for the period 2000-2100. The scenarios range from low to high emissions (intensive reduction efforts as compared to limited reduction efforts) *(van Vuuren et al. 2011).*

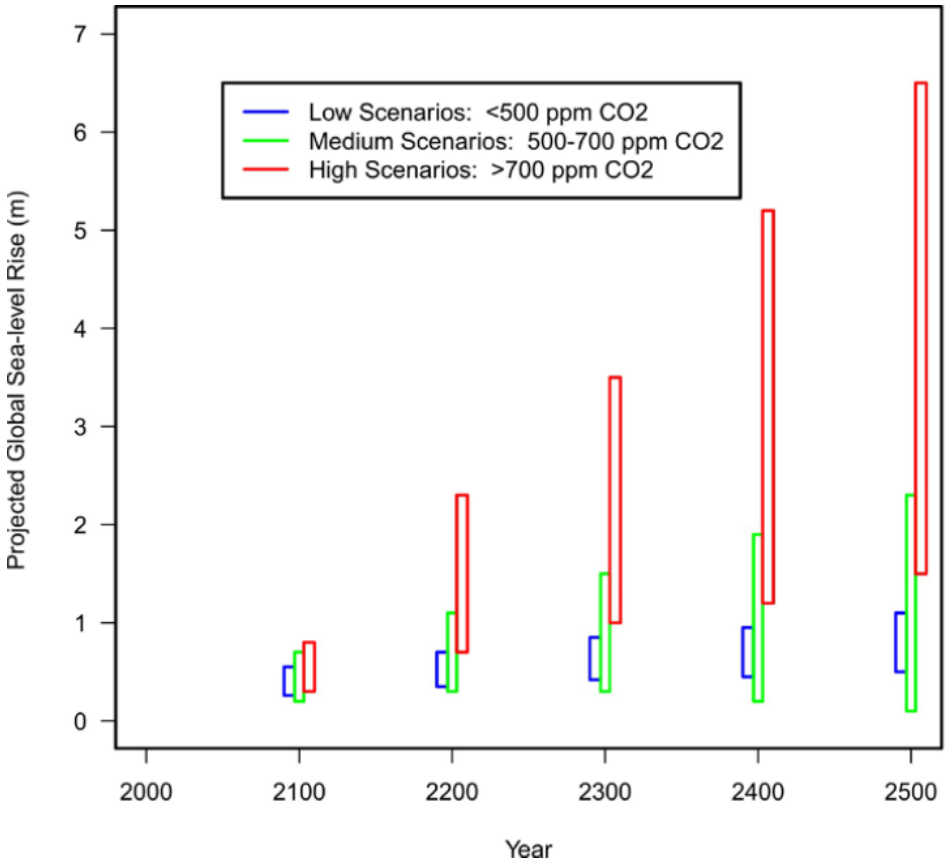


FIGURE 5-2: Projected global sea-level rise for the period 2100 to 2500, showing a range of scenarios based on anticipated concentrations of atmospheric carbon dioxide in 2100 (*James et al 2014, p20).*

"What is the use of having developed a science well enough to make predictions if, in the end, all we are willing to do is stand around and wait for them to come through?" *(Nobel Laureate, F. Sherwood Rowland, a pioneer in the field of ozone depletion. 1996 Interview with the non-profit organization Climate Communication).*

Unless greater efforts are made worldwide to reduce carbon emissions, scenarios for global warming that place concentrations of carbon dioxide somewhere between 500-700 ppm by 2100 become more likely. As the atmosphere continues to heat up, the future stability of the West Antarctic ice sheet becomes more uncertain, and there is a greater potential for relative sea levels that are significantly higher than those on current planning agendas. Changes to climate and weather patterns will also continue, increasing in severity over time. Decision-makers should by now be aware that rising seas are already affecting coastal water levels, and that projected increases in sea levels will continue PAST the 2100 threshold, which marks only the first 100 years of shifting conditions (Figure 5-2).

While it is true that many of today's decision-makers may not in their lifetimes be severely affected by the impacts of a changing climate, future generations will bear the burdens created by inaction during our watch. Already climate change is predicted to result in more severe weather events, occurring across larger areas. Additional stresses to unique and to already threatened species, habitats and ecosystems may result in increased extinctions and irreversible and potentially negative changes in the landscape. Rising seas will significantly alter conditions along Canadian coasts, especially in the East where rising sea level will be exacerbated by land subsidence in some areas of the coast. While much has been said to date about sea levels that rise as much as one metre, less is being reported about long-term concerns. Even with significant reductions in emissions, seas will continue to rise throughout this century. Without reductions, the projected longer-term changes will be much more severe (Nicholls et al. 2011).

Never before in human history has the future been so reliant on what civilization does today. We may not be able to reverse the processes we have set in motion, reducing emissions, but improving atmospheric conditions and planning for future changes will do much to reduce or slow the pace of changes, to improve the quality of life, and increase the options for sustainability available to the generations to come.

5.2 WHAT IS MITIGATION?

The IPCC has continued to emphasize the need to reduce greenhouse gas emissions, as the primary effort towards slowing or possibly reversing the planet's change in climate. Human efforts to reduce the sources, or to enhance the sinks of greenhouse gases are often referred to collectively as 'mitigation'. Mitigation efforts generally have two thrusts: reduction of greenhouse gas emissions to the atmosphere (to change the Earth's radiative balance and reduce the effects of greenhouse warming), and removal of existing carbon dioxide or other GHGs from the atmosphere (e.g., through land management, reforestation, ocean iron fertilization).

Reduction in greenhouse gas emissions can too often be seen to be a problem for big industry, where the largest changes in total emissions could be accomplished. However, greenhouse gas reduction is a broader problem that requires all individuals and sectors of society to participate in its solution through personal and organizational commitment to change. Much can be done to reduce demands for energy for transportation, heating, cooling and industry operations, to facilitate the move to alternative, sustainable forms of energy generation (e.g., solar, wind, tidal) and to become more efficient in our use of energy to serve societal needs.

The IPCC (2014a) reports that urbanization is a growing trend throughout the world, with more than 52% of the global population already resident in urban areas. Urban populations are expected to account for as much as 69% of the world's people by 2050, which is only 35 years away. In rapidly urbanizing area, large gains in GHG reduction can be achieved where innovation in policy and practice alter traditional development and building patterns. Efficiencies in technology and modifications to human behaviour can significantly reduce human demands on energy and for consumer goods and services. Waste reduction, together with recycling initiatives, can ensure more efficient use and recovery of existing resources, including energy. Retrofit of existing structures, and sustainable design requirements for new buildings can reduce energy requirements for heating and cooling especially where structures can and will represent long-term, locked-in demands on resources. Innovations in the design and construction of new buildings would increase passive measures to aid heating and cooling, and result in overall reduction in energy demands. Within urban areas, tree canopy can contribute not only to removal of GHGs, but also to overall improvements in air quality and reduction in urban heat islands. While many cities throughout the world are now addressing planning for climate change, few have taken a comprehensive look at their existing and potential future land use planning strategies, especially on measures that reduce sprawl, create sustainable neighbourhoods, and promote public transit.

Mitigation efforts should not overlook the gains to be made from the removal of GHGs from the atmosphere through innovations in agriculture, reforestation and sustainable management of existing forested lands. Agricultural practices that rely on improvements in cropland and grazing land management, and the restoration of organic soil management are cost-effective mitigation options. Reforestation, which has the potential to create substantial sinks for carbon sequestering, can also reduce heating of the earth's surface, improve water storage and water quality, and reduce the potential for soil erosion and landslides

Mitigation efforts can mean switching to **renewable energy** sources, employing **new technology** and/or **retrofitting** older equipment to reduce emissions, **changing planning and management** policies, and **altering societal behaviour.** Mitigation also includes efforts to expand forests or to enhance other mechanisms that remove CO_2 from the atmosphere.

'MITIGATION', in the context of climate change, is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). *IPCC 2014b, p4*

THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

The ultimate objective is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner". *(IPCC 2014b, p4; UNFCCC: Available at: http://bigpicture.unfccc.int/).*

5.2.1 CANADA'S EFFORTS TO REDUCE EMISSIONS

Canada's greenhouse gas emissions are predominantly the result of the manufacturing and consumption of fossil fuels to provide energy for transportation, electricity, heating, manufacturing, construction and mining (Table 5-1). While in the past few years, some reductions in greenhouse gas emissions have been achieved, Canada is a long way from its stated goals.

When total contributions are compared, Alberta, Ontario and Quebec contribute most of the emissions (Figure 5-3). Most of the provinces and territories are reducing their carbon dioxide (CO_2) emissions, with Ontario demonstrating the greatest change. Alberta is noteworthy as its contributions have risen (GOV/CAN/ECCC 2018), largely related to their oil and gas sector, which produced energy for use by the rest of the country. Canadian provinces and territories, which have developed a range of approaches and policies to reduce greenhouse gas emissions (Figures 5-4, 5-5) (Holmes et al. 2012), have together with the federal government, recently engaged in collaborative discussions towards a more common reduction strategy and alternative options.

TABLE 5-1: Changes in GHG* emissions by economic sector for the period 1990-2011 (excluding LULUCF - land use, land use change, and forestry*) (as adapted from GOV/CAN/EC 2013).*

Mt CO_2 equivalent	1990	2000	2005	2011
Transportation	128	155	168	170
Oil and Gas	101	150	165	163
Electricity	94	129	121	90
Buildings	70	82	84	84
Emissions Intensive and Trade Exposed Industries	93	85	87	78
Agriculture	54	66	68	68
Waste and Other Sectors	50	51	49	49
National GHG Emissions Total	**591**	**718**	**737**	**702**

*GHG's included are: Carbon dioxide (CO_2), methane (CH_4), Nitrous oxide emissions (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulphur-hexafluorides (SF_6).

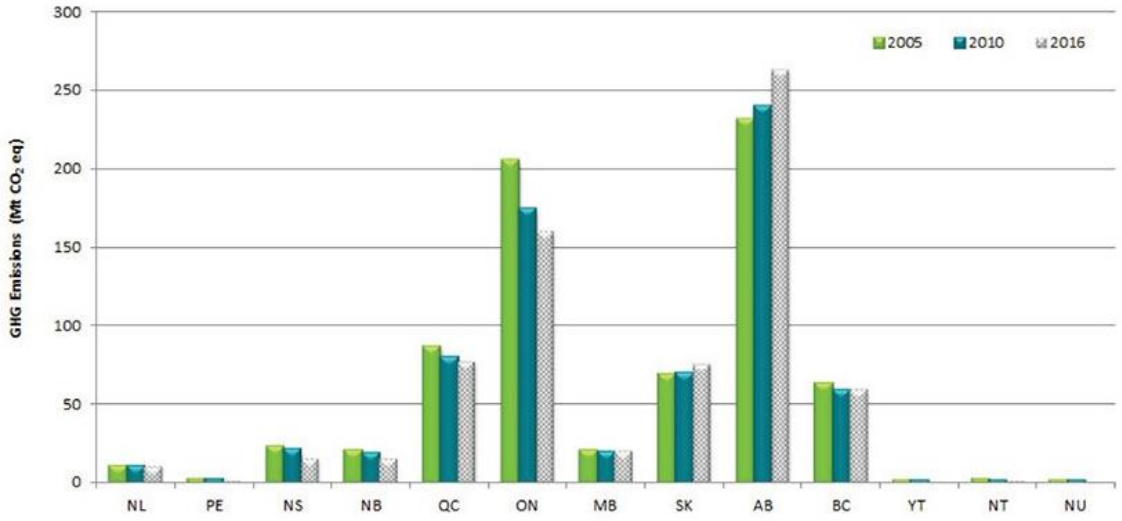


FIGURE 5-3: Greenhouse gas emissions by province and territory, Canada, 2005, 2010 and 2016 *(GOV/CAN/ECCC 2018).*

"…Canada intends to achieve an economy-wide target to reduce our greenhouse gas emissions by 30% below 2005 levels by 2030." *(GOV/CAN 2015)*

How are we as a nation going to make that happen?

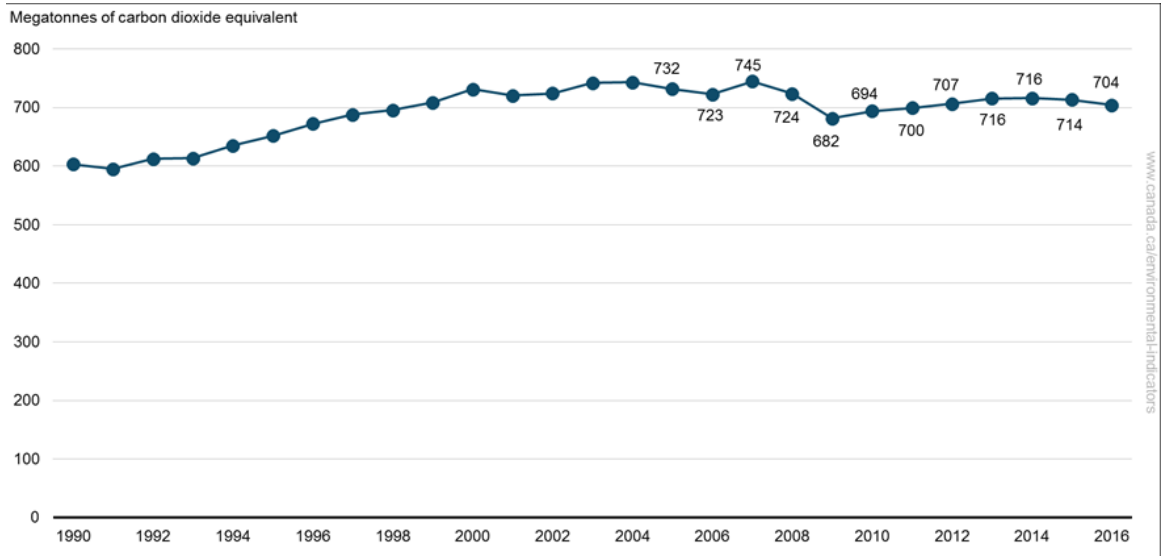


FIGURE 5-4: National greenhouse gas emissions, Canada, 1990 to 2016.
Note: The national indicator tracks seven GHGs: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and nitrogen trifluoride (NF_3) released by human activity (reported in Mt of CO_2). Canada signed the Copenhagen Accord in December 2009, thereby committing to reducing its GHG emissions to 17% below 2005 levels by 2020.

(*Environment and Climate Change Canada (GOV/CAN/ECCC 2018) National Inventory Report 1990–2013: Greenhouse Gas Sources and Sinks in Canada.*

Available at: https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2018.html).

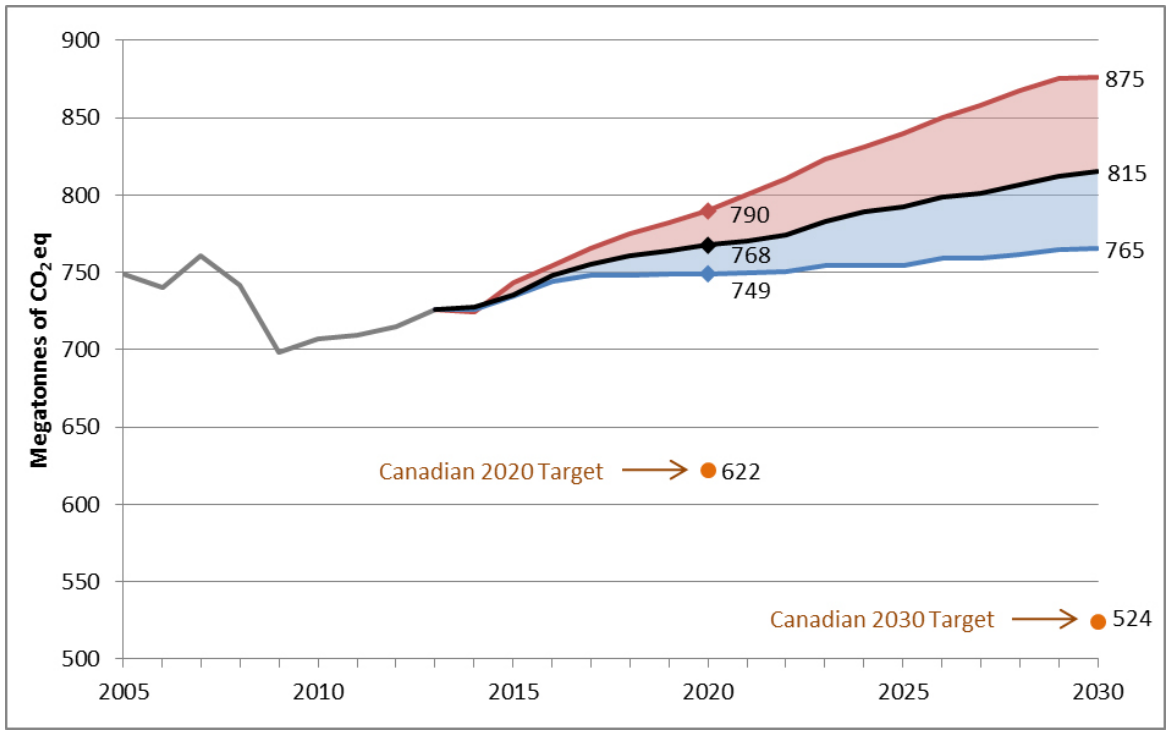


FIGURE 5-5: Canada's emission projections in 2020 and 2030 *(GOV/CAN/ECCC 2018. Available at: http://ec.gc.ca/ges-ghg/default.asp?lang=En&xml=8BAAFCC5-A4F8-4056-94B1-B2799D9A2EE0).*

In December of 2015, at the Paris UN COP meetings on global emissions, Canada led delegates in proposing a 2° Celsius cap on increases in global temperature, noting that a 1.5 ° Celsius target would be more beneficial to the planet and to working towards limiting the impacts to human society.

5.2.2 ACHIEVING A LOW CARBON ECONOMY

The Conference of the Parties agreement on climate change achieved in Paris in 2015 (COP21) has stimulated new momentum in climate policy in 170 nations to move towards low-carbon economies. The challenge to keep global warming below 2° Celsius is constrained by the fact that the IPCC estimates 65% of the carbon budget needed to attain that goal has already been used. To come close to attaining the carbon goals, a significant proportion of the oil and gas reserves will have to remain in the ground as 'unburnable carbon'. It has been estimated that globally a third of oil reserves, half of gas reserves, and 80 percent of coal reserves should remain unused, unless a method for carbon recapture is developed (Figure 5-6). For Canada, these estimates translate into 74% of oil reserves, 24% of gas reserves and 75% of coal reserves. Extraction of oil from open pit mining of natural bitumen drops to negligible after 2020 because of the costs of production (McGlade and Ekins 2015).

For communities, businesses and individuals, the challenges are two-fold. As policies to reduce dependencies on carbon-based fuels are implemented, investment in some carbon industries may face increasing risks of becoming stranded, (e.g., a loss of value, or increased potential for liabilities long before their expected economic life). Falling prices for oil and gas, a switch to alternative energy products, and reduced demands resulting from efficiencies in consumption and changes in consumer behaviour can significantly affect the viability of traditional carbon industries, the communities that are dependent upon them and the industries that rely upon carbon consumption as one of the foundations for their sector (e.g., international tourism). Alternatively, communities and sectors that divest themselves of dependencies on GHC-producing forms of energy, face challenges related to reducing energy demands, moving to alternative fuels, and improving well-being through direct and passive adaptation such as improved public transportation, and measures to increase sheltering of buildings.

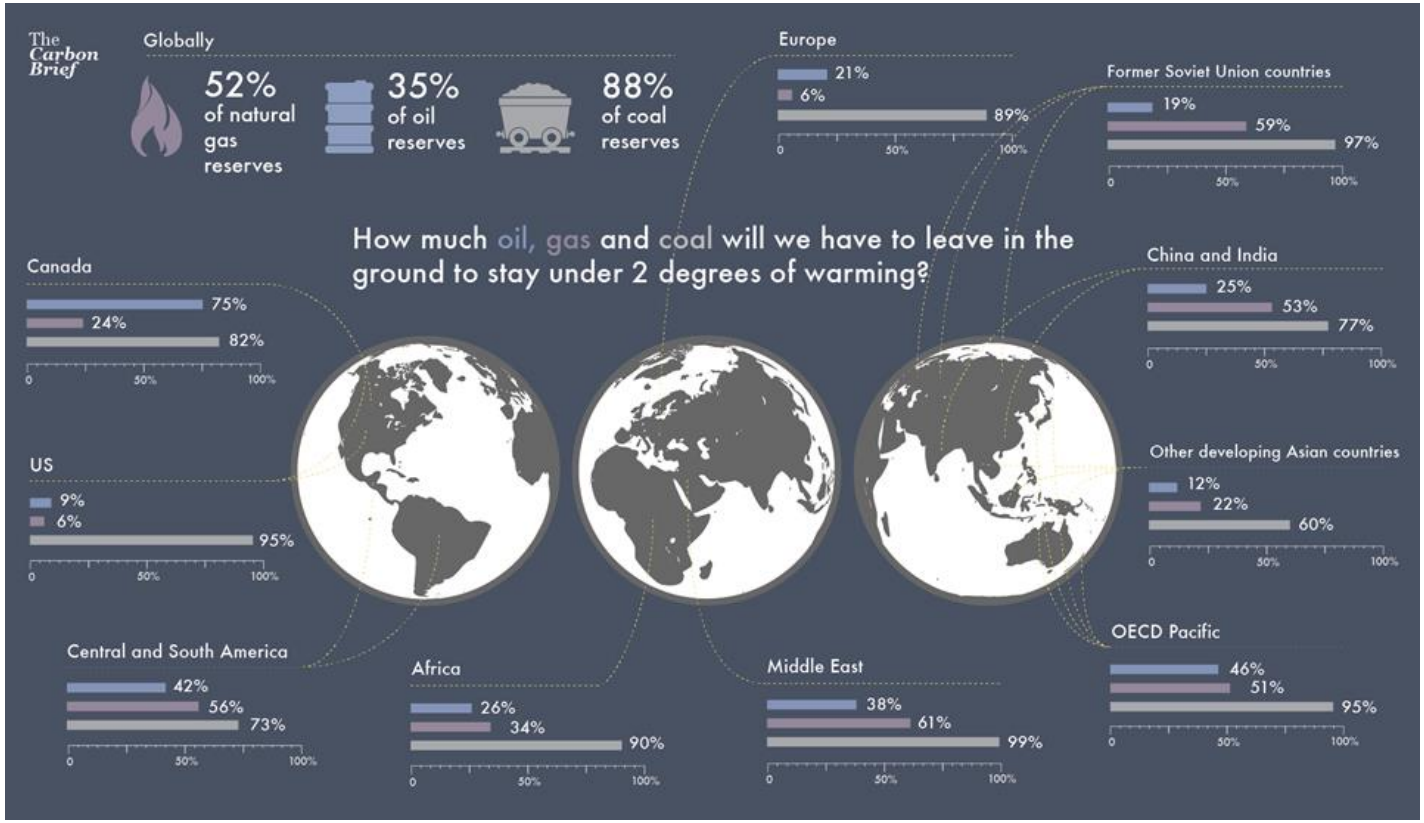


Figure 5-6: Estimated oil, gas and coal reserves that should remain unused. *(Carbon Brief (UK Journalism Website covering climate science and policy and energy policy. Available at; https://www.carbonbrief.org/meeting-two-degree-climate-target-means-80-per-cent-of-worlds-coal-is-unburnable-study-says).*

5.3 WHAT IS ADAPTATION?

As evidence of an already changing climate begins to amass, governments, communities and organizations have increasingly focussed on the need to plan for adaptation to both short and long-term environmental change. Adaptation is often seen as a social, economic and political process of adjustment to the actual or anticipated effects of climate change on human systems (Adger et al. 2005; Burkett and Davidson 2012; Bassett and Fogelman 2013; Fazey et al. 2015). But there are many definitions.

Adaptation is also an ecological process whereby species and habitats change to absorb effects, or move to an altered state, which may or may not affect the reliability of some ecosystem services. In human systems, adaptation efforts seek to reduce vulnerability, to moderate or avoid harm, to enhance resilience to existing or anticipated change, and to position society so as to be better prepared to exploit new and beneficial opportunities. In some natural systems, human intervention in adaptation may facilitate the adjustment of ecosystems to anticipated changes in climate conditions and its effects.

Planning for adaptation (Burkett and Davidson 2012, p xviii) is the result of "a deliberate policy decision based on an awareness that conditions have changed, or are about to change, and that action is required to return to, to maintain, or to achieve a desired state".

ADAPTATION is not one activity or decision, but "a continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes." (*Adger et al. 2005, p78).*

"ADAPTATION: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm, or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." *(Field et al. 2014. p40).*

"ADAPTATION is an iterative risk management process that relies on multiple feedback loops as new information is acquired. The process is evolutionary, shaped by people and knowledge, and the outcomes of practice". *(IPCC 2014a, p9).*

ADAPTATION IN CANADA

"Adaptation involves making adjustments in our decisions, activities and ways of thinking in response to observed or expected changes in climate, with the goals of

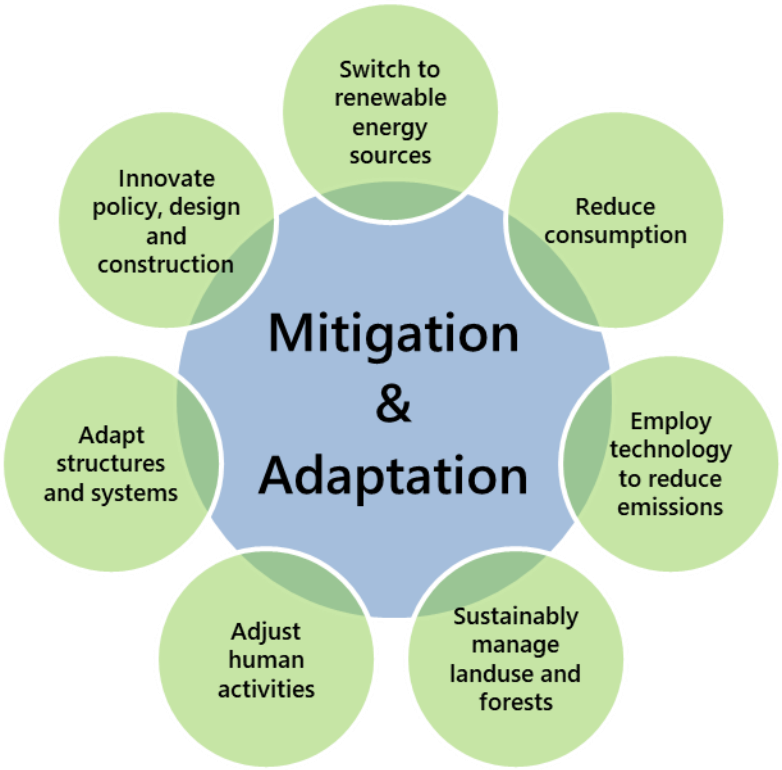
(a) reducing harm and

(b) taking advantage of potential opportunities. Adaptation can include behavioural changes, operational modifications, technological interventions, planning changes and revised investment practices, regulations and legislation.

While adaptation in the natural environment occurs spontaneously, adaptation in human systems often benefits from careful planning that is guided by both scientific research and detailed understanding of the systems involved. "

(Warren and Lemmen 2014).

5.3.1 A UNIFIED APPROACH TO CHANGE



With the 2014/2015 assessments, the IPCC increased its focus to include adaptation to climate change as an activity necessary to prepare the world for changes that are already upon us and changes that are to come. In much of the literature, mitigation has been discussed separate from adaptation, as though the two are not intrinsically linked. But mitigative efforts will have effects on both short- and long-term initiatives in adaptation (e, g., proposed shifts to biofuels could increase demands on land and water resources), and adaptation efforts will have consequences for mitigation (e.g., using air conditioning to deal with higher temperatures increases energy demands). When communities and organizations develop climate change action plans, it can be difficult to define policies and activities in the context of only one of these two categories. By example, enhancing the urban canopy is both mitigative (i.e., it will increase carbon uptake) and adaptive (i.e., it will improve shading, reduce heat and provide shelter from wind).

To be at their most effective, approaches to reducing the risks and managing responses to climate change will require individuals, communities and organizations to embrace both mitigative and adaptive actions to avoid or reduce anticipated impacts to environment and to society (Locatelli et al. 2015; Watkiss et al. 2015).

"Because **mitigation** is intended to reduce the harmful impacts of climate change, it is part of a broader policy framework that also includes **adaptation** to climate impacts". *(IPCC 2014b, p37)*

We basically have three choices: mitigation, adaptation and suffering. We're going to do some of each. The question is what the mix is going to be. The more mitigation we do, the less adaptation will be required and the less suffering there will be. *(Attributed to John P. Holdren, Assistant to the President (Obama) for Science and Technology and Director, Office of Science and Technology Policy,*

In this text, ***adaptation*** is understood to include:

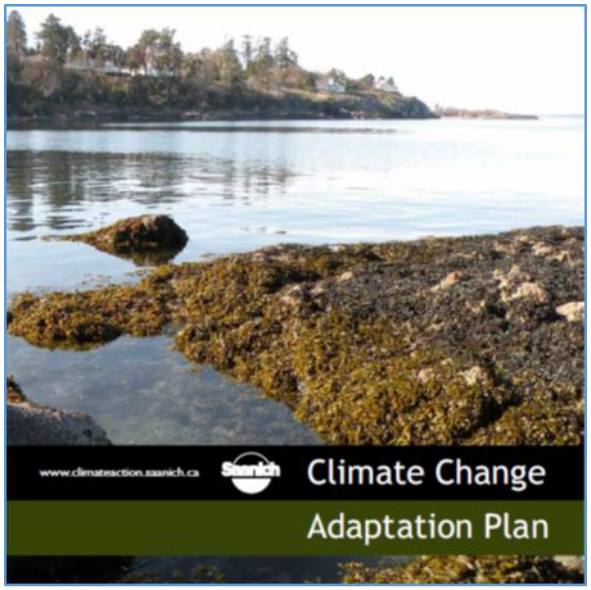
- mitigation efforts to reduce emissions, as well as
- adaptive efforts to increase capacity to cope with change.

Each climate change strategy will include mitigative and adaptive options, **but no single option will be sufficient by itself**. Effective implementation will depend on policies and cooperation at all scales of governance and industry and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives. *(IPCC 2014c Climate Change Synthesis Report AR5 WGII, III).*

5.4 CURRENT APPROACHES TO ADAPTATION

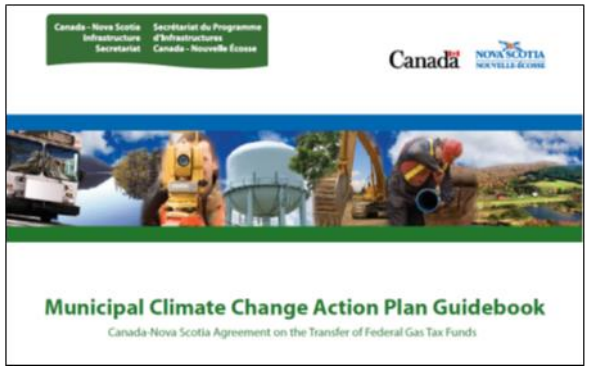
For decades, throughout Canada many governments, organizations and communities have been addressing existing and projected changes in the climate through the development of adaptation plans and guidelines. A wide range of approaches have been used, some more oriented to general policy and others focused on responses to specific conditions such as sea-level rise. Many of the provinces and territories have made significant gains in assessing the potential risks and in devising overarching policy to guide adaptation and mitigation.

For a number of years, Natural Resources Canada's Climate Change Directorate, the Adaptation Platform and other government initiatives have been reporting on science-based assessments of climate change and climate change adaptation Available at: https://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-platform/10027). NRCan also supported and cost-shared the formation of Regional Adaptation Collaboratives in six regions across the country, focused on helping communities prepare for and adapt to local impacts. The federal government has also used the application process for gas tax refunds to encourage Canadian municipalities to include adaptation and mitigation in planning for local sustainability (In Nova Scotia, the provincial government went a step further, requiring separate Municipal Climate Change Action Plans) (GOV/CAN/CAN-NS 2011; GOV/CAN/NS 2011).



Some of the earliest initiatives have been in communities faced with threats from water level changes. A review (2015-2016) of a selection of coastal (including the Great Lakes) Canadian community adaptation plans and guidelines noted that they generally fell into one of the following four categories (Tables 5-2, 5-3):

- **CATEGORY 1:** A broad assessment of the existing and potential threat posed by climate change. Less information on guidance for adaptation and development.
- **CATEGORY 2:** A broad guideline on adaptation policy and principles, with little regional focus.
- **CATEGORY 3:** A more targeted approach that focuses on local context for adaptation but without specific details.
- **CATEGORY 4:** A guideline that includes specific mitigation and adaptation options for use in a defined location/region, offering local guidance for action.



These, and other, short- and long-term initiatives have contributed significantly to an improved understanding of the effects of changing conditions at the local level, and bolstered community and organizational capacity by providing access to scientists, technology and other resources not normally found within the capacity of municipalities. The projects advanced local knowledge on climate change and its impacts, furthered understanding of exposure and vulnerability to hazards, and proposed early steps towards the development of risk management processes to address anticipated issues. Many approaches focused on single attributes of climate change (e.g., sea-level rise, severe weather) as opposed to taking a broader look at how a changing environment would affect the well-being of the community. Fewer studies proposed specific activities to mitigate greenhouse gas emissions. The citations for a range of regional, provincial and local adaptation plans are included in the Additional Readings Section at the end of this chapter

TABLE 5-2: Summary of selected coastal municipal plans and guidelines for adaptation to climate change

LOCATION	REPORT	WEB ACCESS	CAT
NORTH COAST			
Iqaluit NU	Climate change impacts, infrastructure risks, and adaptive capacity project 2007	N/A	4
	Climate change adaptation action plan for Iqaluit 2010	https://www.cip-icu.ca/Files/Resources/IQALUIT_REPORT_E	3
WEST COAST			
Vancouver BC	Climate change adaptation strategy	http://vancouver.ca/files/cov/Vancouver-Climate-Change-Adaptation-Strategy-2012-11-07.pdf	3
North Vancouver BC	Climate change adaptation plan	http://www.cnv.org/~/media/75fc8450fba74fb6b8b7443dc0990966.pdf	3
Victoria BC	P1 and P2 Report	http://www.victoria.ca/assets/Departments/Sustainability/Documents/Adaptation%20Phase%201%20and%202%20Report.pdf	4
Saanich BC	Climate change adaptation plan	http://www.saanich.ca/living/climate/pdf/saanich_adaptation_plan_web_adopted_oct2411.pdf	3
Burnaby BC	Operational and supporting documents	https://www.burnaby.ca/City-Services/Planning/Environmental-Planning/Climate-Change.html	2
Surrey BC	Climate adaptation strategy	http://www.surrey.ca/files/Climate_Adaptation_Strategy_-_FINAL.pdf	4
Gibsons BC	Coastal climate change	http://www.gibsons.ca/include/get.php?nodeid=662	4
EAST COAST			
Montréal QC	Climate change adaptation plan 2015-2020	http://ville.montreal.qc.ca/pls/portal/docs/PAGE/ENVIRO_FR/MEDIA/DOCUMENTS/PACCAM_2015-020_SUMMARY.PDF	4
	Climate protection corporate action plan 2005	https://ville.montreal.qc.ca/pls/portal/docs/page/enviro_fr/media/documents/climate_corporate_action_plan.pdf	3
Trois Rivière	Plan d'adaptation aux changements climatiques –2005	http://citoyen.v3r.net/docs_upload/documents/langue1/Environnement/Plan_d_adaptation.pdf	4
Province of Nova Scotia	Municipal Climate Change Action Plan Guidebook (Provincial policy)	https://www.fcm.ca/Documents/tools/PCP/municipal_climate_change_action_plan_guidebook_EN.pdf	NA
Halifax Regional Municipality NS	Municipal Climate Change Action Planning	http://www.halifax.ca/energy-environment/environment/documents/2-MunicipalClimateChangeActionPlanReport.pdf	4
Yarmouth NS	Municipal Climate Change Action Plan	https://www.district.yarmouth.ns.ca/images/stories/PDF/Reports/MCCAP_Thriving_in_Uncertainty_Combined_Document_January_31_2014.pdf	4
Cape Breton Regional Municipality NS	Municipal Climate Change Action Plan	http://www.cbrm.ns.ca/images/Planning/MCCAP_Final_Report_adopted_by_Council.pdf	4
Charlottetown PE	Town plan review and Adapting to sea-level rise	http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/mun/pdf/13-0647-Charlottetown_e.pdf	2
Stratford PE	Climate change adaptation action plan	https://www.fcm.ca/documents/reports/PCP/climate_change_adaptation_action_plan_for_stratford_pei_EN.pdf	4
St. John's NL	GHG reduction strategy	https://www.fcm.ca/Documents/reports/PCP/City_of_St_Johns_Climate_Change_Action_Plan_2010_EN.pdf	4

TABLE 5-3: Summary of Great Lakes coastal municipal plans and guidelines for adaptation to climate change

LOCATION	REPORT	WEB ACCESS	CAT
GREAT LAKES COAST			
Toronto ON	Climate Change Action Plan:	http://www1.toronto.ca/City%20Of%20Toronto/Environment%20and%20Energy/Programs%20for%20Residents/Files/pdf/C/clean_air_action_plan.pdf	3
	The power to live green-2009	http://www1.toronto.ca/city_of_toronto/environment_and_energy/key_priorities/files/pdf/2009-10_report.pdf	3
	Ahead of the storm – Preparing Toronto for climate change	http://www1.toronto.ca/City%20Of%20Toronto/Environment%20and%20Energy/Our%20Goals/Files/pdf/A/ahead_of_the_storm.pdf	3
	Climate change mitigation – A strategic approach for cities-2010	http://trca.on.ca/dotAsset/81363.pdf	2
	Getting to carbon neutral: A guide for Canadian municipalities - TRCA	http://www.trca.on.ca/dotAsset/68031.pdf	2
	Climate change: Natural heritage risk assessment framework & adaptive management	http://www.trca.on.ca/dotAsset/68031.pdf	2
	Integration of climate change impacts and adaptation into municipal policy and programs: A focus on water management	http://www.trca.on.ca/dotAsset/26632.pdf	2
	Mainstreaming risk-based management of climate change impacts in Canada: Which guidance is needed-2010	http://www.trca.on.ca/trca-user-uploads/CCRMS_Paper_FINAL_V5.pdf	2
	A climate of concern: climate change and health strategy for Toronto – 2015	http://www.toronto.ca/legdocs/mmis/2015/hl/bgrd/backgroundfile-81509.pdf	3
	Exploring health and social impacts of climate change in Toronto-2013	http://www.toronto.ca/legdocs/mmis/2013/hl/bgrd/backgroundfile-62786.pdf	2
Niagara ON	Niagara Region community climate change action plan -2013	http://www.fcm.ca/Documents/reports/PCP/Niagara_Region_Community_Climate_Change_Action_Plan_EN.pdf	3
	Niagara Region corporate climate change action plan-2013	https://www.niagararegion.ca/government/planning/pdf/climate/Corporate-Climate-Action-Plan.pdf	3
	Adapting to climate change: Challenges for Niagara 2012	http://www.niagaraknowledgeexchange.com/wp-content/uploads/sites/2/2014/05/Adapting_to_Climate_Change.pdf	3
Hamilton ON	Taking action on climate change in Hamilton – A community plan - 2014	https://www.dropbox.com/s/w1e3hzrrsae3uoa/Hamilton%20CCAP%20FINAL%202015.pdf?dl=0	3
	The economic impact of climate action priorities -2015	https://www.dropbox.com/s/5071hsu8t8ktsb7/Background-Economic%20Impact%20Report-Final%202015.pdf?dl=0	3
	Hamilton Conservation Authority climate change strategy-2012	https://conservationhamilton.ca/images/PDFs/Climate%20Change/HCA%20Climate%20Change%20Strategy%20March%201%202011.pdf	3
	GRIDS background study: Hamilton's vulnerability to climate change – 2004	http://www2.hamilton.ca/NR/rdonlyres/6FF4F619-2C2C-487C-8813-C11A73DA03E8/0/BackgroundStudyFinal.pdf	3
Oakville ON	Climate change primer	http://www.oakville.ca/assets/general%20-%20environment/ClimateChangePrimer.pdf	3
	Climate change strategy - Technical report – 2014	http://www.oakville.ca/assets/general%20-%20environment/Version_1.1_FINAL_Climate_Change_Strategy.pdf	3
	Environmental strategic plan	http://www.oakville.ca/assets/general%20-%20environment/Environmental_Strategic_Plan_2005.pdf	4

STRENGTHS OF EARLY APPROACHES

- Development of methodologies to proactively engage the public
- Shared perspectives on goals and public valuations of vulnerable assets
- Early attention to the need to address overland flooding
- Constructive dialogues on the need to reduce vulnerabilities to catastrophic losses
- Preliminary estimates of the economic value of affected assets and the potential for damage and/or loss
- Assessment of capacity in emergency response resources
- Community- university alliances to build local capacity
- Increased emphasis on the need for good science
- Knowledge dissemination to the public
- Development of initial guidelines to assist in changes to development planning and management
- Along marine coasts - the focus has been on response to sea-level rise

MISSED OPPORTUNITIES

- Limited engagement across sectors and levels of governments
- Limited national / regional policy or guidelines on mitigation and adaptation efforts
- Lack of integration into existing policies, plans and practices
- Little updating of regulations and codes (e.g., environmental, waste treatment, construction)
- 'Business as usual' in many development planning and permitting activities
- Limited resources for new science and technology
- Continued separation of adaptation and sustainability policies
- Limited recognition of the roles played by natural features (e.g., beaches, dunes, wetlands, coastal and urban forests)
- Lack of understanding of the secondary impacts of climate change on primary industry sectors and social well-being
- Failure to change current practices in waterfront development
- Along marine coasts-the focus was on response to sea-level rise.

Action to date on climate change in Canada could be separated into two categories:

- Early efforts (i.e., pre-2012) in which governments, communities, industries and organizations attempted to understand the threats associated with a changing global environment, and how that could affect them either locally, or in the national or international contexts of their work and/or markets.
- More recent efforts (i.e., 2012 to date) during which time the public (and many governments) have accepted scientific warnings about human induced global warming and have realized that continued greenhouse gas emissions will launch society into a period of unprecedented change and catastrophe experienced at a global and a local level.

Because much of the earlier work was often led through environmentally focussed agencies and organizations, it often did not gain the widespread acceptance needed across industrial, economic and planning sectors. While gains were made in planning for climate change, most dealt with traditional responses to the need to update protection from floodwaters, be they riverine or marine.

The argument about tenuous connections between increasingly severe weather and a warming global climate continued, often supported by the lack of statistically relevant data on the probability for continued occurrence of intense storm events. Less emphasis was placed on local efforts to reduce GHG emissions, probably because there was little impetus by higher levels of government to initiate the sort of societal change that would be needed to achieve significant reductions in the harvest, transportation and use of fossil fuels.

As a result, most of the past decade of work on climate change has had as its focus the engagement of the public in 'bottom up' goal setting and planning initiatives that may or may not have received the attention needed by decision-makers responsible for initiating recommended changes to current practice.

REFERENCES

Adger, W. N., N. W. Arnell, and E. L. Tompkins. 2005. Successful adaptation to climate change across scales. Global Environmental Change 15:77-86.

Bassett, T.J., and C. Fogelman. 2013. Déjà vu or something new? The adaptation concept in the climate change literature. Geoforum, 48, 42–53.

Burkett, V. R., and M. A. E. Davidson. 2012. Coastal impacts, adaptation and vulnerability: A technical input to the 2012 National Climate Assessment, National Oceanic and Atmospheric Agency, Washington DC. 150 pp.

Fazey, I., R. M. Wise, C. Lyon, C. Câmpeanu, P. Moug, and T. E. Davies. 2015. Past and future adaptation pathways. Climate and Development.

Field, C.B., V.R. Barros, K.J. Mach, M.D. Mastrandrea, M. van Aalst, W.N. Adger, D.J. Arent, J. Barnett, R. Betts, T.E. Bilir, J. Birkmann, J. Carmin, D.D. Chadee, A.J. Challinor, M. Chatterjee, W. Cramer, D.J. Davidson, Y.O. Estrada, J.-P. Gattuso, Y. Hijioka, O. Hoegh-Guldberg, H.Q. Huang, G.E. Insarov, R.N. Jones, R.S. Kovats, P. Romero-Lankao, J.N. Larsen, I.J. Losada, J.A. Marengo, R.F. McLean, L.O. Mearns, R. Mechler, J.F. Morton, I. Niang, T. Oki, J.M. Olwoch, M. Opondo, E.S. Poloczanska, H.-O. Pörtner, M.H. Redsteer, A. Reisinger, A. Revi, D.N. Schmidt, M.R. Shaw, W. Solecki, D.A. Stone, J.M.R. Stone, K.M. Strzepek, A.G. Suarez, P. Tschakert, R. Valentini, S. Vicuña, A. Villamizar, K.E. Vincent, R. Warren, L.L. White, T.J. Wilbanks, P.P. Wong, and G.W. Yohe. 2014. Technical summary. In: Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 35-94.

GOV/CAN. 2015. Canada's commitment to greenhouse gas reductions. Submission to the United Nations Climate Change (UNFCCC). 5 p. Available at http://www4.unfccc.int/submissions/INDC/Published%20Documents/Canada/1/INDC%20-%20Canada%20-%20English.pdf

GOV/CAN/EC. 2013. Canada's emissions trends. Environment Canada, Ottawa. 77 pp.

GOV/CAN/ECCC. 2018. National Inventory Report 1990–2016: Greenhouse gas sources and sinks in Canada. Canada's submission to the United Nations Framework Convention on Climate Change: Executive Summary. Cat. No. En81-4/1E-PDF. Available at: https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2018.html

GOV/CAN-NS. 2011. The municipal climate change action plan guidebook. Canada -Nova Scotia Infrastructure Secretariat, Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds, Halifax NS. 36 pp.

GOV/CAN/NS. 2011. The municipal climate change action plan guidebook. Canada -Nova Scotia Infrastructure Secretariat, Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds, Halifax NS. 36 pp.

Holmes, M., P. Lingl, D. Marshall, I. Bruce, M. Carter, and F. Moola. 2012. All over the map 2012: A comparison of provincial climate change plans. Suzuki Foundation, Vancouver BC. 104 pp.

IPCC. 2014a. Summary for policymakers. Pages 1-32 in C. B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, and a. L. L. W. P.R. Mastrandrea, editors. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge UK.

IPCC. 2014b. Climate Change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)].

IPCC. 2014c. Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland. 151 pp.

James, T. S., J. A. Henton, L. J. Leonard, A. Darlington, D. L. Forbes, and M. Craymer. 2014. Relative sea-level projections in Canada and the adjacent mainland United States. Geological Survey of Canada Open File 7737:72.

Locatelli, B., G. Fedele, V. Fayolle, and A. Baglee. 2015. Synergies between adaptation and mitigation in climate change finance. International Journal of Climate Change Strategies and Management. 8:1; 112-128.

McGlade, C., and P. Ekins. 2015. The geographical distribution of fossil fuels unused when limiting global warming to 2° C. Nature 517:187-190.

Nicholls, R. J., N. Marinova, J. A. Lowe, S. Brown, P. Vellinga, D. De Gusmao, J. Hinkel, and R. S. Tol. 2011. Sea-level rise and its possible impacts given a 'beyond 4 C world' in the twenty-first century. The Royal Society: Mathematical, Physical and Engineering Sciences 369:161-181.

United Nations. 2000. Millennium Declaration. Resolution 55/2. United Nations General Assembly, New York, 6-8 September 2000, New York. 9 pp.

United Nations General Assembly. 2000, United Nations Millennium Declaration, Resolution 55/2, United Nations A/RES/55/2, 18 September 2000.

United Nations General Assembly. 2015. Transforming our world: 2030 Agenda for Sustainable Development. The United Nations General Assembly, 70th Session Agenda Items 15 and 116, Rio de Janeiro. 35 pp.

van Vuuren, D. P., J. Edmonds, M. Kainuma, K. Riahi, A. Thomson, K. Hibbard, G. C. Hurtt, T. Kram, V. Krey, J.-F. Lamarque, T. Masui, M. Meinshausen, N. Nakicenovic, S. J. Smith, and S. K. Rose. 2011. The representative concentration pathways: An overview. Climatic Change 109:5-31.

Watkiss, P., M. Benzie, and R. J. T. Klein. 2015. The complementarity and comparability of climate change adaptation and mitigation. Climate Change 6:541-557.

Warren, F.J. and Lemmen, D.S. 2014. Introduction; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, (ed.) F.J. Warren and D.S. Lemmen; Government of Canada, Ottawa, ON, p. 20.

ADDITIONAL READING

MITIGATION AND ADAPTATION

Bassett, T.J., & Fogelman, C. 2013. Déjà vu or something new? The adaptation concept in the climate change literature. Geoforum, 48, 42–53.

Chisari, O., S. Galiani, and S. Miller. 2013. Optimal adaptation and mitigation to climate change in small environmental economies. Inter-American Development Bank, Department of Research and Chief Economist. 417 pp.

CitiGROUP GPS. 2015. Energy Darwinism II: Why a low-carbon future doesn't have to cost the earth. CitiGROUP, Global Perspectives and Solutions. 132 pp.

Georgescu, M., P. E. Morefield, B. G. Bierwagen, and C. P. Weaver. 2014. Urban adaptation can roll back warming of emerging megapolitan regions. Proceedings of the National Academy of Sciences 111:2909-2914.

Gouldson, A., Colenbrander, S., Sudmant, A., Godfrey, N., Millward-Hopkins, J., Fang, W. and Zhao, X. 2015. Accelerating low-carbon development in the world's cities. Contributing paper for Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate. New Climate Economy. Washington DC. Available at: http://newclimateeconomy.report/misc/working-papers

GOV/CAN/NB. 2016. Transitioning to a low-carbon economy: New Brunswick's climate change action plan. Government of New Brunswick, CA. 25 pp.

GOV/CAN/EC. 2015. A breakdown of Canada's 2013 greenhouse gas emissions by economic sector (percent share and absolute emissions in megatonnes of carbon dioxide equivalent). Accessible from www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F60DB708-1

GOV/UK/SCOT. 2017. Transitioning to a low-carbon economy; challenges and opportunities. Ernst & Young LLP, UK. 37 pp.

GOV/USA/NRC. 2015. Climate intervention: Carbon dioxide removal and reliable sequestration. National Research Council. Committee on Geoengineering Climate, Washington DC. 140 pp.

GOV/USA/NRC. 2015. Climate intervention: Reflecting sunlight to cool earth. National Research Council. Committee on Geoengineering Climate, Washington DC. 234 pp.

GRCI. 2012. Annual Global Review 2012 Global cities. 978-0-9870988-3-2, Global Cities Research Institute, RMIT University, Melbourne, Australia. 233 pp.

Hamin, E. M., and N. Gurran. 2009. Urban form and climate change: Balancing adaptation and mitigation in the US and Australia. Habitat international 33:238-245.

Hamin, E. M., and N. Gurran. 2012. Space for adapting: reconciling adaptation and mitigation in local climate change plans. Resilient Cities 2:317-324.

Henstra, D. 2015. The multilevel governance of climate change: Analyzing Canada's adaptation policy regime. Annual Meeting of the Canadian Political Science Association, University of Ottawa.

IPCC. 2014. Climate Change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment, Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge UK. 1454 pp.

Lemprière, T., W. Kurz, E. Hogg, C. Schmoll, G. Rampley, D. Yemshanov, D. McKenney, R. Gilsenan, A. Beatch, and D. Blain. 2013. Canadian boreal forests and climate change mitigation. Environmental Review 21:293-321.

Lowe, A., J. Foster, and S. Winkelman. 2009. Ask the climate question: Adapting to climate change impacts in urban regions. Center for Clean Air Policy, Washington DC. 44 pp.

Mallon, K., E. Hamilton, M. Black, B. Beem, and J. Abs. 2013. Adapting the community sector for climate extremes: Extreme weather, climate change and the community sector-Risks and adaptations. National Climate Change Adaptation Research Facility, Gold Coast. 286 pp.

Martens, P., C. T. Chang, and D. McEvoy. 2012. Integrating Adaptation and Mitigation to Climatic Changes. Regions Magazine 288:18-20.

Parker, P., and S. Oneill. 2012. Energy blocks: Getting back to zero. University of Waterloo, CMHC External Research Program 2010. 118 pp.

Richardson, G. R. A. 2010. Adapting to climate change: An introduction for Canadian municipalities. Natural Resources Canada, Ottawa ON. 40 pp.

SFU/ACT. 2018. Low carbon resilience: ACTPAC briefing note. Adaptation to Climate Change Team, Simon Fraser University. 2 pp.

Snover, A. K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. Preparing for climate change: A guidebook for local, regional, and state governments. Center for Science in the Earth System (The Climate Impacts Group), Joint Institute for the Study of the Atmosphere and Ocean, University of Washington and King County, Washington, in association with ICLEI - Local Governments for Sustainability, Oakland, CA. 186 pp.

Thomas, H. 2003. The role of coastal seas-margins in the global carbon cycle and the importance of interacting with terrestrial and atmospheric communities. CO2 supply from the North Sea to the North Atlantic Ocean-evidence for the continental shelf pump. In OCCP Workshop, Ocean Carbon Coordination Program, Paris

UN. 2015. Transforming our world: The 2030 Agenda for Sustainable Development. Draft resolution United Nations summit for the adoption of the post-2015 development agenda UN 70th Session Agenda Items 15 and 116.35 pp.

Wollstonecraft, T. 2010. Transition to a low-carbon economy. Goldman Sachs Group Inc. 8pp.

WRI/UNDP/UNEP/WB. 2011. World resources 2010–2011: Decision making in a changing climate - Adaptation challenges and choices. World Resources Institute in collaboration with UNDO, UNEP and the World Bank, Washington DC. 184 pp.

ADAPTATION PLANS/GUIDES (NATIONAL & PROVINCIAL)

Batterson, M., and D. Liverman. 2010. Past and future sea-level change in Newfoundland and Labrador: Guidelines for policy and planning. current research: Geologic Survey Report 10-1:129-141.

Boyle, J., M. Cunningham, and J. Dekens. 2013. Climate change adaptation and Canadian infrastructure: A review of the literature. International Institute for Sustainable Development, Winnipeg MN. 40 pp.

EAC. 2008. Exploring issues, Engaging partners: Risk management, climate change & coastal planning. Ecology Action Centre, Coastal Issues Committee, Halifax NS. 25 pp.

Ford, J. D., and B. Smit. 2004. A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. Arctic: 389-400.

Gleeson, J., Gray, P., Douglas, A., Lemieux, C.J., and Nielsen, G. 2011. A practitioner's guide to climate change adaptation in Ontario's ecosystems. Ontario Centre for Climate Impacts and Adaptation Resources, Sudbury ON. 74 pp.

GOV/CAN/ALTA. 2010. Climate change adaptation framework: Manual. Alberta Sustainable Resource Development, Edmonton AL. 38 pp.

GOV/CAN//BC. 2002. Stormwater planning: A guidebook for British Columbia. Governments of British Columbia and Canada, Victoria BC. 244 pp.

GOV/CAN/BC. 2003. dike design and construction guide: Best management practices for British Columbia. A report prepared by Golder Associates Ltd. and Associated Engineering (B.C.) Ltd. for the Province of British Columbia, Ministry of Water, Land and Air Protection, Flood Hazard Management Section, Environmental Protection Division, Victoria BC. 110 pp.

GOV/CAN/BC. 2010. Urban forests: A climate adaptation guide. Government of British Columbia, Fraser Basin Council, and Natural Resources Canada Victoria BC. 55 pp.

GOV/CAN/BC. 2011. Climate change adaptation guidelines for sea dikes and coastal flood hazard land use: Draft policy discussion paper. Project No. 143111, A report prepared by Ausenco Sandwell for the Ministry of Environment of the Government of British Columbia, Victoria BC. 75 pp.

GOV/CAN/BC. 2011. Climate change adaptation guidelines for sea dikes and coastal flood hazard land use: Guidelines for management of coastal flood hazard land use. Ausenco Sandwell for the

GOV/CAN/BC. 2011. Climate change adaptation guidelines for sea dikes and coastal flood hazard land use: Sea dike guidelines. A report prepared by Ausenco Sandwell for the Ministry of Environment of the Government of British Columbia, Victoria BC. 59 pp.

GOV/CAN/BC. 2011. Coastal floodplain mapping: Guidelines and specifications. A report prepared by Kerrwood Leidal Associates Ltd. for the Ministry of Forests, Lands and Natural Resources of the Government of British Columbia, and Natural Resources Canada, Victoria BC. 91 pp.

GOV/CAN/BC. 2011. Rethinking our water ways: A guide to water and watershed planning for BC communities in the face of climate change and other challenges. Fraser Basin Council, Victoria BC. 56 pp.

GOV/CAN/BC. 2012. Cost of adaptation: Sea dikes and alternative strategies: Final Report. EB3762, A report prepared by Delcan for the Ministry of Forests, Lands and Natural Resources of the Government of British Columbia, and Natural Resources Canada, Victoria BC. 123 pp.

GOV/CAN/BC. 2012. Preparing for climate change: An implementation guide for local governments in British Columbia. A report prepared by West Coast Environmental Law for the Government of British Columbia, Vancouver BC. 110 pp.

GOV/CAN/BC. 2013. Sea level rise adaptation primer: A toolkit to build adaptive capacity on Canada's south coasts. A report prepared by the Arlington Group Planning + Architecture Inc., EBA Engineering Consultants Ltd., DE Jardine Consulting, and Sustainability Solutions Group for the Ministry Environment of the Government of British Columbia, Victoria BC. 201 pp.

GOV/CAN/BC. 2014. Considerations for addressing climate change adaptation for transportation infrastructure in highway management, design, operation and maintenance in British Columbia: Best practices document B.C. Ministry of Transportation and Infrastructure, Nodelcorp

GOV/CAN/BC. 2014. Sea level rise in BC: Mobilizing science into action. A report prepared by Sustainability Solutions Group, MC3 for the British Columbia Ministry of Environment, Victoria BC.

GOV/CAN/NS. 2011. The municipal climate change action plan assistant: Learning from others. A report prepared by Elemental Sustainability Consulting Ltd. for the Canada -Nova Scotia Infrastructure Secretariat, Halifax NS. 36 pp.

GOV/CAN/NS. 2011. The municipal climate change action plan: Appendix A: Risk assessment to infrastructure. Canada -Nova Scotia Infrastructure Secretariat, Halifax NS.

GOV/CAN/C-CIARN. 2004. Reducing the vulnerability of coastal trails & boardwalks to storm surge, flooding, erosion and sea ice. C-CIARN Coastal Zone Report 04-3, Government of Canada, Canadian Climate Impacts and Adaptation Research Network, Coastal Zone Sector Coordinating Offices, Ottawa. 35 pp.

GOV/CAN/C-CIARN. 2005. Climate change adaptation in Atlantic Canada: Adapting water management in First Nations communities to climate change. Sixth Workshop of the Atlantic Region of the Canadian Climate Impacts and Adaptation Research Network (C-CIARN Atlantic) in conjunction with the Atlantic First Nations Environmental Network, Moncton NB. 92 pp.

GOV/CAN/DFO/EC. 1999. Shoreline structures and design: A guide for structures along estuaries and large rivers. Fisheries and Oceans Canada, Environment Canada, Vancouver BC. 142 pp.

GOV/CAN/IC. 2006. Adapting infrastructure to climate change in Canada's cities and communities: A literature review. Infrastructure Canada, Research & Analysis Division, Ottawa. 23 pp.

GOV/CAN/MAN. Planning resource guide: Climate change adaptation through land use planning. Government of Manitoba, Winnipeg MN. 10 pp.

GOV/CAN/NB. 2005. A coastal areas protection policy for New Brunswick. Sustainable Planning Branch, Department of the Environment and Local Government, Government of New Brunswick, Fredericton, NB. 15 pp.

GOV/CAN/NB. 2014. New Brunswick climate change adaptation project profiles. Sustainable Planning Branch, Department of the Environment and Local Government, Government of New Brunswick Fredericton, NB. 8 pp.

GOV/CAN/NRCAN. 2010. Adapting to climate change: An introduction for Canadian municipalities. Cat. No. M174-6/2010E-PDF (On-line), Natural Resources Canada, Ottawa. 48 pp.

GOV/CAN/NS. 2001. Local government resource handbook. Service Nova Scotia and Municipal Relations, Halifax NS. 403 pp.

GOV/CAN/NS. 2005. Adapting to a changing climate in Nova Scotia: Vulnerability assessment and adaptation options. Government of Nova Scotia, Halifax NS. 105 pp.

GOV/CAN/NS. 2011. Guide to considering climate change in environmental assessments in Nova Scotia. Nova Scotia Environment, Halifax NS. 20 pp

GOV/CAN/NS. 2011. Guide to considering climate change in project development in Nova Scotia. Nova Scotia Environment, Halifax NS. 48 pp.

GOV/CAN/NS. 2012. Setbacks and vegetated buffers in Nova Scotia: A review and analysis of current practices and management options. HydroLogic Systems Research Group for the Government of Nova Scotia, Departments of Environment, Fisheries and Aquaculture, Halifax NS. 122 pp.

GOV/CAN/ON. 2011. A practitioner's guide to climate change adaptation in Ontario's ecosystems. Ontario Centre for Climate Impacts and Adaptation Resources, Sudbury ON. 74 pp.

GOV/CAN/ON. 2015. Ontario's climate change discussion paper 2015. Ontario Ministry of the Environment and Climate Change, Toronto ON. 44 pp.

GOV/CAN/Parks. 2007. Prince Edward Island National Park of Canada and Dalvay-by-the-Sea National Historic Site of Canada management plan. Parks Canada, Charlottetown PE. 85 pp.

GOV/CAN/PEI. 2015. Prince Edward Island and climate change: A strategy for reducing the impacts of global warming. Government of Prince Edward Island, Department of Environment, Charlottetown PE. 44 pp.

GOV/CAN/PEI. 2003. Buffer zone brochure. Government of Prince Edward Island, Charlottetown PE.

GOV/CAN/PEI. 2012. Coastal area development regulations. Page 77 Planning Act Subdivision and development Regulations, Province of Prince Edward Island Canada.

Holmes, M., P. Lingl, D. Marshall, I. Bruce, M. Carter, and F. Moola. 2012. All over the map 2012: A comparison of provincial climate change plans. David Suzuki Foundation, Vancouver. 104 pp.

Hotte, N., and H. Nelson. 2015. Economic instruments for adaptation to climate change in forestry: Final report. Produced through the Adaptation Platform Economics Working Group, Natural Resources Canada, the Government of British Columbia Ottawa. 255 pp.

HRM. 2007. ClimateSMART: Climate Change: Developer's risk management guide. Halifax Regional Municipality, Halifax NS. 35 pp.

ICLEI. 2007. Preparing for climate change: A guidebook for local, regional, and state governments. Center for Science in the Earth System (The Climate Impacts Group), Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, and King County, Washington for ICLEI - Local Governments for Sustainability, Oakland CA. 186 pp.

Lamont, G., J. Readshaw, J. Robinson, and P. St.-Germain. 2014. Greening shorelines to enhance resilience: An evaluation of approaches for adaptation to sea level rise. Stewardship Centre for British Columbia and Natural Resources Canada. 46 pp.

MaPP. 2014. Regional climate change framework: Version 2.1; Draft Report. Marine Planning Partnership for the North Pacific Coast. 19 pp.

NatureServe. 2013. Tools for coastal climate adaptation planning: A guide for selecting tools to assist with ecosystem-based climate planning. NatureServe and the Ecosystem-based Management Tools Network, Arlington VA. 48 pp.

Nelitz, M., S. Boardley, and R. Smith. 2013. Tools for climate change vulnerability assessments for watersheds. Canadian Council of Ministers of the Environment (CCME). 125 pp.

SFU/ACT. 2011. Climate change adaptation and water governance: Summary for decision-makers. Adaptation to Climate Change Team, Simon Fraser University, Vancouver BC. 38 pp.

SFU/ACT. 2011. Summary report: Climate change adaptation and water governance. Simon Frazer University, Adaptation to Climate Change Team (ACT), Vancouver BC.

West Coast Environmental Law. 2012. Preparing for climate change: An implementation guide for local governments in British Columbia. BC Regional Adaptation Collaborative (RAC) Preparing for Climate Change: Securing BC's water Future, Vancouver BC. 108 pp

ADAPTATION PLANS/GUIDES (LOCAL-CANADA)

Barron, S. C., G.; Carmichael, J.; Flanders, D.; Pond, E.; Sheppard, S.; Tatebe, K. 2012. A climate change adaptation planning process for low-lying, communities vulnerable to sea level rise. Sustainability Science 4.

Beaulieu, N., J. Santos Silva, and S. Plante. 2015. Using a vision of a desired future in climate change adaptation planning: lessons learned in the municipality of Rivière-au-Tonnerre (Québec, Canada). Climate and Development:1-11.

Bizikova, L., T. Neale, and I. Burton. 2008. Canadian communities' guidebook for adaptation to climate change: Introducing an approach to generate mitigation co-benefits in the context of sustainable development: First Edition. Environment Canada and University of British Columbia, Toronto ON. 104 pp.

Black, R. A., J. P. Bruce, and I. D. M. Egener. 2010. Adapting to climate change: A risk-based guide for local governments: Volume 1. A report prepared by Summit Enterprises International Inc. 34 pp.

Bowron, B., and G. Davidson. 2011. Climate change adaptation planning: A Nunavut toolkit: Canadian Institute of Planners. 29 pp.

Bowron, B., and G. Davidson. 2011. Climate change adaptation planning: A handbook for small Canadian communities. Natural Resources Canada and the Canadian Institute of Planners. 59 pp.

Bowron, B., and G. Davidson. 2011. Climate change adaptation planning: Case studies from Canadian communities. Natural Resources Canada and the Canadian Institute of Planners. 67 pp.

Brinkman, D., J. Casey, M. Buel, S. Cohen, Chavez, R. J. Kaplan, D. Marmorek, R. Matthews, K. McPherson, J. Melton, G. Piggot, J. Porter, L. Reese-Hansen, D. Robinson, R. Sydneysmith, J. Smith, J. Tesluk, R. Thompson, and D. Williams. 2012. Climate change adaptation planning for Northwest Skeena communities. 29 pp.

Chester Hazards and Climate Project Team. 2014. The City of Chester Vision 2020 Climate adaptation planning elements. City of Chester, Pennsylvania USA. 89 pp.

City of Charlottetown. 2010. Integrated Community Sustainability Plan, City of Charlottetown, PEI. A report prepared by Stantec Consulting Ltd, Charlottetown PE. 115 pp.

City of Iqaluit. 2007. The City of Iqaluit's climate change impacts, infrastructure risks & adaptive capacity project. Iqaluit, NU. 88 pp.

City of North Vancouver. 2013. Climate change adaptation plan. City of North Vancouver, North Vancouver BC. 27 pp.

City of Surrey. 2013. Climate action strategy. Surrey, BC. 140 pp.

City of Surrey. 2013. Community climate action strategy: reducing emissions and adapting to climate change. City of Surrey, BC. 22 pp.

City of Thunder Bay. 2015. Climate-ready city: City of Thunder Bay climate adaptation strategy. Thunder Bay ON. 116 pp.

City of Vancouver. 2013. Climate change adaptation strategy. A report prepared by The Sustainability Group. 74 pp.

County of Richmond. 2010. Richmond integrated community sustainability plan (ICSP) - Final submission., A report prepared for the Municipality of the County of Richmond, Arichat NS. 61 pp.

County of Richmond. 2013. Municipal climate change action plan. A report prepared by the Université Sainte-Anne, Marine Research Centre, for the Municipality of the County of Richmond, Arichat NS. 80 pp.

District of West Vancouver. 2012. Shoreline protection plan 2012-2015. District of West Vancouver, West Vancouver Shoreline Preservation Society, Balanced Environmental Services Inc., Integrated Planning and Consulting Services Inc., West Vancouver BC. 19 pp.

Doiron, S. 2012. From climate change plans to by-laws: It's time to act. Plan Canada:5.4

Ekistics Planning and Design. 2012. City of Charlottetown, Comprehensive waterfront management plan: Final Report. City of Charlottetown, Charlottetown, 100 pp.

Forbes, D. L., G. K. Manson, J. Charles, K. R. Thompson, and R. B. Taylor. 2009. Halifax harbour extreme water levels in the context of climate change: Scenarios for a 100-year planning horizon. Natural Resources Canada, Dartmouth NS. 21 pp.

Forbes, D. L., T. L. Webster, and C. MacDonald. 2012. Projecting and visualizing future extreme water levels for climate change adaptation in Charlottetown Harbour, Prince Edward Island, Canada (DRAFT). Managing Adaptation to Environmental Change in Coastal Communities: Canada and the Caribbean (C-Change) Project. 35 pp.

Fraser, J., and M. Strand. 2011. Climate change adaptation for local government: A resource guide. Pacific Institute for Climate Solutions, Vancouver BC. 26 pp.

GOV/CAN/NL. 2006. Exercise Dolphin Repot: Town of Channel-Port aux Basques 14th-15th June 2006. A report prepared by SeaCom International Inc., St. John's NL. 34 pp.

GOV/CAN/NRCAN. 2010. Adapting to climate change: An introduction for Canadian municipalities. Cat. No. M174-6/2010E-PDF (On-line), Natural Resources Canada, Ottawa. 48 pp.

GOV/CAN/NRCAN. 2011. Guide to writing community climate change adaptation case studies. A report prepared for Natural Resources Canada by the Clean Air Partnership, the Fraser Basin Council and the British Columbia Ministry of Environment. 26 pp.

Golden, A. D. M., C. and M. A. Smith. 2015. “Blue-ice”: Framing climate change and reframing climate change adaptation from the indigenous peoples' perspective in the northern boreal forest of Ontario, Canada. Climate and Development 7:401-413.

GOMC. 2014. Municipal climate change adaptation around the Bay of Fundy: Status and needs. Gulf of Maine Council on the Marine Environment. 42 pp.

Greenberg, D. A., W. Blanchard, B. Smith, and E. Barrow. 2012. Climate change, mean sea level and high tides in the Bay of Fundy. Atmosphere-Ocean 50:261-276.

Guilbault, S., P. Kovacs, and G. R. A. Richardson. 2016. Cities adapt to extreme heat: Celebrating local leadership. Institute for Catastrophic Loss Reduction London ON. pp.

HRM. 2007. ClimateSMART: Climate Change: Developer's risk management guide. Halifax Regional Municipality, Halifax NS. 35 pp.

ICLEI. 2007. Preparing for climate change: A guidebook for local, regional, and state governments. A report written by the Center for Science in the Earth System (The Climate Impacts Group), Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, and King County, Washington for ICLEI -Local Governments for Sustainability, Oakland CA. 186 pp.

ICLEI. 2010. Changing climate; changing communities: Guide and workbook for municipal climate adaptation. ICLEI Local Governments for Sustainability and Natural Resources Canada, Toronto. 79 pp.

ICLEI-Oceania. 2008. local government climate change adaptation toolkit. ICLEI-Local Governments for Sustainability, Cities for Climate Protection Australia Adaptation Initiative, Melbourne AU. 68 pp.

Jordan, P. T., Mount Allison University, Rural Small-Town Programme, and Canada Mortgage and Housing Corporation. 2002. Residential development in coastal communities: addressing climate change through sustainable coastal planning: Case study analysis. Canada Mortgage and Housing Corp., Ottawa. 38 pp.

Lerner, J. 2011. Climate change adaptation in Clayoquot Sound: Ahousaht Hesquiaht and Tla-o-qui-aht community-based climate change adaptation plans Ecotrust Canada. 226 pp.

Lewis, J., and K. Miller. 2010. Ayuliqtuq: Action and adaptation in Nunavut: Climate change adaptation action plan for Iqaluit. Government of Nunavut, Canadian Institute of Planners, Natural Resources Canada, Indian and Northern Affairs Canada, Intelligent Futures, and the Cowichan Valley Regional District. 31 pp.

Saanich Council. 2011. Saanich climate change adaptation plan. The Corporation of the District of Saanich, Saanich, BC. 41 pp.

Stevens, M. R., and S. Hanschka. 2014. Municipal flood hazard mapping: The case of British Columbia Canada. Natural Hazards 73:907-932.

Toronto and Region Conservation and ESSA Technologies. 2012. Mainstreaming climate change adaptation in Canadian water resource management: The state of practice and strategic directions for action. Toronto and Region Conservation Authority, Toronto ON. 79 pp.

Town of Gibsons. 2012. Gibsons Harbour area plan. A report prepared by Matrix Architecture and Planning Inc., G.P. Rollo and Associates Land Economists, Pottinger Gaherty Environmental Consultants, MVH Urban Planning & Design, Calum Srigley, Don Wuori Landscape Studio and Dr. Alison Shaw for the Town of Gibsons, Gibsons BC. 60 pp.

UBC/CALP. 2010. Local climate change visioning and landscape visualizations guidance manual. A report prepared by the University of British Columbia, Collaborative for Advanced Landscape Planning for the British Columbia Ministry of Community and Rural Development, with assistance from the BC Climate Action Secretariat and the Pacific Institute for Climate Solutions, Victoria. 84 pp.

Urban Strategies Inc., BDA Landscape Architects, and Stantec. 2011. Charlottetown eastern gateway waterfront master plan. Charlottetown PE. 110 pp.

Vancouver, C. o. 2012. City of Vancouver: Climate change adaptation strategy. A report prepared by The Sustainability Group for the City of Vancouver, Vancouver BC. 74 pp.

West Coast Environmental Law. 2012. Preparing for climate change: An implementation guide for local governments in British Columbia. A project of the BC Regional Adaptation Collaborative (RAC) Preparing for Climate Change: Securing BC's water Future, Vancouver BC. 108 pp.

ADAPTATION PLANS/GUIDES (USA)

CIG. 2007. Preparing for climate change : a guidebook for local, regional, and state governments. center for science in the earth system: The Climate Impacts Group, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, King County, WA. 186 pp.

City of Chicago. 2008. Chicago climate action plan: Chicago area climate change quick guide: Adapting to the physical impacts of climate change for municipalities and other organizations. 34 pp.

CRMC. 2011. Urban coastal greenways policy for the Metro Bay Region: Cranston, East Providence, Pawtucket, and Providence: An amendment to the Providence Harbor Special Area Management Plan. Coastal Resources Management Council, Providence, RI. 57 pp.

Georgetown Climate Center. 2011. Adaptation tool kit: Sea-level rise and coastal land use: How governments can use land-use practices to adapt to se-level rise. Georgetown Law, Washington DC. 100 pp.

Goldstein, A., and K. Howard. The great American adaptation road trip. Lessons learned about how hometowns across the United States are building their resilience to climate change. Georgetown Climate Center, Washington DC.

GOV/USA/ALASKA. 2011. Climate change adaptation planning manual for coastal Alaskans and marine dependent communities. A report prepared by the Alaska Sea Grant Marine Advisory Program and the Alaska Center for Climate Assessment and Policy at the University of Alaska, Fairbanks. 49 pp.

GOV/USA/CAL. 2012. California adaptation planning guide: Defining local and regional impacts. A report prepared by the California Emergency Management Agency and the California Natural Resources Agency. 81 pp.

GOV/USA/CAL. 2012. California adaptation planning guide: Identifying adaptation strategies. A report prepared by the California Emergency Management Agency and the California Natural Resources Agency. 68 pp.

GOV/USA/EPA. 2008. Synthesis of adaptation options for coastal areas. Government of the United States Environmental Protection Agency, Office of Air and Radiation, Office of Water, Climate Ready Estuaries Program, Washington DC. 32 pp.

GOV/USA/EPA. 2014. Being prepared for climate change: A workbook for developing risk-based adaptation plans. Environmental Protection Agency, Office of Water, Climate Ready Estuaries, Washington DC. 120 pp.

GOV/USA/EPA. 2014. Climate change action plan. Environmental Protection Agency, Office of Water, Climate Ready Estuaries, Washington DC. 64 pp.

GOV/USA/NC. 2014. CAMA Handbook for development in coastal North Carolina. North Carolina Department of Environment and Natural Resources, Division of Coastal Management., Raleigh NC. 62 pp.

GOV/USA/NOAA. 2002. Mainstreaming adaptation to climate change (MACC): Climate change impacts on land use planning and coastal infrastructure. US National Oceanic and Atmospheric Administration, National Ocean Service (NOS), Washington DC. 38 pp.

GOV/USA/NOAA. 2010. Adapting to climate change: A planning guide for State coastal managers. National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean and Coastal Resource Management, Washington DC. 138 pp.

GOV/USA/NPS. 2016. Coastal adaptation strategies handbook. U.S. Department of the Interior, National Parks Service, NPS 999/134090 Washington DC. 160 pp.

GOV/USA/USAID. 2009. Adapting to coastal climate change: A guidebook for development planners. United States Agency for International Development (USAID), and the Coastal Resources Center, University of Rhode Island (CRC-URI) and International Resources Group (IRG), Washington DC. 164 pp.

Heinz Center. 2007. A survey of climate change adaptation planning. H. John Heinz III Center for Science, Economics and the Environment, Island Press, Washington DC. 100 pp.

ICLEI/LGS USA. 2012. Sea level rise adaptation strategy for San Diego Bay. Prepared by ICLEI-Local Governments for Sustainability for the project's Public Agency Steering Committee, with the support of The San Diego Foundation. 133 pp.

Kirshen, P., K. Knee, and M. Ruth. 2008. Climate change and coastal flooding in Metro Boston: impacts and adaptation strategies. Climatic Change 90:453-473.

Kling, D., and J. N. Sanchirico. 2009. An adaptation portfolio for the United States coastal and marine environment. A report of Resources for the Future. 70 pp.

Norcross-Nu'u, Z., C. Fletcher, M. Barbee, A. Genz, and B. Romine. 2008. Bringing sea-level rise into long range planning considerations on Maui, Hawaii. Pages 107-116. American Society of Civil Engineers (ASCE).

Parkinson, R. W. 2010. Municipal adaptation to sea-level rise: City of Satellite Beach, Florida. A report submitted by RW Parkinson Consulting, Inc. to the City of Satellite Beach, Florida. 27 pp.

Portman, M. E., D. Jin, and E. Thunberg. 2009. Waterfront land use change and marine resource conditions: The case of New Bedford and Fairhaven, Massachusetts. Journal of Ecological Economics 68:2354-2362.

Riggs, S. R., S. J. Culver, D. V. Ames, D. J. Mallison, D. R. Corbett, and J. P. Walsh. 2008. North Carolina's coasts in crisis: A vision for the future. Department of Geological Sciences, Thomas Harriot College of Arts and Sciences, Institute for Coastal Science and Policy, East Carolina University. 32 pp.

Rosenzweig, C., W. D. Solecki, R. Blake, M. Bowman, C. Faris, V. Gornitz, R. Horton, K. Jacob, A. LeBlanc, and R. Leichenko. 2011. Developing coastal adaptation to climate change in the New York City infrastructure-shed: process, approach, tools, and strategies. Climatic Change 106:93-127.

Silton, A. C., and J. Grannis. 2010. Virginia Case Study: Stemming the tide: How local governments can manage rising flood risks. University of Virginia, Georgetown Climate Center, Georgetown State-Federal Climate Resource Center, Georgetown, VA. 24 pp.

Snover, A. K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. Preparing for climate change: A guidebook for local, regional, and state governments. Center for Science in the Earth System (The Climate Impacts Group), Joint Institute for the Study of the Atmosphere and Ocean, University of Washington and King County, Washington, in association with ICLEI - Local Governments for Sustainability, Oakland, CA. 186 pp.

University of Delaware. 2014. Natural hazard and climate change adaptation tool kit for Delaware Communities. University of Delaware, Newark, DE. 44 pp.

Vogel, J., K. M. Carney, J. B. Smith, C. Herrick, M. Stults, M. O'Grady, A. St. Juliana, H. Hosterman, and L. Giangola. 2016. Climate adaptation: The state of practice in U.S. communities. A report written by Abt Associates. 264 pp.

Woodruff, S. C., and M. Stults. 2016. Numerous strategies but limited implementation guidance in US local adaptation plans. Nature Climate Change.

ADAPTATION PLANS/GUIDES (AUSTRALIA AND OTHER)

Beer, A., S. Tually, M. Kroehn, J. Martin, R. Gerritsen, M. Taylor, M. Graymore, and J. Law. 2014. Australia's country towns 2050: What will a climate adapted settlement pattern look like? National Climate Change Adaptation Research Facility, Gold Coast. 139 pp.

City of Copenhagen. 2011. Copenhagen climate adaptation plan: Copenhagen carbon neutral by 2025. Copenhagen. 100 pp.

Engineers Australia. 2012. Climate Change adaptation guidelines in coastal management and planning. Engineers Australia National Committee on Coastal and Ocean Engineering, Crows Nest NSW Australia. 113 pp.

Forsythe, P. J. 2009. Planning on a retreating coastline: Oamaru, North Otago, New Zealand. Government of New Zealand, Dunedin, NZ. 57 pp.

GOV/AUSTRAL. 2008. Perth draft coastal planning strategy: Chapter 7 Planning issues, objectives and recommendations. Government of Australia, Perth Australia. 84-109 pp.

GOV/AUSTRAL. 2009. Climate change risks to Australia's coast: A first pass national assessment. Government of Australia, Department of Climate Change, Sydney Australia. 172 pp.

GOV/AUSTRAL/NSW. 2003. Coastal design guidelines for New South Wales. Government of Australia, State of New South Wales, Coastal Council. 88 pp.

GOV/AUSTRAL/NSW. 2008. North coast urban design guidelines. A report prepared by Hassel for the State of New South Wales Department of Planning. 140 pp.

GOV/AUSTRAL/NSW. 2009. Draft NSW coastal planning guideline: Adapting to sea level rise. Consultation draft – Not government policy. State of New South Wales, Department of Planning, Sydney. 28 pp.

GOV/AUSTRAL/NSW. 2010. Coastal Councils: Climate change adaptation plan. A report prepared by Marsden Jacob Associates for the Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS) Thornton NSW 117 pp.

GOV/AUSTRAL/NSW. 2010. New South Wales planning guideline: Adapting to sea level rise. Government of Australia, State of New South Wales Department of Planning, Sydney Australia. 28 pp.

GOV/AUSTRAL/ONSLOW. 2011. LandCorp: Onslow Townsite planning: Coastal setbacks and development levels. A report prepared by M. P. Rogers & Associates Pl, Onslow, Australia.

GOV/AUSTRAL/WA. 2012. State Coastal Planning Policy guidelines: Draft State Planning Policy 2.6. Prepared under Part Three of the Planning and Development Act 2005 by the Western Australian Planning Commission, Perth AUS. 28 pp.

GOV/NZ. 2008. Climate change effects and impacts assessment: A guidance manual for local government in New Zealand-2nd edition. Government of New Zealand, Ministry for the Environment, Wellington. 167 pp.

GOV/NZ. 2008. Coastal hazards and climate change: A guidance manual for local government in New Zealand: 2nd Edition. Government of New Zealand, Ministry for the Environment, Wellington, New Zealand. 139 pp.

GOV/NZ. 2009. Rural subdivision design guide. Kapiti Coast District Council, Paraparamu, NZ. 44 pp.

ICLEI Oceania. 2008. Local government climate change adaptation toolkit. ICLEI – Local governments for sustainability, Cities for Climate Protection Australia Adaptation Initiative, Melbourne AU. 68 pp.

IISD. 2013. ADAPTool Guidebook: V2.0 for existing policies. International Institute for Sustainable Development Report submitted to Climate Change Impacts and Adaptation Division, Natural Resources Canada Winnipeg MN. 24 pp.

Gross, J. E., S. Woodley, L. A. Welling, and J. E. M. Watson. 2016. Adapting to climate change: Guidance for protected area managers and planners. IUCN, Best Practice Protected Areas Guidelines Series No. 24 Gland Switzerland. xviii + 129 pp.

Macintosh, A. 2012. Coastal adaptation planning: A case study on Victoria. Australian National University, Centre for Climate Law and Policy, Canberra. 30 pp.

Niven, R. J., and D. K. Bardsley. 2013. Planned retreat as a management response to coastal risk: A case study from the Fleurieu Peninsula, South Australia. Regional Environmental Change 13:193-209.

Nursey-Bray, M., D. Fergie, V. Arbon, L.-I. Rigney, R. Palmer, J. Tibby, N. Harvey, and L. Hackworth. 2013. Community based adaptation to climate change: The Arabana, South Australia., National Climate Change Adaptation Research Facility, Gold Coast. 133 pp.

TCPA/RTPI. 2018. Planning for climate change: A guide for local authorities. Town and Country Planning Association and the Royal Town Planning Institute. London, UK. 61 pp. Available at: http://www.rtpi.org.uk/media/2852781/TCPA%20RTPI%20planning%20for%20climate%20change%20guide_final.pdf

Stanley, J., B. Birrell, P. Brain, M. Carey, M. Duffy, S. Ferraro, S. Fisher, D. Griggs, A. Hall, T. Kestin, C. Macmillan, I. Manning, H. Martin, V. Rapson, M. Spencer, C. Stanley, W. Steffen, M. Symmons, and W. Wright. 2013. What would a climate-adapted settlement look like in 2030? A case study of Inverloch and Sandy Point. Monash University, National Climate Change Adaptation Research Facility, Gold Coast. 221 pp.

Trück, S., S. Mathew, A. Henderson-Sellers, R. Taplin, T. Keighley, and W. Chin. 2013. Climate adaptation decision support tool for local governments. Prioritising climate change adaptation investments for local governments with particular focus on extreme events, MacQuarrie University, National Climate Change Adaptation Research Facility, Gold Coast. 38 pp.

West, J. M., and D. Brereton. 2012. Climate change adaptation in industry and business: A framework for best practice in financial risk assessment, governance and disclosure. Griffith University, University of Queensland, National Climate Change Adaptation Research Facility, Gold Coast. 144 pp.

RESOURCES ON THE WEB

CARBON BRIEF

https://www.carbonbrief.org/

A UK-based website that covers the latest developments in climate science, climate policy and energy policy. The Brief specialises in clear, data-driven articles and graphics to help improve the understanding of climate change, both in terms of the science and the policy response.

CLIMATE CHANGE ADAPATATION COMMUNITY OF PRACTICE (CCACoP)

http://www.climateontario.ca/p_ccac.php

The Ontario Centre for Climate Impacts and Adaptation Resources is an interactive online community that provides a space where researchers, experts, policy makers and practitioners can come together to ask questions, generate ideas, share knowledge and communicate with others who are also working in the field of climate change adaptation. CCACoP emails regular notices of new publications, workshops and webinars free of charge to subscribed members.

ENVIRONMENT AND CLIMATE CHANGE CANADA

http://letstalkclimateaction.ca/index.php?lang=en

The site invites discussion on plans to encourage clean economic growth, reduce GHG emissions in Canada and prepare for the impacts of climate change.

FUTURE EARTH

http://www.futureearth.org/

Future Earth is a major international research platform providing knowledge and support to accelerate our transformations to a sustainable world. The hub will coordinate new, interdisciplinary approaches to research on three themes: Dynamic Planet, Global Sustainable Development and Transformations towards Sustainability. It also aims to be a platform for international engagement to ensure that knowledge is generated in partnership with society and users of science. It is open to scientists of all disciplines, natural and social, as well as engineering, the humanities and law.

NUNANVUT CLIMATE CHANGE CENTRE PERMAFROST DATA BANK

http://climatechangenunavut.ca/en/nunavut-permafrost-databank

The Databank contains permafrost information for Nunavut in one central, user-friendly location. Information includes temperature and depth of permafrost data, best practices and guidelines for building on permafrost, and much more!

WORLD OCEANS OBSERVATORY

http://worldoceanobservatory.org/

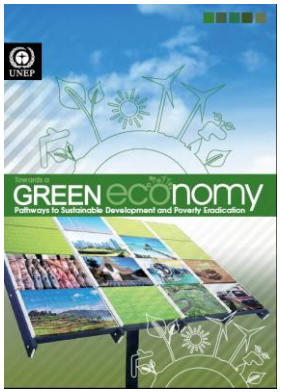
World Ocean Observatory is the leading organization advocating for the health and sustainability of the ocean through an accessible worldwide network of communication. Through education, partnership, information exchange, public connection, and relentless communications, W2O is committed to building an expansive global community of Citizens of the Ocean to promote and conserve marine resources for the future of all mankind.

THE WORLD RESOURCES INSTITUTE

http://www.wri.org/

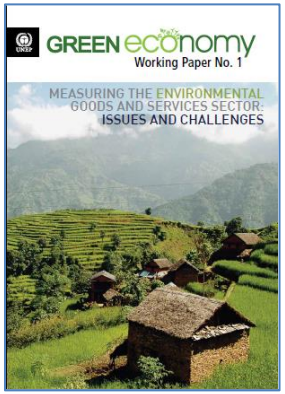
The World Resources Institute is a global research organization that includes more than 450 researchers and staff whose expertise spans over 50 countries. Teams work with leaders to advance big ideas into workable action that sustains natural resources, which are the foundation for opportunity and for human well-being. The WRI focusses on six critical issues at the intersection of environment and development: climate, energy, food, forests, water and cities and transport.

KEY REPORTS



UNEP. 2011. Towards a green economy: Pathways to sustainable development and poverty eradication. United Nations Environment Programme, UNEP/GRID-Arendal, Nairobi, Kenya. 631 pp.

Available at:
http://www.unep.org/greeneconomy/Portals/88/documents/ger/ger_final_dec_2011/Green%20EconomyReport_Final_Dec2011.pdf



UNEP. 2014. Measuring the environmental goods and services sector: Issues and challenges. United Nations Environment Programme, Nairobi, Kenya. 34 pp.

Available at:
http://www.unep.org/greeneconomy/portals/88/documents/WorkingPaperEGSSWorkshop.pdf

6 SEEKING A BETTER FUTURE

6.1 THERE'S MORE TO THIS THAN SEA LEVEL RISE

As the planet warms and environments change, governments, communities and sectors across Canada will be forced to simultaneously plan for, act against, and respond to both the catastrophic damages from increasingly severe weather and the onset of creeping hazards associated with the ever-changing climate.

While sea-level rise is increasingly becoming an issue for some of Canada's marine coasts, it is not the only challenge facing our society. Villages, towns and cities across the nations share most of the same threats associated with extreme weather, increasing periods of heat and cold, destabilized soils, higher concentrations of ground level ozone, damaged structures, and pressures to maintain environmentally sensitive economic sectors.

The policies and practices employed today must be relevant across a range of altering spatial and temporal conditions. Planning now for current resilience and future sustainability offers the widest range of opportunities to best address the immediate and coming challenges. Decision-makers who avoid timely planning and/or action may increasingly be held liable for failure to notify the public of anticipated changes in vulnerability and risk, and for allowing development policy and permitting to proceed without needed changes.

TABLE 6-1: Anticipated challenges to policy, planning and operations

Planning policy and development management	Increased uncertainty in long term land use planning and in infrastructure location, design, and operation
	Changes to urban expansion and waterfront development plans
	Damage/loss to public and private property
	Increased costs for insurance, legal action related to public liabilities
	Costs to retrofit existing structures
	Increased hazards to local land use
Infrastructure	Damage to shorelines and local infrastructure from severe weather and rising water levels
	Damage to infrastructure and services (e.g., energy, communications, transportation, water and wastewater, health)
	Increased hazards to local land use
	Damage to public port and marine facilities, seawalls, and other protective structures
Economic development	Impacts to regional and local rural industries (e.g., agriculture, fishing, tourism, forestry)
	Milder winters strain some industries, open opportunities for others (e.g., agriculture, tourism, forestry)
	Costs for sustainable retrofit will need innovative funding opportunities
Social and community planning	Climate refugees result in increasing population and changing demographics
	Climate refugees revitalize failing communities through influx of younger families
	Climate stress imposes new constraints on lower income residents and other disadvantaged members of society
	Impacts may affect drinking water supply and quality
Recreation and culture	Closure of recreational areas (e.g., pools, beaches) due to water shortages and/or water quality
	Loss of cultural spaces to increasing threats will require the creation of new places in safer areas
Health services, well-being	Increases in the range and seasonality of vector borne diseases
	Higher temperatures, and flooding increase incidences of food and water-borne diseases
	Extreme temperature and precipitation conditions contribute to public safety and well-being
Emergency readiness and response	Increased pressure on disaster readiness and response systems and resources
	Additional resources will be needed to establish and equip emergency shelters for sometimes longer stays by evacuees
Litigation	Legal challenges where decision-makers failed to address climate change in a wide range of planning, development, and service activities

6.1.1 THE COMPLEXITY OF LEADERSHIP

Much good work has already been done, but some situations may require a broader approach to reduce contributions to global warming and to successfully capture the potential benefits of the changing climate, while avoiding the myriad impacts to human society and to individual well-being.

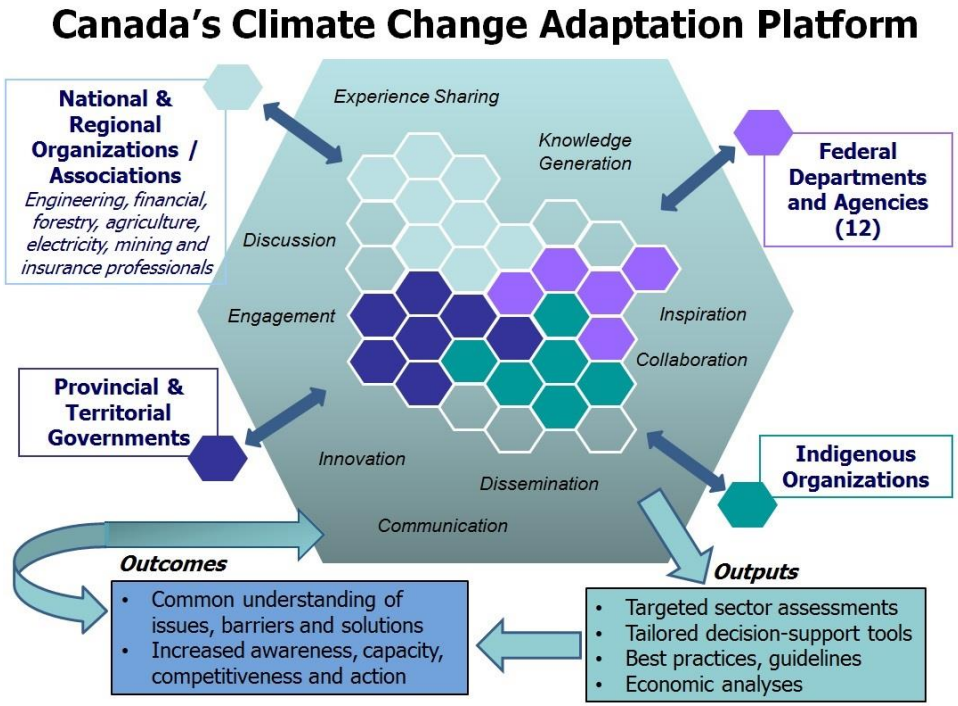


Figure 6-1: The complexities involved in outreach by Canada's Climate Adaptation Platform. Note: This chart does not include municipal governance. *(NRCan. Available at; https://www.nrcan.gc.ca/environment/impacts-adaptation/adaptation-platform/10027).*

The responsibilities for management of land and water resources in Canada can be fragmented across various levels and sectors of government (Figure 6-1) (Henstra 2015). At the federal level, systems were created when the distribution of Canadian population was 80% rural and only 20% urban. Consequently, federal policies and programs have dealt primarily with the management of resources and not with the management of communities. In today's world, 80% of Canadians live in urban centres and only 20% remain in rural areas, increasing demands on local levels of government. Municipalities are challenged with the provision of services to growing populations, relying on taxation as their primary mechanism to raise funds. This situation can result in short-term management with limited opportunities to plan for or to execute widespread change. Policies that direct the management of local assets may originate with federal or regional levels of government, but action is best accomplished at the local level, through careful education of the public, and the collaborative engagement of local governments.

It is widely accepted that reduction of existing and anticipated risks can offer the best path towards enhancing the capacity of local governments to withstand, and/or to adapt to both the insidious (long-term) and catastrophic (rapid onset) hazards now associated with a changing climate. To be successful, planning, design, construction, and management that addresses anticipated changes in environmental conditions will be complex adventures, undertaken by many actors, having wide-spread ramifications that affect all levels of industry and society. While significant strides have been made in adaptation planning in some areas, many efforts still operate outside of core planning and development activities, and/or have yet to affect operations, making implementation difficult and reducing the potential for measurable gains. At the same time, it must be recognized that responses to this complicated issue increase the demand on already constrained fiscal and human resources, limiting local capacity to make effective changes until threats become imminent. In the face of economic uncertainties, many players in the private sector wait for government to establish a direction for change through policy or regulatory instruments, arguing fiscal limitations and the need to align closely with anticipated government expectations as the rationale to delay their own action.

6.2 FACING MOUNTING CHALLENGES

Climate change poses three immediate challenges to Canadian society. First, we must reduce the emissions of greenhouse gases from current numbers if we are to slow the pace of the changing climate and avoid the anticipated and severe impacts to the environment and to society. Second, we need to prepare society and the economy for the impacts that are occurring and will continue to occur. And third, we need to plan now for anticipated impacts that have yet to manifest.

In many planning, design, construction and management activities, it can be difficult to distinguish between efforts that can be described as mitigation and efforts described as adaptation. In this document, effects to reduce emissions and to improve carbon sequestering (*mitigation*) and efforts to change how society faces ongoing and anticipated changes (*adaptation*) are both generally accepted as being efforts towards *adaptation*.

In seeking opportunities to reduce emissions, the oil and gas sector is often targeted because it is one of the largest contributors to greenhouse gases in Canada. However, responsibility for emission reductions should not be left with the resources extraction sectors. As a society, we demand energy to fuel our homes, to run our businesses, and to transport ourselves and our goods. The production of energy and its use in transportation and in buildings accounts for a whopping 72% (520 of 725 Mt) of the gases emitted annually (Figure 6-2).

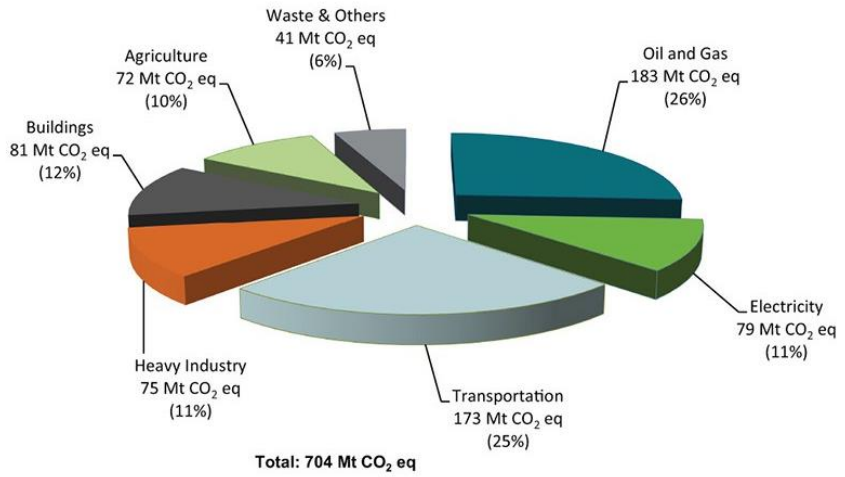
This places the burden of reducing energy demands on the backs of every Canadian. New development should address the requirements of a changing climate in siting, design and construction. Existing structures will need retrofit to reduce energy consumption, improve resilience and ensure safety and well-being of users. Public infrastructure such as water, wastewater and transportation systems will need to be re-assessed and adjusted to anticipated changing conditions. And overall, if we are to manage the future to our benefit, a significant change will be needed in individual, corporate and government behaviour. A new way of thinking. A new way of being.

THREE CATEGORIES OF RESPONSE TO A CHANGING CLIMATE

REDUCE EMISSIONS/SEQUESTER CARBON: Environmental changes are already taking place. The window is closing for opportunities to slow the pace of change, and to moderate anticipated extremes. Immediate efforts to reduce emissions are needed across all sectors. Enhancing our ability to sequester carbon will help.

PREPARE FOR RAPID ONSET HAZARDS: Changes associated with significant weather events (e.g. storm surges, extreme wind and wave activity, erosion, landslides) are already happening in some areas, and with little warning. Hazards created by severe weather may intensify or become more frequent because of the changes in climate. Planning and design for changing conditions can avoid impacts, reduce damage and improve human safety and well-being.

PLAN NOW FOR SLOW ONSET HAZARDS: Environmental changes, such as increasingly extreme temperatures, drought, and sea-level rise, that impact cumulatively or progressively over the long term are termed 'slow onset' or 'creeping' hazards. Planning for these changes should take place early to avoid impacts, minimize damages, reduce costs and create new opportunities.



Note: Totals may not add up due to rounding.

FIGURE 6-2: Breakdown of greenhouse gas emissions in Canada in 2016 by economic sector *(GOV/CAN/ECCC 2018. Available at: https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2018.html).*

6.2.1 THE BENEFITS OF INTERDISCIPLINARY APPROACHES

The complexity of the problems posed by climate change is reflected in the wide-ranging impacts to environment and to society, and in the multiple ramifications of even the simplest actions taken in response. For this reason, most challenges will benefit from an interdisciplinary approach that engages an array of appropriate disciplines and professions, that respects local knowledge and that honours the benefits of community collaboration (Figure 6-3). Teams must be place-based, because conditions may vary geographically.

While traditional approaches to problem-solving often utilize a standard design process (problem delineation, design, specification, construction, operation and maintenance), climate change demands two additional steps implemented at the beginning of the process – team building and goal setting.

Because creativity and innovation will drive many solutions to climate impacts, it is important that all players are engaged and contributing early in the process. Community knowledge, education and support will enhance knowledge, result in shared goals and contribute to successful implementation. Challenged by the need to respect multiple perspectives, design professionals will have to reach past established norms, and engage contractors early in the process, to expand upon the opportunities available for workable alternatives to traditional practice.

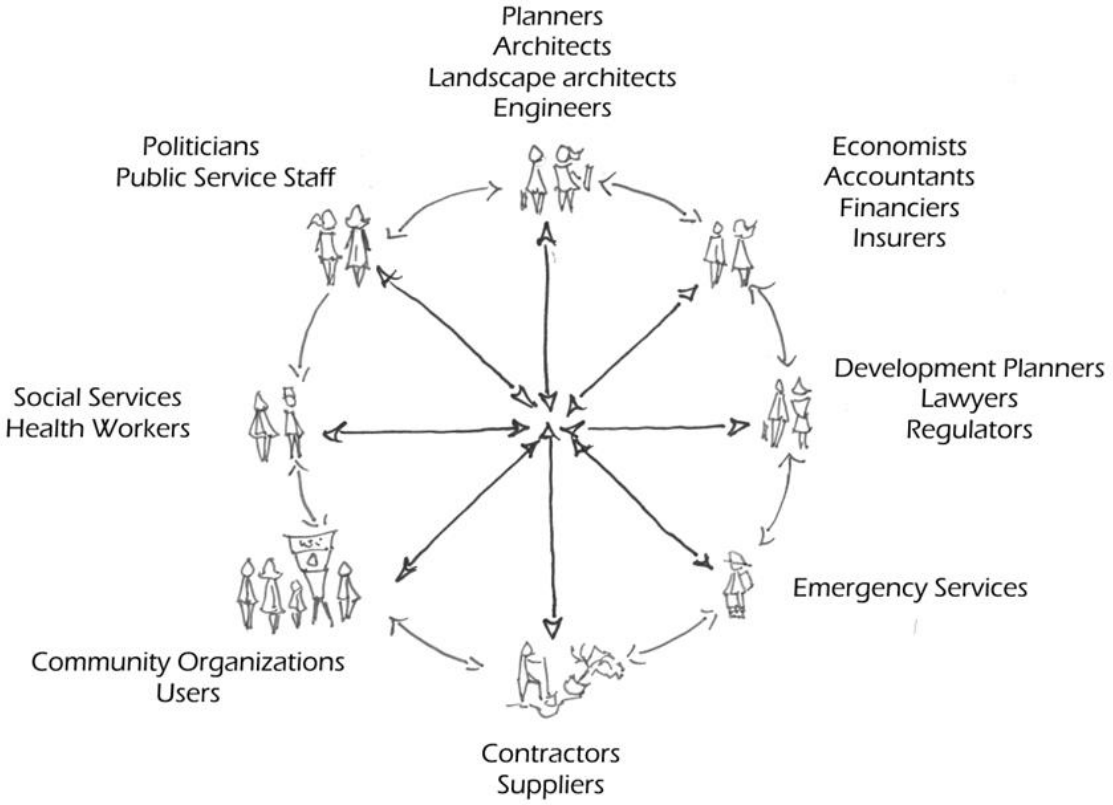


FIGURE 6-3: Innovative planning and design requires the engagement of many specialist, and community players into a collaborative team *(adapted from Thompson and Sorvig 2008).*

6.2.2 BUILDING ON WHAT WE HAVE

Depending on location, ownership, scale and operational factors, there can be a wide range of tools and instruments administered by municipal, county/district, provincial/territorial and/or federal authorities to manage land development, resource extraction, construction and maintenance of structures, utilities, water, wastewater, solid waste and transportation systems and other myriad components of society (Table 6-2). Whether applied in anticipation or in response to a climate related impact, these existing regulatory instruments, tools and standards could be adapted to reduce risk through avoidance of impact, to minimize the damages anticipated and to advance proactive planning for change.

Careful examination of tools we already have in place could provide significant opportunities to reduce greenhouse gas emissions, reform community development patterns, increase green infrastructure, and avoid or reduce vulnerabilities to hazards created or exacerbated by a changing environment. However, significant complexities are encountered when attempting to work across the sectors and levels of government. Development planning and management will benefit most when a multi-pronged process requires an array of government agencies to collaborate in their efforts to protect people, property and the environment.

As our physical environment changes, there will be wide-spread and knock-on impacts across ecosystems and across society, requiring careful re-examination of current regulatory instruments and practice to ensure that:

- all instruments accurately reflect existing and anticipated changes in the environment, including anticipated changes that could affect the long-term life of the proposed development;
- alterations to regulatory instruments accept entrained uncertainty in projections for future conditions (e.g., height of storm surge; extreme precipitation events), but that such uncertainty does not postpone making needed changes now;
- changes to regulatory instruments are co-ordinated across related policy, programs, and enforcement practices to ensure a united approach; and
- there are periodic reviews of the effectiveness of regulatory instruments to ensure ongoing relevance to the issues at hand.

TABLE 6-2: A sample checklist of existing instruments and tools that support assessment of changing conditions, inform interventions and advance future planning for change of existing and new development

INFORMATION, INSTRUMENTS AND TOOLS	APPLICABLE TO SITUATION (Y/N)	UPDATED FOR CLIMATE CHANGE (Y/N)	INCORPORATED INTO PLANNING, DESIGN, MANAGEMENT (Y/N)
Global climate change scenarios			
Anticipated extremes of heat and cold			
Predictive planetary sea-level rise models			
Anticipated temperature changes			
Anticipated changes in local precipitation			
Changes in return periods for severe weather			
Changes in growing season conditions			
Local sea level change predictions			
Local flood scenarios/guidelines			
Return periods for severe weather			
Municipal plans and bylaws			
Zoning restrictions, setbacks and easements			
Development agreements, conditions and guidelines			
Building standards and codes			
Operation and management protocols			
Stormwater management plans			
Water and energy conservation measures			
Enhancements to urban canopy			
Retrofit requirements for existing structures			
Regional and local transportation plans			
Environmental regulations			
Environmental assessment requirements			
Financial and insurance instruments			
Emergency response and evacuation protocols			

6.2.3 THE SPECIAL CASE FOR ENVIRONMENTAL ASSESSMENT AND REGULATION

Environmental assessment processes at the Provincial and Federal levels have, for some years now, required project proponents to comment on the contribution of the construction and operation of their initiative to climate change. As concerns rise over the need to mitigate greenhouse gas emissions and to anticipate changes in local environmental conditions, assessment processes will likely require more stringent examination of a range of factors with direct and indirect ramifications to and from climate change. Complications will arise over estimated life-cycle impacts given continuing uncertainties on the timing and scope of future changes in the environment attributed to global warming.

With the exception of stormwater management guidelines, many of the environmental requirements applied to industrial, commercial, institutional and residential development within Canada come under the jurisdiction of federal and provincial/territorial governments. Changes in the physical environment attributed to climate change and severe weather events may alter local and regional conditions sufficiently to require governments to adjust regulations, standards and codes of practice such as:

- requirements for mitigation of greenhouse gas emissions could spur changes to air quality regulations;
- higher water temperatures in fresh-water and nearshore coastal environments, and/or lower surface water flows during drought, increases the potential for eutrophication, requiring additional levels of treatment for municipal sewage and for industrial and commercial effluents;
- increased precipitation events above current design standards for significant storms (e.g., 1 in 10, 1 in 25 year), exceed the capacity for municipal stormwater collection and disposal systems, resulting in damage to:
  - infrastructure and in erosion, sedimentation and (additional) contamination of waterways;
  - increased precipitation and associated overland flooding results in contamination of surface waters affecting water quality in drinking water and limiting recreational use of waterways;
  - increased precipitation places higher demands on current practices in erosion and sedimentation control during construction and operation;
  - extraction permits for surface water use (e.g., drinking water, irrigation) are constrained by drought conditions and or contamination;
  - accepted practice for the removal, transportation and disposal of contaminated sediments and soils may no longer be appropriate;
  - more intense storms with associated high intensity wave conditions re-suspend contaminants entrained in bottom sediments, resulting in impacts to local fisheries, and potentially requiring the closure of some fisheries as food sources; and
  - tailings / treatment ponds used in the mining sector and/or by other industrial activities may no longer function adequately (e.g., residence time) requiring increased pond size, strengthening of containment systems, and/or additional treatment.

Also, of concern are the effects of a changing environment on special places, such as parks, conservation areas and cultural landscapes. While there may be little that can be accomplished through human interventions, a reduction in the stresses to these assets from existing and potential human activities can improve their capacity to withstand some of the anticipated changes associated with changing climatic condition and severe weather events.

6.2.4 USING FISCAL INCENTIVES

As early as 2005, the National Roundtable on the Environment and the Economy (NRTEE) had estimated that the average annual costs of climate change for Canada would be $5 Billion by 2020 rising to consume as much as $43 Billion by 2050 (GOV/CAN/NRTEE 2011). It is becoming widely accepted that efforts to reduce greenhouse gas emissions and early attention to avoidance of impact is more economically rational than the costs of recovery. Costs associated with damage to infrastructure, environments and human well-being have already placed significant and unsustainable demands on the financial capacity of governments, industry, communities, financial institutions and individuals. Throughout the country, the prospect of increasing hazards (e.g., overland flooding, landslides, wind and wave damage) is contributing to a re-examination of insurance coverage, government subsidies for damage, and personal and public risk. Whether the objectives are to reduce emissions, to stave off the worst of anticipated changes, to proactively adapt to avoid hazards and to reduce damages, or to anticipate how change will provide economic and social opportunities, the money spent today will reduce negative economic impacts and improve capacity to capture benefits.

When examining how economic leverage is used or can be used to affect decision-making, there are three categories for how monetary incentives can work for or against proactive planning for climate change: positive economic incentives; negative economic incentives (or disincentives; and perverse incentives that arise when practice conflicts with new policy (AID Environment 2004).

In some situations, decisions on whether to abide by the intent of positive incentives can be significantly affected by factors that include:

- the financial consequences and the political and social acceptability of failing to comply;
- the complexity, costs and effectiveness of alternative options;
- the degree of compatibility with other political, economic, environmental and social goals; and
- overall compatibility with market interests.

While many incentives fall within the responsibility of governments, other institutional strictures (e.g., insurance, mortgages) could be applied to alter both development practice and industrial and commercial operations.

INCENTIVES FOR CHANGE

POSITIVE INCENTIVES promote and encourage beneficial change (e.g. rebates for energy conservation retrofit to buildings, lower taxes on low-impact developments, reduced costs for public transportation). Positive incentives can also indirectly effect beneficial change when measures such as wastewater reduction and treatment have knock-on benefits to the health of ecosystems, to support for natural assets (e.g. wetlands) that afford protection from storm events, to quality of life, and to the profitability of sectors such as tourism.

DISINCENTIVES generally encompass a range of financial penalties for activities that can add to emissions or contribute negatively to efforts to manage changing conditions (e.g. higher costs for parking in downtown areas, fines for failures to disconnect roof drains, fines for cutting mature trees);

PERVERSE INCENTIVES arise when existing practices reward unsustainable behaviour. Government subsidies and tax breaks to the fossil fuel industry are perhaps some of the most egregious examples of perverse incentives at a time when nations are attempting to reduce GHG emissions. However, other examples of perverse incentives include areas where residents are still required to connect roof drainage to stormwater collection systems, or where rebates are offered to farmers to continue maintaining dyked land as farmland rather than returning it to salt marsh.

6.2.5 OVERCOMING OBSTACLES

Many communities, organizations and individuals face considerable obstacles in gaining the understanding, acceptance and willingness to change behavior and to alter structures and systems, whether the focus is on mitigation of greenhouse gas emissions or adaptation to a changing climate (Mukheibir et al. 2013). Identifying obstacles is an important exercise, because failure to acknowledge the issues complicates solving the problem and moving forward. At the local level, progress towards change can be obstructed by limitations in resources and conflicting priorities for action. Planning and management systems can be resistant, especially in municipalities where town plans traditionally require lengthy processes for public consultation before changes can be made. Industrial and commercial ventures can fear loss of competitive advantages if they are the first of their sector to invest resources in mitigation and adaptation.

There is no single process, framework or pathway for mitigation and adaptation that can solve all these issues or that can satisfy the myriad needs of local planning and implementation. It is accepted that leadership is critical, as is the capacity to capture existing and potential synergies that ensure lowest costs and highest benefits. It is also clear (IPCC 2012) that to be successful, adaptation processes must pay careful attention to acquiring the following attributes:

OBSTACLES TO ADAPTATION

- Historic predictability in environmental conditions, leading to low importance given to natural disasters and vulnerability to hazards.
- Tensions created between short political and budget cycles of municipal governments and the need for city managers to have a long-term vision on climate change.
- Inadequate knowledge of anticipated changes in local environmental conditions.
- Championing adaptation to climate change has been led mainly by environmental vs economic development departments.
- Local governments are relegated to observer status in national and international discussions on climate change.
- Conflicts over data sharing across levels of government and disciplines of research.
- Concerns about protecting private property rights.
- Limited fiscal resources/human capacity to develop and apply data collected using technologies such as LiDAR.
- Inadequate predictive modelling of impacts possible from a range of climate change scenarios
- Inadequate understanding of the linkages between environmental conditions and societal well-being.
- Lack of relevant information developed at scales appropriate for local application.
- Delay in leadership from higher levels of government.
- Fragmented and ineffective institutional arrangements, with special reference to poor coordination across the sectors and levels of government in Canada.
- Assertions that planning and design decision-making must wait for changes in codes and regulations and/or precise information on needed changes to existing structures, new investments, and/or zoning of land use.
- Continued reliance on existing standards for planning, design and operation of systems (e.g., water, wastewater, stormwater, and flood zoning).
- Reluctance to be the first community or industry to initiate action on mitigation and adaptation.
- Often constrained financial and human resources assigned to immediate and traditional priorities.
- Limitations to options for raising funds to support new initiatives in proactive planning for climate change, or to respond to damages being incurred from extreme weather.
- Inability for many communities to address the residual damages of climate change (i.e., the things that cannot be avoided), because they have no economic or feasible options.
- Lack of political support for action.

(adapted from Beatley 2009; CIG 2007; Nicholls 2007; Rosenzweig et al. 2011; Simpson et al. 2012)

6.3 MAINSTREAMING PRINCIPLES AND GOALS

Without strong, shared principles to guide change, efforts can remain fragmented, short-term, and cost prohibitive. While it is possible for individuals, organizations, communities and sectors to develop and to implement their own plans for adaptation to change, working in isolation from international, national, regional and provincial/territorial policies and practices can be difficult, and may result in failures to capture the widest possible range of benefits from risk reduction measures. Where possible and pragmatic, it may be best to become fully informed and participatory in top-down policy and practise development. It will also be important to ensure that planning for a changing climate is not relegated to one aspect of a business or community, but fully integrated across all systems and sectors, or ***mainstreamed***.

Mainstreaming climate change in governance and/or private sector management could include a range of approaches and activities including (Wamsler 2015):

- Strategic collaboration among relevant internal as well as external players;
- Revision or creation of policies, regulations and instruments that improve harmonization and encourage action;
- Modification of existing institutional structures and working arrangements to enhance resources, action responsibility, and improve visibility for action on climate change;
- Re-alignment of on-the-ground activities to reflect policy changes and to implement action;
- Development and communication of new instructions for operations and development decision-making; and
- Resources to support new initiatives in mitigation and adaptation.

To make this happen across our complex society, there is a growing need for strong, practical and insightful leadership to coordinate requirements for new development and to inform decision-making on mitigation and adaptation. Leadership can facilitate the development of a shared understanding of the challenges and a common vision of the future. Good leadership can bring together the multiple components of an organization that will be affected by either the impacts of climate change, or by the adaptation responses to those changes.

o

MAINSTREAMING: The incorporation of climate change considerations into established or ongoing development programs, policies, or management strategies rather than developing adaptation and mitigation initiatives separately. (*Burkett and Davidson 2012)*

"Integrating climate change and sea-level rise into infrastructure planning improves risk and life-cycle cost management and will reduce the vulnerability of B.C.'s critical infrastructure."

(Lemmen et al. 2008. From impacts to adaptation)

Leadership is the art of getting someone else to do something you want done, …because they want to do it.

Attributed to Dwight D. Eisenhower

6.3.1 USING PRINCIPLES TO GUIDE POLICY DEVELOPMENT

Guiding principles can outline a clear vision for managing human use of the landscape that is based on respect for the past, responsiveness to the needs of today, and advance proactive planning measures that anticipate future conditions and hazards and provide timely responses to complicated situations.

Guiding principles provide a foundation for policy and decision-making that can be relevant at all levels of government and to any or all parties involved in community development and management, including the private sector, conservation organizations, and individual property owners. Adoption of guiding principles provides a context and focus for identifying issues, offers support for priority setting, and provides focus for action.

Once a suite of guiding principles has been adopted, goals and measurable objectives can be developed to act on those principles, tailored to specific local conditions and needs (Kanuri et.al. 2016). Well-stated goals and objectives provide a framework for what needs to be done, how it should be done, and how it can be determined if it was done well.

15 PRINCIPLES TO GUIDE POLICY DEVELOPMENT IN A CHANGING WORLD

This list is a sample of principles for guiding policy development that was gleaned from efforts to promote sustainability and resilience, and from the principles and goals of a range of initiatives in development planning in Canada and throughout the world *(Ballinger et al. 2000; Field et al. 2001; GOV/AUSTRAL/NSW 2009; GOV/AUSTRAL/WA 2012; GOV/UK 2010; GOV/UK/DEFRA 2006a, 2006b; Hamin and Gurran 2009; IOC 2009; Simpson et al. 2012; Tomlinson and Helman 2006; UN 2012; UNEP/GPA 2005, 2009).*

GAIN support from all levels and sectors of government, and from affected decision-makers.

EMPLOY risk assessment tools focussed on creating resilient and sustainable communities and systems.

ADOPT ecosystem-based approaches to management that protect ecosystems and ecosystem services.

REDUCE demands for energy and support renewable energy initiatives.

IMPROVE opportunities for carbon sequestering.

ADDRESS proactively the threats and options for protection of cultural assets.

ENHANCE the capacity of natural features to protect people and their livelihoods.

ENTRENCH planning and design principles that reduce energy consumption and improve sustainability.

REDUCE risk and improve resilience through retrofitting existing structures and systems.

BUILD with insight and innovation.

ADVOCATE for the benefits of early migration away from increasingly hazardous areas.

ENSURE social justice and seek opportunities to continue public access to assets.

ENGAGE the public through communication of opportunities, constraints, and shared risk.

CONTINUE risk assessment that include indicators of socioeconomic change and ecosystem health.

SHARE good practices and lessons learned.

6.4 GUIDING PRINCIPLES FOR CHANGE

One of the challenges being experienced in planning for adaptation to climate change is the lack of a framework for what needs to be done, who needs to do it and how they should be guided in their actions. Perhaps, as a society, and as professionals, we need to restate basic principles that should be understood, but somehow, are not often enough heard in discussions on policy, planning and design.

Within landscape architecture in Canada, there was a need to articulate a framework to guide thinking, and eventually, decision-making. Colleagues told us that, increasingly, clients sought to be informed on changes in weather and climate and the import of those changes on their decisions. Responding to need for planning and design professional to re-engage as leaders on a broad array of public policy, the Canadian Society of Landscape Architects, through its Committee on Climate Adaptation, has been working to confirm principles at the core of the profession; to reaffirm commitments to principles that advance human well-being, argue for social justice, and promote effective stewardship of the environment.

Throughout the world, in the 21st century there has been a restatement of basic principles, an expectation for how humans will interact with each other, and a resurgence of the need to share responsibility for how actions at home affect worldwide economics, environments and the safety and well-being of distant communities.

The discussion on what to do about climate change has become part of the dialogue on fundamental values so aptly reflected in The Millennium Declaration.

THE MILLENNIUM DECLARATION

The 2000 Millennium Declaration of the United Nations declares the following six values to be fundamental to individual societies and to international relations in the twenty-first century:

- **"FREEDOM.** Men and women have the right to live their lives and raise their children in dignity, free from hunger and from the fear of violence, oppression or injustice. Democratic and participatory governance based on the will of the people best assures these rights.
- **EQUALITY.** No individual and no nation must be denied the opportunity to benefit from development. The equal rights and opportunities of women and men must be assured.
- **SOLIDARITY.** Global challenges must be managed in a way that distributes the costs and burdens fairly in accordance with basic principles of equity and social justice. Those who suffer or who benefit least deserve help from those who benefit most.
- **TOLERANCE.** Human beings must respect one other, in all their diversity of belief, culture and language. Differences within and between societies should be neither feared nor repressed but cherished as a precious asset of humanity. A culture of peace and dialogue among all civilizations should be actively promoted.
- **RESPECT FOR NATURE.** Prudence must be shown in the management of all living species and natural resources, in accordance with the precepts of sustainable development. Only in this way can the immeasurable riches provided to us by nature be preserved and passed on to our descendants. The current unsustainable patterns of production and consumption must be changed in the interest of our future welfare and that of our descendants.
- **SHARED RESPONSIBILITY.** Responsibility for managing worldwide economic and social development, as well as threats to international peace and security, must be shared among the nations of the world and should be exercised multi-laterally. As the most universal and most representative organization in the world, the United Nations must play the central role."

United Nations General Assembly. 2000, United Nations Millennium Declaration, Resolution 55/2, United Nations A/RES/55/2, 18 September 2000, page 2

THE IFLA GLOBAL ACCORD

In searching for ways global principles could be brought to bear on local decision-making, Canadians – working with the International Federation of Landscape Architects – articulated a framework for practice, based on three guiding principles for planning and design outlined in the **IFLA Global Accord – planning for a changing future**

(Available at: http://iflaonline.org/professional-practice-and-policy/working-groups-and-task-forces/climate-change/).

The Accord's three linked principles: *resilience, transformation and sustainability,* provide decision-makers with a foundation for their work to reduce emissions and to adapt to existing and anticipated changes in their environment. The Accord draws on individual and collaborative ingenuity to promote the innovative new perspectives and technologies necessary to create the prosperous future we have as yet only dreamed about.

In 2017, the IFLA Global Accord was ratified by the five world regions (IFLA Europe, IFLA Middle East, IFLA Africa, IFLA Americas, and IFLA Asia-Pacific) and the IFLA World Council (76 national associations). The Canadian Society of Landscape Architects was the first national association to ratify the Accord, and work is apace to promote the Accord's principles throughout the profession, across allied professions and economic sectors and throughout the myriad levels of government.

6.4.1 ENHANCING RESILIENCE

Resilience at its heart is a concept we use to improve our understanding of how persistence and transformation co-exist within and transform living systems, including humans and human society (Adger et al. 2011; Folke et al. 2011). Resilience describes the capacity to absorb change without being changed. When thresholds are exceeded, and tipping points are reached, species, ecosystems, individuals and society may transform into altered states, sometimes altering to a positive reality, sometimes to a negative one. The same is true for buildings, utilities, municipal systems, transportation networks. Fostering resilience supports the well-being of existing systems, and in the case of human society, encourages individual creativity, innovation, and enterprise. Building resilience into infrastructure is not without cost. However, the costs associated with full replacement of damaged systems may outweigh the costs of strengthening or duplicating existing systems so that they can still perform to an acceptable standard after disaster events.

Within human society, resilient organizations demonstrate that they have the capacity to absorb impacts and stresses (within limits), and/or to renew components or processes that were damaged by change. Resilient organizations are also more likely to be able to seize upon emerging opportunities to reorganize their elements and processes in new and innovative ways (GRCI 2012).

Resilience is also a characteristic of individual human well-being. Strong individuals are better able to withstand, or to recover from disease, damage and/or stresses. The psychological resilience of an individual reflects their capacity to adapt well to adversity, trauma, tragedy, threats or other sources of stress such as family or relationship issues, challenges to health and well-being, and/or concerns about financial viability or conflicts in the workplace. Resilient people may be knocked down by life but will come back stronger from difficult experiences.

Becoming resilient is not a passive activity. Resilient people and systems do not simply cope with events as they occur, they survive and adapt, becoming better able to respond to the next circumstance. Communities in Canada exemplify what it is for a society to be resilience: to not only absorb challenges and to survive, but to adapt, and to transform so as to embrace all opportunities for a better future (Figure 6-3).

RESILIENCE: "The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation. "(IPCC 2014, p5)

re•sil•ient [ri-zil-yuhnt] adj.

1. Able to bounce back after change or adversity.
2. Capable of preparing for, responding to, and recovering from difficult conditions.

Syn.: TOUGH

(City of New York 2013)

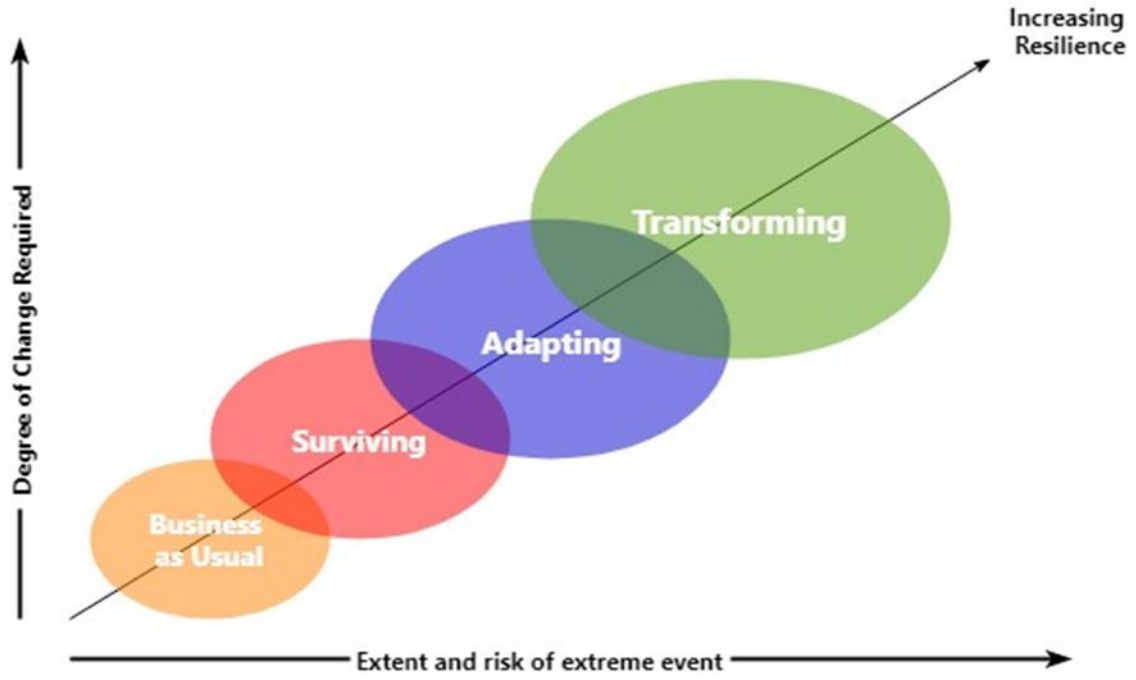


FIGURE 6-3: Surviving, adapting and transforming as components of resilient living *(Adapted from The Royal Society 2014).*

"The capacity of individuals, communities and systems to survive, adapt, and grow in the face of stress and shocks and even transform when conditions require it."

(Rockefeller Foundation)

If collaboration is the core of resilience, **self-reliance is the driving force.** Self-reliance by individuals, by organizations and by communities has historically been the cornerstone for human society in Canada. However, in the past century, as our society and communities have advanced, we have become more expectant that technology and institutions will ensure our well-being, and less engaged in engineering our own path towards a prosperous future.

Climate change will result in major anticipated changes to our environment, as well as myriad other direct and indirect impacts that may be unforeseen. This is the period in our history when reliance on experience must run in tandem with personal and institutional ingenuity. We must rely on individual creativity and work collaboratively to ensure a resilient present and a sustainable future.

IMAGE CREDIT: C. Mercer Clarke

The Killick – Canadian ingenuity at work

A killick is "an anchor made of an elongated stone encased in pliable sticks, bound at the top and fixed in two curved cross-pieces, used in mooring nets and small boats". (Source: Dictionary of Newfoundland English, Online). The term is believed to have originated either from the Irish or Scots Gaelic to describe an ingenious method for creating an anchor from readily found materials. In Canada, Newfoundland fishermen have for generations used killicks of all sizes and shapes as temporary (or permanent) replacements for lost anchors. Killicks are the perfect example of the application of heritage and ingenuity in promoting self-reliance.

LOW CARBON RESILIENCE: A BETTER PATH FORWARD

Throughout Canada, communities facing the complex and often costly challenges of the changing climate may also be constrained by limited financial and human resources. However, with proactive and insightful planning and design, existing or restored natural systems can be used to supplement existing structures and/or to deliver ecosystem services (e.g. sheltering, stormwater management, flood protection) that may reduce costs while improving quality of life in urban areas (SFU ACT 2016).

IMAGE CREDITS C. Mercer Clarke

LOW CARBON RESILIENCE

Historically, greenhouse gas reduction (climate change mitigation) and building resilience to climate change impacts (adaptation) have been approached as separate processes. Combining these strategies can achieve co-benefits and save time and money. Municipalities are moving forward on both adaptation and mitigation planning, and we have a limited window of opportunity in which to implement low carbon resilience to avoid the risk of both building in vulnerability to climate change impacts and inadvertently increasing emissions. *SFU/ACT 2017, p10*

"Ecosystem-based "green infrastructure" projects can help municipalities adapt to climate change impacts such as flooding and extreme heat, and offer multiple co-benefits.

However, cities are not necessarily valuing ecosystem contributions to benefits such as improved property safety and prices; the cultural, spiritual, physical and mental health of residents; water, food and energy security; carbon emissions reductions; water and air pollution reductions, and recreational values.

Furthermore, lack of capacity can make it difficult for neighbouring municipalities to collaborate on managing for ecosystem health across jurisdictional boundaries." *SFU/ACT. 2017, p5.*

6.4.2 ADVANCING POSITIVE TRANSFORMATIONS

In many cases, pursuing resilience in a settlement or society involves a pursuit of stability, an attempt to fortify against changes in the hope that their negative impacts may be prevented. In doing so, however, the society or settlement becomes hardened, and brittle, in a state where it may be capable of resisting a normal suite of changes that it is built to tolerate, but which risks a serious collapse when those capacities are surmounted, particularly with long-term gradual shifts in conditions which that society does not adjust for.

This is why efforts to achieve positive transformative for societies must become a fundamental principle of policy and planning. Stability must be redefined to represent not just a physical stability, but a broader and proactive resilience that requires active pursuit of positive transformation, to proactively adjust to conditions before their negative impacts can be deeply felt. Transformative societies do more than *react* to change, they *embrace* the potential that change brings. By abandoning brittle resistance to change, and adopting this fluidly strong sense of transformative development, a better and truer form of social stability can emerge, one which looks forward to the future self it must become, rather than backward to maintain the past self it once was.

In terms of climate change, positive transformation involves measures such as proactive reductions of GHG emissions, to keep planetary warming within manageable rates. It involves proactively adjusting development patterns in advance of changing flood dynamics, to mitigate the immediate and long-term impacts upon residents. It involves adjusting societal outlooks to reinforce a custodial perspective and an active involvement on the part of most, if not all, of those resident in the region. By accepting that change is inevitable and imminent, we can discard the idea of retaining the dysfunctional past that puts us at risk, to embrace positive transformation towards a better future.

At a time when much of Canada's infrastructure requires repair and/or upgrading, when there is real social and economic benefit to inner city renewal, and when we have finally come to realize the benefits of operating more sustainably with nature than against it, the opportunities to rethink the structures and patterns of human society have seldom been greater. Since we must spend significant resources on our communities and our infrastructure, why not create a vision better suited to provide for the well-being of all?

The 2014 IPCC report highlights:

"that we have the means to limit climate change and its risks, with many solutions that allow for continued economic and human development.

However, stabilizing temperature increase to below 2°C relative to pre-industrial levels will require an urgent and fundamental departure from business as usual.

Moreover, the longer we wait to act, the more it will cost and the greater the technological, economic, social and institutional challenges we will face."

(IPCC 2014 Synthesis Report, p v).

We will build more infrastructure in the next 40 years than (in the) past 4000 years. *Parag Khanna, Author. 2018*

6.4.3 ENSURING SUSTAINABILITY

Throughout the world, there has been a growing acceptance of the need to identify and to integrate within planning and design practice the guiding principles, goals and objectives that promote sustainability (UN 2015). Sustainability is an overarching goal for a future in which environmental, social and economic considerations are balanced in the pursuit of an improved quality of life. In a prosperous society, humans rely on a healthy environment to provide food and resources, safe drinking water and clean air for all its citizens.

The concept of sustainable development first emerged in the late eighties as documented in a report of the World Commission on Environment and Development (Brundtland 1987). In Canada, environmentally sustainable economic development was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept seeks to irrevocably link the continuing viability of natural systems with the cultural, political, and economic demands of a developing human society.

Sustainability is at last a ***practical*** goal. As weather systems intensify, and climate changes place increasing demands on infrastructure, environments and society, the cost of replacing damaged structures, protecting threatened landscapes and rescuing people at risk will rapidly become unsupportable demands on human and fiscal resources. It is now no longer merely ***nice*** to consider the effects of decisions made today on future society, it is ***prudent*** and insightful.

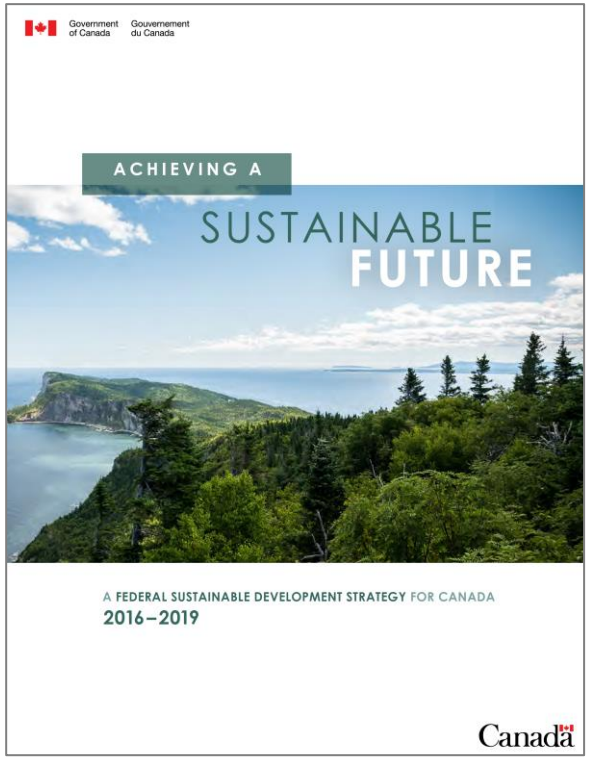
In recent years, the United Nations had renewed its convictions that sustainability is the pathway not only to prosperity for all nations, but to a secured global peace (UN Millennium Declaration 2000). Sustainability of ecosystems and communities has become an increasingly important goal for short term as well as long term planning. As climate change disrupts ecosystems and communities, increasing demands on resources such as water and food can result in the migration of populations away from areas of strife, towards areas that promise safety and security. Nations such as Canada, which are relatively well-equipped to plan for and to adapt to local effects of climate change, will need to address these impacts of more severe effects of climate change on relatively far-flung areas of the world, as they strive to successfully and sustainably incorporate large numbers of climate refugees into their societies.

Considerable guidance on the meaning of sustainability in the modern world, and how organizations and individuals can contribute can be found at the United Nations, from documents such as the Federal Sustainability Strategy for Canada (2016-2019), or from community sustainability plans, which in some communities in Canada have been related to impending changes due to shifts in climate and weather.

> **"It lies in your power,** and therefore is your responsibility, to reach the goals that you have defined"
>
> *(Kofi Annan, Secretary General, The United Nations 2000)*

SUSTAINABLE DEVELOPMENT is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"
Government of Canada: Federal Sustainable Development Act

SUSTAINABILITY calls for a decent standard of living for everyone today without compromising the needs of future generations.



GOVERNMENT OF CANADA
FEDERAL SUSTAINABLE DEVELOPMENT STRATEGY (2016-2019). Available at: *http://fsds-sfdd.ca/index.html#/en/goals/*

THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

(UN General Assembly 2015 p14: Available at https://sustainabledevelopment.un.org/post2015/transformingourworld).

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Although reinterpreted over time, **peace, freedom, development,** and the **environment** remain prominent issues and aspirations. *(Kates et al. 2005)*

THE CIRCLES OF SUSTAINABILITY

Human communities, whether they are villages, towns or cities, have become crucial to the changes needed to address both our continued contributions to greenhouse gases and our efforts to adapt to a steadily altering environment.

To better understand and to manage the critical intersection between human society and the environment, James (2015) (Figure 6-4) uses four dimensions for sustainability: ecology, economics, politics and culture, and portrays the performance towards sustainability.

The dimensions are comprised of a myriad of inter-linked processes and pathways that interact with each other and affect the health and sustainability of both the local and the global environment. These views of our future anticipate that well-being in human communities will depend as much on our ability to promote sustainable practices in sectors such as agriculture, fisheries, and forestry, as it will on changes to our expectations for the production and consumption of goods and services.

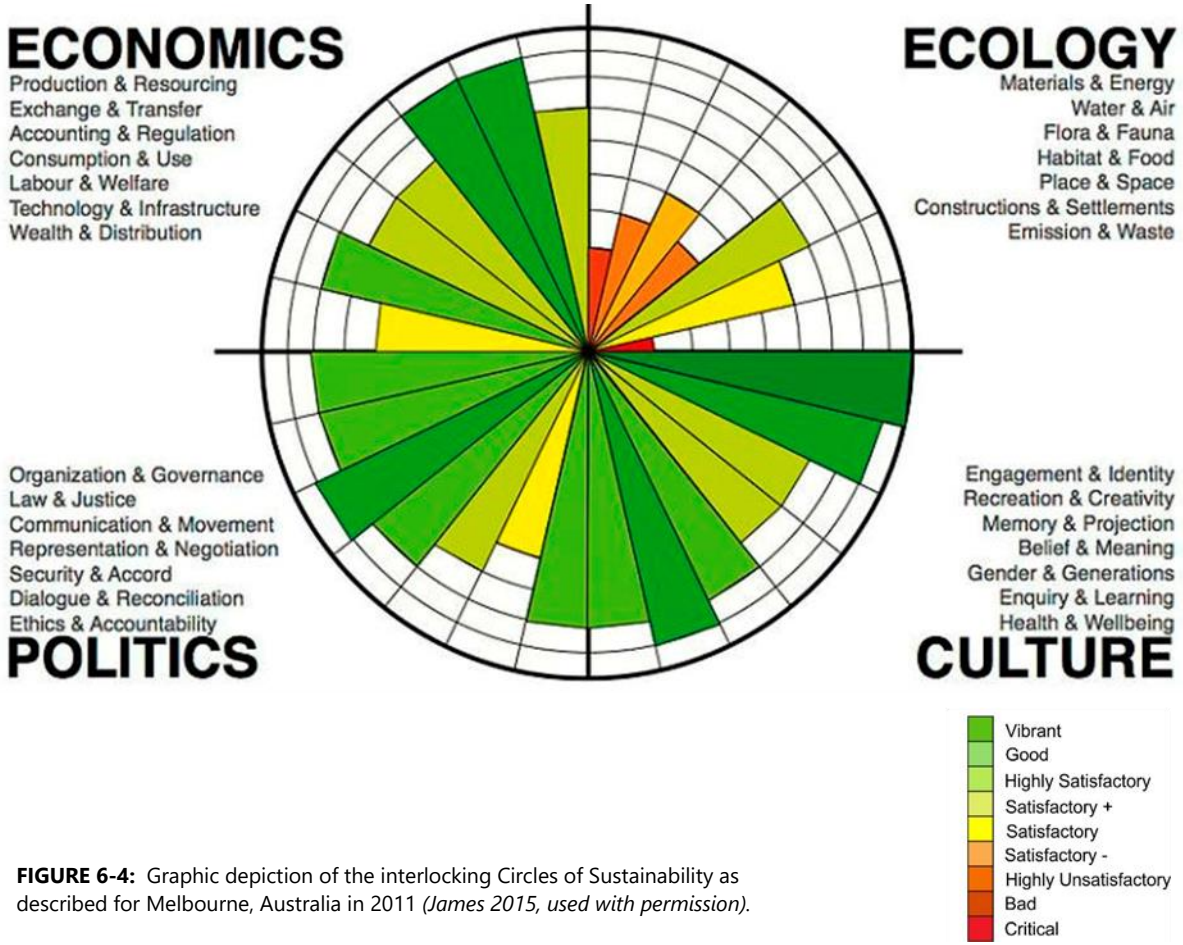


FIGURE 6-4: Graphic depiction of the interlocking Circles of Sustainability as described for Melbourne, Australia in 2011 *(James 2015, used with permission).*

CORE PRINCIPLES FOR ACTION:

"ECOLOGY: Beyond choosing technical responses that enhance climate change adaptation, cities should seek to generate deeper and more integrated relationships with nature both inside the city and beyond the urban boundary.

ECONOMICS: In adopting a 'no regrets' precautionary approach, urban development should be based on an economy organized around negotiated social needs rather than the conventional drive to economic growth.

POLITICS: In adapting to climate change, cities should begin now to develop a clear vision and detailed adaptation plans through both expert deliberation and engaged civic involvement. These plans should be embedded across the board in all policymaking.

CULTURE: In developing climate adaptation responses, cities should treat the process as one of deep cultural engagement involving broad cultural issues of social learning, symbolism, visualization, aesthetics and well-being." *(James 2015, p196)*

6.5 FRAMING THE DISCUSSION

When responding either to a single and imminent threat, or a longer process to plan for a changing environment, it is critical that discussion is framed to ensure that the benefits and costs of all options, shorter or longer term, are adequately assessed. Originating with early UNESCO and IPCC reports, organizations and individuals in Canada have for some time categorized efforts towards adaptation to a changing climate under three headings: Accommodate, Protect, Retreat. In much of the current literature, these have been appropriate categories, as the focus was on responding to the effects of sea-level rise and severe weather along the coast. However even in coastal areas climate-related impacts will affect more than the immediate nearshore, and while rising seas and flood waters may be the predominant issue facing many communities and ecosystems today, climate change will result in a broader array of impacts, affecting environments and society throughout the country (Glavovic et al. 2008).

While they have come into more common use in Canada in climate planning dialogues, terms such as accommodate, protect and retreat use a combative language supportive of views that see climate related impacts as something to be conquered and overcome, rather than as inevitable change that will require societal adjustments. *Protect* can be the basis for inopportune and costly decisions for increasingly expensive infrastructure. *Retreat* conjures up a sense of failure, of being beaten in the fight against the changing elements.

Realistically, decision-makers will have few pathways for response. They can determine that action on potential threats should be ***deferred*** to a more appropriate time. They can implement changes in practice and in structures that allow builders and users to ***persist*** with their operations in their current location for a period. Or it can be determined that now, or in the future, there will be a need to remove structures and relocate activities away from areas deemed hazardous- to ***migrate*** to better conditions (Figure 6-5). No one approach for adjusting to climate change will meet all anticipated challenges. Most planning, design and operational efforts in mitigation and adaptation will include one or more actions from all three approaches, anticipated to change over time as conditions continue to change.

Throughout all efforts to anticipate and to plan for changes in the environment, it is essential that there is an ongoing and continuous process of stakeholder-scientist interactions, that walks across disciplinary barriers, and engages expert professionals, municipal staff and elected officials, provincial and territorial governments and national climate adaptation agencies and resources. Welcoming new ideas and innovative approaches must be a core component of actions that not only allow society to continue, but to prosper.

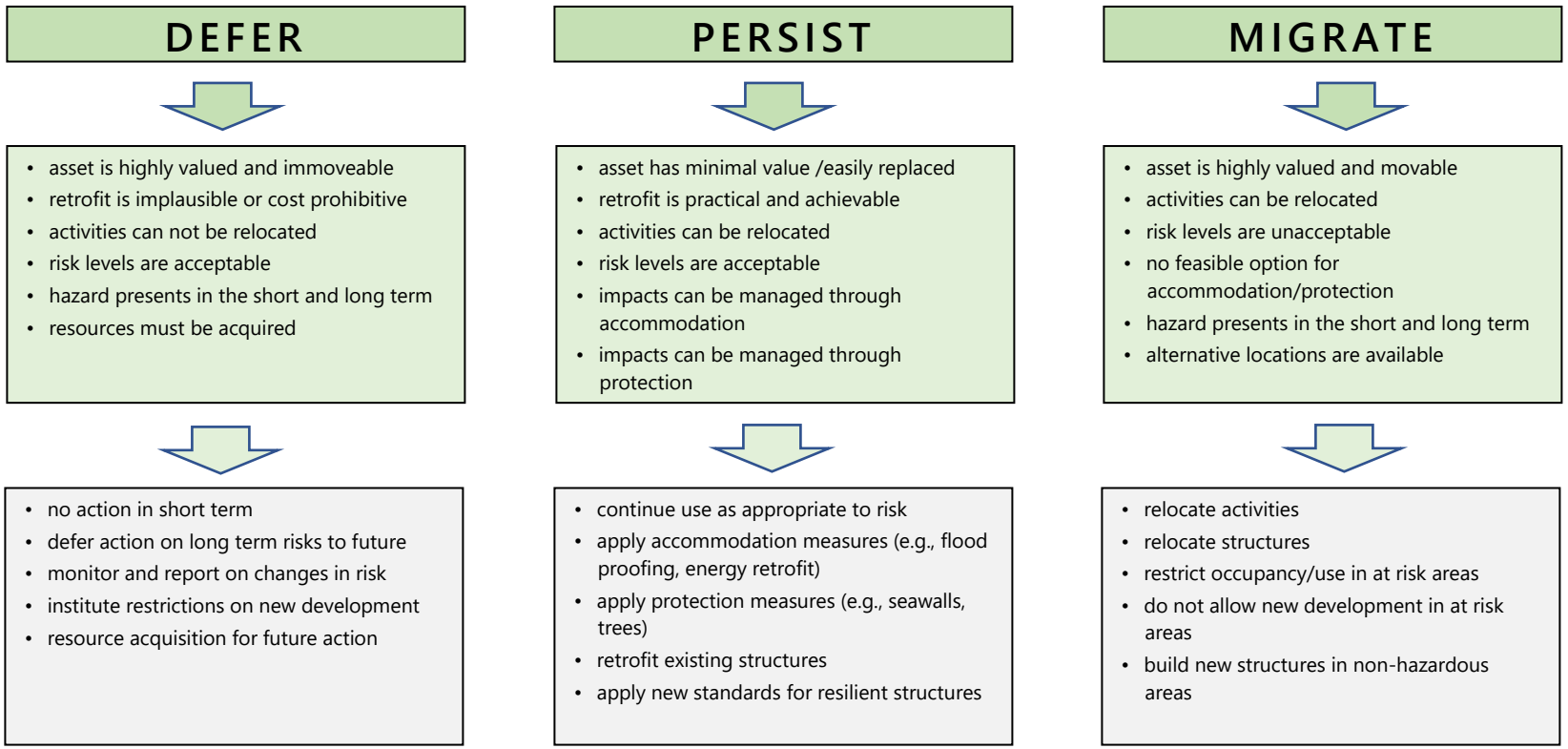


FIGURE 6-5: An alternative approach to framing the discussion on adaptation/mitigation.

6.5.1 DEFERRING THE RESPONSE

DEFER does not mean 'do nothing' or ''business as usual'. As is the case in much planning and management decision-making, decisions on an issue may be deferred due to factors such as:

- the responsibility for action falls to a different department, agency or level of governance;
- it is inappropriate to act now on an issue that will occur at some point in the future;
- there are insurmountable limitations in current fiscal or human resources; and/or
- additional information is needed to inform decision-making.
- In the context of planning for a changing climate, DEFERRING decision-making is an appropriate approach when:
- there is a partner willing to accept responsibility and act on needed changes;
- the anticipated hazards are not projected to materialize for some time;
- necessary resources must be found before action can be taken; and/or decisions should wait on the provision of needed data on the issue and/or the conclusions of risk management processes.

In all situations, choosing to DEFER decision-making on adaptation to climate change should only proceed where provisions are made to gather needed information and resources or where timely reassessment of the decision is entrenched within management processes.

SAMPLE INITIATIVES INCLUDED IN A *DEFER* APPROACH

- Establishment of a reporting structure responsible for managing data on changing conditions and/or regular updates to senior management.
- Identification and documentation of offices and individuals responsible for specific roles in adaptation planning and for implementation.
- Establishment of collaborative relationships amongst appropriate levels of government (e.g., agencies responsible for potable water quality management and regulation).
- Periodic review of hazards and adaptation options to ensure that anticipated timing and actions for hazard avoidance or hazard adaptation remain viable.
- Calculation of anticipated future costs for adaptation, and development of financing options to ensure sufficient resources will be available when needed.
- Re-assessment of readiness and response measures to anticipated disaster scenarios.

6.5.2 PERSISTING IN PLACE OR ACTIVITY

In much of the literature on adaptation to climate change in coastal areas, the focus has been on impacts associated with sea-level rise, storm surge, and severe weather. Consequently, approaches have relied on mechanisms to accommodate rising water, or infrastructure to protect against the threat of flooding. The broader interpretation of anticipated impacts from climate change on a broader class of landscapes and communities requires a more inclusive approach to mechanisms to avoid, reduce or respond to anticipated risks associated not only with damage from flooding, but also to address a range of complicated factors such as extremes of heat and cold, changing seasonality, altered precipitation patterns, and increased threats of physical disturbance such as landslides, erosion, and subsidence.

To PERSIST means that structures remain largely in place, while actions are taken to protect them from anticipated risks (e.g., seawalls, flood-proofing, stabilization of shorelines, retrofitted buildings) or that adjustments are made to human use so as to accommodate to changing circumstances (e.g., suspension of activity during periods of increased threat, seasonal vs year-round use of sites). *PERSISTING* in place can be associated with high costs and requirements for expert planning, design and maintenance. Where retrofitting of existing structures and infrastructure can be accomplished, actions taken now will be much more cost effective than reactive measures to repair damage from changing conditions, or efforts to resolve the anticipated impacts to human health and well-being.

In some circumstances, persisting *PERSISTING* may be a time dependent approach that requires continued monitoring of changing circumstances, with provisions to abandon locations and activities should threat levels increase. In these situations, persisting *PERSISTING* in place will become a somewhat temporary measure as efforts towards minimizing the risks associated with climate change become cost prohibitive or impractical. The practicality and associated costs of choosing to PERSIST in place become more important when applied to the sustainability of cultural and ecological assets important to local populations and to Canadian (or indeed international) human society. With time, and especially as the result of threats such as rising seas, the opportunity to protect historic sites, natural parks, and areas of cultural importance will diminish. Where PERSIST has been chosen as the preferred approach to adaptation, it is especially important that planning activities engage a number of professional disciplines in efforts to prioritize risks, to identify options and to ensure that whatever actions are decided upon, care is taken to ensure that the results are respectful of local environmental, societal, cultural, and economic conditions.

Choosing to PERSIST as you are should only be used when it does not increase the risk to human safety or health, with special care taken to ensure that the burden of risk is not assumed by those who are more socially vulnerable (e.g., old or young, disabled, economically or socially disadvantaged).

SAMPLE INITIATIVES INCLUDED IN A *PERSIST* APPROACH

INITIATIVES THAT ADVANCE *ACCOMODATION* OF ANTICIPATED CHANGES

- Advanced planning to reduce GHG contributions and avoid impacts.
- Adjustments to human use of areas designated as temporarily hazardous.
- Flood-proofing buildings to reduce damage from overland inundation.
- Retro-fitting structures to improve resilience to changing conditions (e.g., roof-strengthening, upgraded insulation, secondary energy sources).
- Budgeting for damages from periodic flooding of places and buildings.
- Periodic re-evaluation of changing conditions to ensure that expectations for safety and well-being remain unchanged.
- Augmented resources and training for disaster response.
- Insurance against anticipated damages.

INITIATIVES THAT PROVIDE *PROTECTION* FROM ANTICIPATED CHANGES

- Assessment of anticipated changes in flood levels, periodicity and areas under threat.
- Protection for existing natural habitats (e.g., dune complexes, salt marshes) in recognition of their contributions to reduction of wave energy and reduction in flood potential.
- Augmentation of existing hard protection measures (e.g., seawalls, dykes) to meet changing circumstances.
- Review of stormwater management policies and infrastructure to reduce up-stream loading and to ensure down-stream capacity to meet changing flows due to high precipitation events.
- Consideration of multiple approaches to prevent flooding from stormwater and/or sea-level rise and storm surges, to include the development of 'soft' armouring alternatives (e.g., afforestation of shore vegetation, beach and littoral drift replenishment, dune and wetland restoration).
- Maintenance of urban tree canopies to provide shelter from wind and to reduce urban heat islands.

6.5.3 MIGRATING TO A BETTER FUTURE

When the option to retreat from a risk has been presented, decision-makers and the public they serve can see choosing such an approach as a failure to deal with an encroaching threat - essentially giving up. But people, structures and ecosystems have been both migrating away from impending threats, and towards more convivial circumstances throughout the history of the planet. Ecosystems and species will adapt and evolve as they have always done, and if they have the capacity, migrate towards better conditions and away from increased competition for resources and space. It is human society that sees the threats posed by the changing environment as challenges to be overcome.

Even with world-wide efforts to reduce greenhouse gases, science has concluded that the process of planetary climate change that has been initiated will continue. In some situations, coastal areas in Canada will be faced with insurmountable risks as the climate changes. Some will present catastrophically in the short-term, others will arrive incrementally over longer time frames. It will become impractical, cost-prohibitive and/or dangerous to human populations to remain in areas experiencing such threats.

MIGRATING over time from unsafe or less supportive conditions created by a changing climate should be a prudent, proactive response intended to seize new opportunities for human health and welfare. With planned migration, changes to human communities can be made over appropriate periods of time, ensuring that new areas for habitation are created with insight and ingenuity, relying on principles that ensure sustainability and promote aesthetics.

Canada will increasingly need to address the issues associated with needed migration of people of other nations that are disappearing beneath rising sees, that are experiencing war and other forms of conflict, and from environments that are no longer hospitable for human populations. Migration will place some pressures on existing communities and infrastructure that insightful planning will help to reduce.

SAMPLE INITIATIVES INCLUDED IN A *MIGRATE* APPROACH

INITIATIVES THAT REDUCE RISK THROUGH AVOIDANCE OF HAZARDS

- Documentation of the timing, scale and spatial scope of unavoidable hazards.
- Designation of areas unsafe for human use or occupation.
- Designation of areas where reconstruction or major repairs would not be permitted.
- Designation of no-build areas (e.g., setbacks, flood plains).

INITIATIVES THAT REDUCE RISK BY RELOCATION TO SAFER AREAS

- Designation of non-hazardous areas for new development.
- Long term planning to relocate public infrastructure at safer sites.
- Withdrawal of government subsidies such as flood damage reimbursement.
- Provision of financial support for removal to safer areas.


IMAGE CREDIT: C. Mercer Clarke

REFERENCES

Adger, W. N., K. Brown, D. R. Nelson, F. Berkes, H. Eakin, C. Folke, K. Galvin, L. Gunderson, M. Goulden, and K. O'Brien. 2011. Resilience implications of policy responses to climate change. Wiley Interdisciplinary Reviews: Climate Change 2:757-766.

AID Environment. 2004. Integrated marine and coastal area management (IMCAM) approaches for implementing the convention on biological diversity. CBD Technical Series No. 14, National Institute for Coastal and Marine Management (RIKZ), Coastal Zone Management Centre, the Netherlands, the Secretariat of the Convention on Biological Diversity, Montreal. 51 pp.

Ballinger, R. C., J. S. Potts, N. J. Bradly, and S. J. Pettit. 2000. A comparison between coastal hazard planning in New Zealand and the evolving approach in England and Wales. Ocean & Coastal Management 43:905-925.

Beatley, T. 2009. Planning for coastal resilience: Best practices for calamitous times. Island Press, Washington DC. 179 pp.

Brundtland, G. H. 1987. Our common future. A report by the World Commission on Environment and Development to the 42nd Session of the General Assembly the United Nations. 374 pp.

Burkett, V. R., and M. A. E. Davidson. 2012. Coastal impacts, adaptation and vulnerability: A technical input to the 2012 National Climate Assessment. Cooperative Report to the 2013 National Climate Assessment, National Oceanic and Atmospheric Administration, Washington DC. 150 pp.

CIG. 2007. Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. Center for Science in the Earth System: The Climate Impacts Group, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, King County, WA. 186 pp.

City of New York. 2013. A stronger, more resilient New York. New York, NY. 223 pp. Available at: http://www.nyc.gov/html/sirr/html/report/report.shtml

Field, J. C., D. F. Boesch, D. Scavia, R. Buddemeier, V. R. Burkett, D. Cayan, M. Fogarty, M. Harwell, R. Howarth, and C. Mason. 2001. Potential consequences of climate variability and change on coastal areas and marine resources. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Report for the US Global Change Research Program. Cambridge University Press, Cambridge, UK:461-487.

Folke, C., Å. Jansson, J. Rockström, P. Olsson, S. R. Carpenter, F. S. Chapin III, A.-S. Crépin, G. Daily, K. Danell, and J. Ebbesson. 2011. Reconnecting to the biosphere. Ambio 40:719-738.

Glavovic, B. C. 2008. Sustainable coastal communities in the age of coastal storms: Reconceptualising coastal planning as 'new' naval architecture. Journal of Coastal Conservation 12:125-134

GOV/AUSTRAL/NSW. 2009. New South Wales sea level rise policy statement. Government of Australia, State of New South Wales Department of Planning. Sydney Australia. DECCW 009/708. 9 pp.

GOV/AUSTRAL/WA. 2012. State coastal planning policy guidelines: Draft State Planning Policy 2.6. Prepared under Part Three of the Planning and Development Act 2005 by the Western Australian Planning Commission. Perth. 28 pp.

GOV/CAN/ECCC. 2018. Greenhouse gas emissions. Environment and Climate Change Canada. Available at: https://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F60DB708-1

GOV/CAN/NRTEE. 2011. Paying the price: The economic impacts of climate change for Canada. Cat. No.: En133-40/4-2011E, National Round Table on the Environment and the Economy, Ottawa. 168 pp.

GOV/UK. 2010. Planning Policy Statement 25 Supplement: Development and coastal change practice guide. United Kingdom, Department for Communities and Local Government. London. 58 pp.

GOV/UK/DEFRA. 2006a. Shoreline management plan guidance: Volume 1: Aims and requirements. United Kingdom, Department for Environment, Food and Rural Affairs, London. 54 pp.

GOV/UK/DEFRA. 2006b. Shoreline management plan guidance: Volume 2: Procedures. United Kingdom, Department for Environment, Food and Rural Affairs, London. 84 pp.

GRCI. 2012. Annual Global Review 2012 Global ciites. Global Cities Research Institute, RMIT University, Melbourne, Australia. 233 pp.

Hamin, E. M., and N. Gurran. 2009. Urban form and climate change: Balancing adaptation and mitigation in the US and Australia. Habitat international 33: 238-245.

Henstra, D. 2015. The multilevel governance of climate change: Analyzing Canada's adaptation policy regime. Annual Meeting of the Canadian Political Science Association, University of Ottawa.28 pp.

IOC. 2009. Hazard awareness and risk mitigation in Integrated coastal area management. Intergovernmental Oceanographic Commission, UNESCO Headquarters. Paris. Manuals and Guides No 50, ICAM Dossier No 5. 143 pp.

IPCC. 2012. Summary for policymakers. Pages 1-19 in C. B. Field, V. Barros, T. F. Stocker, D. Qin, D. J. Dokken, D. J. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. Plattner, S. K. Allen, M. Tignor, and P. M. Midgley, editors. Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

James, P. 2015. Urban sustainability in theory and practice: circles of sustainability. Routledge, New York. 247 pp.

Kanuri, C., Revi, A., Espey, J., & Kuhle, H. 2016. Getting started with the SDGs in Cities. Sustainable Development Solutions Network. 121 pp. Available at: https://sdgcities.guide/

Kates, R. W., T. M. Parris, and A. A. Leiserowitz. 2005. What is sustainable development? Goals, indicators, values and practice Environment: Science and Policy for Sustainable Development 47:8-21.

Lemmen, D. S., F. J. Warren, J. Lacroix, and E. Bush. 2008. From impacts to adaptation: Canada in a changing climate. Catalogue No. M174-2/1-2007, Natural Resources Canada, Climate Change Impacts and Adaptation Division, Ottawa. 453 pp.

Mukheibir P, Kuruppu N, Gero A and J. Herriman. 2013, Cross-scale barriers to climate change adaptation in local government, Australia, National Climate Change Adaptation Research Facility, Gold Coast, 95 pp.

Nicholls, R. J. 2007. Adaptation options for 2 coastal areas and infrastructure: An analysis for 2030. A report to the UNFCCC, Bonn, by the School of Civil Engineering and the Environment, University of Southampton, UK. 35 pp.

Rosenzweig, C., W. D. Solecki, S. A. Hammer, and S. Mehrota. 2011. Climate change and cities: First Assessment Report of the Urban Climate Change Research Network. Cambridge University Press, Cambridge 286 pp.

SFU/ACT. 2016. Low carbon resilience: Transformative climate change planning for Canada. The Adaptation to Climate Change Team (ACT) Simon Fraser University, Vancouver BC. 44 pp.

SFU/ACT. 2017. Low carbon resilience and transboundary municipal ecosystem governance: A case study of Still Creek. The Adaptation to Climate Change Team (ACT) Simon Fraser University Victoria BC. 64 pp.

Simpson, M. C., C. S. L. Mercer Clarke, J. D. Clarke, D. Scott, and A. J. Clarke. 2012. Coastal setbacks in Latin America and the Caribbean: A Study of emerging issues and trends that inform guidelines for coastal planning and development. No. IDB-TN-476, Inter-American Development Bank, Washington DC. 187 pp.

The Royal Society. 2014. Resilience to extreme weather. The Royal Society Science Policy Centre, London UK. 124 pp.

Thompson, J. W., and K. Sorvig. 2008. Sustainable landscape construction. Island Press, Washington DC. 415 pp.

Tomlinson, R. B., and P. Helman. 2006. Planning principles for local government management of coastal erosion and beaches, with a changing climate. Griffiths University, Centre for Coastal Management, Co-operative Research Centre for Coastal Zone Estuary and Waterway Management, SC4 Milestone Report, Southport Australia. 39 p

UN. 2012. The future we want: Resolution adopted by the General Assembly on 27 July 2012. The United Nations General Assembly, Sixty-sixth session. Agenda Item 19, Rio de Janeiro. 53 pp.

UN. 2015. Open Working Group proposal for sustainable development goals. United Nations General Assembly Open Working Group. 24 pp.

UNEP/GPA. 2005. Guiding principles for post-tsunami rehabilitation and reconstruction: The Cairo Principles. United Nations Environment Programme, Tsunami Disaster Task Force in cooperation with the UNEP Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA). Cairo. 8 pp.

UNEP/GPA. 2009. Annotated guiding principles for post-tsunami rehabilitation and reconstruction. United Nations Environment Programme Tsunami Disaster Task Force in cooperation with the UNEP Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA), Cairo. 16 pp.

United Nations General Assembly. 2000, United Nations Millennium Declaration, Resolution 55/2, United Nations A/RES/55/2, 18 September 2000.

Wamsler, C. 2015. Mainstreaming ecosystem-based adaptation: transformation toward sustainability in urban governance and planning. Ecology and Society 20:30.

ADDITIONAL READING

SEEKING A BETTER FUTURE

Baztan, J., O. Chouinard, B. Jorgensen, P. Tett, J.-P. Vanderlinden, and L. Vasseur. 2015. Coastal zones: Solutions for the 21st century. Elsevier, Oxford UK. 351 pp.

CBC. 2010. Adapting to climate change in Canada: What organizations are doing today to prepare for tomorrow. Conference Board of Canada, Ottawa. 11 pp.

CIG. 2007. Preparing for climate change: A guidebook for local, regional, and state governments. center for science in the earth system: The Climate Impacts Group, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, King County, WA. 186 pp.

Falaleeva, M., C. O'Mahony, S. Gray, M. Desmond, J. Gault, and V. Cummins. 2011. Towards climate adaptation and coastal governance in Ireland: Integrated architecture for effective management? Marine Policy 35:784-793.

Fraser, J., and M. Strand. 2011. Climate change adaptation for local government: A resource guide. Pacific Institute for Climate Solutions, Vancouver BC. 26 pp.

Gage, A. 2011. Professionals and climate change: How professional associations can get serious. West Coast Environmental Law, Vancouver BC. 29 pp.

GOV/CAN/NRTEE. 2012. Reality check: The state of climate progress in Canada. Government of Canada: National Round Table on the Environment and the Economy, Ottawa. 176 pp.

GOV/CAN/ON. 2015. Ontario's climate change discussion paper 2015. Ontario Ministry of the Environment and Climate Change, Toronto ON. 44 pp.

Henstra, D. 2015. The multilevel governance of climate change: Analyzing Canada's adaptation policy regime. Annual Meeting of the Canadian Political Science Association, University of Ottawa. 28 pp.

Kunreuther, H., and E. U. Weber. 2014. Aiding decision-making to reduce the impacts of climate change. National Bureau of Economic Research Cambridge, MA. 27 pp.

Maani, K. 2013. Decision-making for climate change adaptation: A systems thinking approach. University of Queensland, National Climate Change Adaptation Research Facility, Gold Coast. 66 pp.

Macintosh, A., A. Foerster, and J. McDonald. 2013. Limp, leap or learn? Developing legal frameworks for climate change adaptation planning in Australia. National Climate Change Adaptation Research Facility, Gold Coast. 262 pp.

Quay, R. 2010. Anticipatory governance: A tool for climate change adaptation. Journal of the American Planning Association 76:496-511.

Seitzinger, S. P., U. Svedin, C. L. Crumley, W. Steffen, S. A. Abdullah, C. Alfsen, W. J. Broadgate, F. Biermann, N. R. Bondre, and J. A. Dearing. 2012. Planetary stewardship in an urbanizing world: Beyond city limits. Ambio 41(8):787-794.

Trück, S., S. Mathew, A. Henderson-Sellers, R. Taplin, T. Keighley, and W. Chin. 2013. Climate adaptation decision support tool for local governments: CATLoG. Developing an Excel spreadsheet tool for local governments to compare and prioritise investment in climate change adaptation. National Climate Change Adaptation Research Facility, Gold Coast. 39 pp.

Wise, R. M., I. Fazey, M. Stafford Smith, S. E. Park, H. C. Eakin, E. R. M. A. van Garderen, and B. Campbell. 2013. Re-conceptualizing adaptation to climate change as part of pathways of change and response. Global Environmental Change 28:325-336.

BUILDING ON WHAT WE HAVE

CSA Group. 2014. Managing changing snow load risks for buildings in Canada's North. Standards Council of Canada Mississauga ON. 68 pp.

Platt, R. H., D. Salvesen, and G. H. Baldwin Ii. 2002. Rebuilding the North Carolina Coast after Hurricane Fran: Did public regulations matter? Coastal Management 30:249-269.

Engineers Canada. 2011. PIEVC engineering protocol for infrastructure vulnerability assessment and adaptation to a changing climate: Revision 10 BETA. Canadian Council of Professional Engineers, Ottawa. 93 pp.

Kunreuther, H., and E. U. Weber. 2014. Aiding decision-making to reduce the impacts of climate change. National Bureau of Economic Research Cambridge, MA. 27 pp.

TCPA/RTPI. 2018. Planning for climate change: A guide for local authorities. Town and Country Planning Association and the Royal Town Planning Institute. London, UK. 61 pp. Available at: http://www.rtpi.org.uk/media/2852781/TCPA%20RTPI%20planning%20for%20climate%20change%20guide_final.pdf

UN Habitat. 2012. Urban patterns for a green economy: Optimizing infrastructure. United Nations Human Settlements Programme (UN-Habitat), Nairobi, Kenya. 93 pp.

UN Habitat. 2014. Planning for climate change: A strategic, values-based approach for urban planners. United Nations Human Settlements Programme (UN-Habitat), Nairobi, Kenya. 160 pp.

OVERCOMING OBSTACLES

Aylett, A. 2015. Institutionalizing the urban governance of climate change adaptation: Results of an international survey. Urban Climate.

Barnett, J., E. Waters, S. Pendergast, and A. Puleston. 2010. Barriers to adaptation to sea-level rise: The legal, institutional and cultural barriers to adaptation to sea-level rise in Australia. The University of Melbourne and the National Climate Change Adaptation Research Facility, Carlton, Victoria AUSTR. 85 pp.

Beatley, T. 2009. Planning for coastal resilience: Best practices for calamitous times. Island Press, Washington DC. 179 pp.

GOV/CAN/NRTEE. 2012. Reality check: The state of climate progress in Canada. Government of Canada: National Round Table on the Environment and the Economy, Ottawa. 176 pp.

Reckien, D., J. Flacke, M. Olazabal, and O. Heidrich. 2015. The influence of drivers and barriers on urban adaptation and mitigation plans: An empirical analysis of European cities. PloS One10:e.

Vergara, W. 2005. Adapting to climate change: Lessons learned, work in progress, and proposed next steps for the World Bank in Latin America. The World Bank, Latin America and Caribbean Region, Environmentally and Socially Sustainable Development Department (LCSES). 57 pp.

MAINSTREAMING PRINCIPLES AND GOALS

Boateng, I. 2008. Integrating sea-level rise adaptation into planning policies in the coastal zone. Integrating Generations: FIG Working Week: TS 3F - Coastal Zone Administration, Stockholm, Sweden. 22 pp.

Costanza, R., F. Andrade, P. Antunes, M. van den Belt, D. Boersma, D. F. Boesch, F. Catarino, S. Hanna, K. Limburg, B. Low, M. Molitor, J. G. Pereira, S. Rayner, and R. Santos. 1998. Principles for sustainable governance of the oceans. Science (Washington) 281:198-199.

Council of Europe. 1999. European Code of Conduct for coastal zones. CO-DBP (99) 11, Committee for the Activities of the Council of Europe in the Field of Biological and Landscape Diversity (CO-DBP), Strasbourg. 97 pp.

de Groot, R. S., R. Alkemade, L. Braat, L. Hein, and L. Willemen. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7:260-272.

Environmental Law Institute. 2007. Lasting landscapes: Reflections on the role of conservation science in land use planning. Environmental Law Institute, Washington DC. 102 pp.

Feltmate, B., and J. Thistlethwaite. 2012. Climate change adaptation: A priorities plan for Canada. A report of the Climate Change Adaptation Project (Canada) University of Waterloo / Intact Financial Corporation, Waterloo ON. 122 pp.

Ford, J. 2008. Emerging trends in climate change policy: The role of adaptation. International Public Policy Review 3:1-16.

Gage, A. 2011. Professionals and climate change: How professional associations can get serious about global warming. West Coast Environmental Law, Vancouver BC. 29 pp.

Gibbs, M., and T. Hill. 2011. Coastal climate change risk - Legal and policy responses in Australia. Government of Australia, Department of Climate Change and Energy Efficiency. 93 pp.

Gilman, E. 2002. Guidelines for coastal and marine site-planning and examples of planning and management intervention tools. Ocean & Coastal Management 45:377-404.

Glavovic, B. C. 2008. Sustainable coastal communities in the age of coastal storms: Reconceptualising coastal planning as 'new' naval architecture. Journal of Coastal Conservation 12:125-134.

GOV/AUSTRAL/WA. 2012. State Coastal Planning Policy guidelines: Draft State Planning Policy 2.6. Prepared under Part Three of the Planning and Development Act 2005 by the Western Australian Planning Commission, Perth AUS. 28 pp.

GOV/CAN/BC. 2012. Preparing for climate change: An implementation guide for local governments in British Columbia. Government of British Columbia, Vancouver BC. 110 pp.

GOV/USA/CAL. 2012. California adaptation planning guide: Identifying adaptation strategies. A report prepared by the California Emergency Management Agency and the California Natural Resources Agency. 68 pp.

GOV/USA/MD. 2011. Maryland's enforceable coastal policies. United States Government of Maryland, Department of Natural Resources,.31 pp.

GOV/USA/WHCEQ. 2010. Recommended actions in support of a national climate change adaptation strategy. The White House Council on Environmental Quality: Progress Report of the Interagency Climate Change Adaptation Task Force Washington DC. 71 pp.

Gurran, N., E. Hamin, B. and D. Norman, 2008. Planning for climate change: Leading practice principles and models for sea change communities in coastal Australia. University of Sydney, Faculty of Architecture Design and Planning.

Inderberg, T. H., S. Eriksen, K. O'Brien, and L. Sygna. 2014. Climate change adaptation and development: Transforming paradigms and practices. Routledge.

Macintosh, A., A. Foerster, and J. McDonald. 2013. Limp, leap or learn? Developing legal frameworks for climate change adaptation planning in Australia. National Climate Change Adaptation Research Facility, Gold Coast. 262 pp.

McKenna, J., A. Cooper, and A. M. O'Hagan. 2008. Managing by principle: A critical analysis of the European principles of integrated coastal zone management (ICZM). Marine Policy 32:941-955.

Morley, P., E. Trammell, I. Reeve, J. McNeill, D. Brunckhorst, and S. Bassett. 2013. Past, present and future landscapes: Understanding alternative futures for climate change adaptation of coastal settlements and communities. National Climate Change Adaptation Research Facility, Gold Coast. 157 pp.

Olsen, S. B. 2003. Crafting coastal governance in a changing world. 2241, University of Rhode Island, CRC/USAID.

Ribeiro, M., C. Loosens, T. Dworak, E. Massey, R. Swart, M. Benzie, and C. Laaser. 2009. Design of guidelines for the elaboration of regional climate change adaptations strategies. Ecologic Institute, European Commission- DG Environment, Vienna. 91 pp.

Smit, B., and O. Pilifosova. 2003. Adaptation to climate change in the context of sustainable development and equity. Pages 881-906 In O. F. C. James J. McCarthy, Neil A. Leary, David J. Dokken, Kasey S. White, editor. Climate Change 2001: Impacts, adaptation and vulnerability. Cambridge University Press, Cambridge UK.

Tomlinson, R. B., and P. Helman. 2006. Planning principles for local government management of coastal erosion and beaches, with a changing climate. Griffiths University, Centre for Coastal Management, Co-operative Research Centre for Coastal Zone Estuary and Waterway Management, SC4 Milestone Report, Southport Australia. 39 pp.

UNEP/GPA. 2005. Guiding principles for post-tsunami rehabilitation and reconstruction: The Cairo Principles. United Nations Environment Programme, Tsunami Disaster Task Force in cooperation with the UNEP Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA), Cairo. 8 pp.

ENHANCING RESILIENCE

Adger, W.N., Brown, K., Nelson, D.R., Berkes, F., Eakin, H., Folke, C., Tompkins, E.L. 2011. Resilience implications of policy responses to climate change. Wiley Interdisciplinary Reviews: Climate Change, 2, 757–766.

Baztan, J., O. Chouinard, B. Jorgensen, P. Tett, J.-P. Vanderlinden, and L. Vasseur. 2015. Coastal zones: Solutions for the 21st century. Elsevier, Oxford UK. 351 pp.

Bours, D., C. McGinn, and P. Pringle. 2014. Monitoring and evaluation for climate change adaptation and resilience: A synthesis of tools, frameworks & approaches: Second edition. Sea Change Community of Practice and UKCIP, Phnom Penh and Oxford UK.

Burby, R. J., R. E. Deyle, D. R. Godschalk, and R. B. Olshansky. 2000. Creating hazard resilient communities through land-use planning. Natural Hazards Review 1:99-106.

CCEI. 2009. Coastal hazards and community resiliency in Delaware. Coastal Community Enhancement Initiative, University of Delaware. 84 pp.

Georgetown Climate Center. 2011. Rebuilding with resilience: Lessons from the Rebuild by Design Competition after Hurricane Sandy. Georgetown Law Washington DC. 102 pp.

Goldstein, A., and K. Howard. 2015. The great American adaptation road trip. Lessons learned about how hometowns across the United States are building their resilience to climate change. Georgetown Climate Center, Washington DC.

Gonsalez, R. 2017. Community-driven climate resilience planning: A framework. National Association of Climate Resilience Planners. 64 pp.

GOV/USA/MASS. 2013. Homeowner's handbook to prepare for coastal hazards. Government of Massachusetts, Sea Grant, Boston MA. 96 pp.

GOV/USA/NAS. 2012. Disaster resilience: A national imperative. Committee on Increasing National Resilience to Hazards and Disasters; Committee on Science, Engineering, and Public Policy; The National Academies, Washington DC. 260 pp.

GOV/USA/NAS. 2015. Healthy, resilient and sustainable communities after disasters: Strategies, opportunities and planning for recovery. National Academy of Sciences, Committee on Post-Disaster Recovery of a Community's Public Health, Medical, and Social Services; Board on Health Sciences Policy; Institute of Medicine, Washington DC. 600 pp.

GOV/USA/NOAA. 2012. Achieving hazard-resilient coastal & waterfront smart growth. National Oceanic and Atmospheric Administration, Washington DC. 26 pp.

GOV/USA/NRC. 2011. Building community resilience through private-public collaboration. Committee on Private-Public Sector Collaboration to Enhance Community Disaster Resilience, Geographical Science Committee, National Research Council Washington DC. 142 pp.

GOV/USA/NRC. 2012. Dam and levee safety and community resilience: A vision for future practice. Committee on Integrating Dam and Levee Safety and Community Resilience; Committee on Geological and Geotechnical Engineering; Board on Earth Sciences and Resources; Division on Earth and Life Studies; National Research Council, Washington DC. 172 pp.

GOV/USA/NRC. 2015. Developing a framework for measuring community resilience: Summary of a workshop. National Research Council. Committee on Measures of Community Resilience: From Lessons Learned to Lessons Applied; Resilient America Roundtable, Policy and Global Affairs Division, Washington DC. 76 pp.

Heinz Center. 2009. Resilient coasts: A blueprint for action. H. John Heinz III Center for Science, Economics and the Environment, Island Press, Washington DC. 9 pp.

ISC. 2010. Promising practices in adaptation and resilience: A resource guide for local leaders. Institute for Sustainable Communities. 107 pp.

Kinney, P. L., T. Matte, K. Knowlton, J. Madrigano, E. Petkova, K. Weinberger, A. Quinn, M. Arend, and J. Pullen. 2015. New York City Panel on Climate Change 2015 Report. Chapter 5: Public health impacts and resiliency. Annals of the New York Academy of Sciences 1336:67-88.

Lyon, C. 2014. Place systems and social resilience: A Framework for Understanding Place in Social Adaptation, Resilience, and Transformation. Society & Natural Resources 27:1009-1023.

McPhearson, T., E. Andersson, T. Elmqvist, and N. Frantzeskaki. 2015. Resilience of and through urban ecosystem services. Ecosystem Services 12:152-156.

Nunes, A. R. 2016. Assets for heath: linking vulnerability, resilience and adaptation to climate change. Tyndall Centre for Climate Change Research, Working Paper 163, University of Warwick. 41 pp.

The Royal Society. 2014. Resilience to extreme weather. The Royal Society Science Policy Centre, London UK. 124 pp.

Vasseur, L. 2012. Getting started with community resilience planning: A kit to implement dialogue on planning community resilience to environmental and climate changes. Training manual prepared for the Southern Gulf of St. Lawrence Coalition on Sustainability and the Coastal Communities Challenges - Community University Research Alliance. 20 pp.

ADVANCING TRANSFORMATION

GOV/USA/NAS. 2014. Livable cities of the future: Proceedings of a symposium honoring the legacy of George Bugliarello. National Academy of Engineering; NYU Polytechnic School of Engineering, National Academy of Sciences, Washington DC. 176 pp.

Lonsdale, K., P. Pringle, and B. Turner. 2015. Transformative adaptation: What it is, why it matters & what is needed. UK Climate Impacts Programme, University of Oxford, Oxford UK. 40 pp.

ENSURING SUSTAINABILITY

APEGBC. 2013. Sustainability guidelines. Association of Professional Engineers and Geoscientists of British Columbia. 13 pp.

Bennett, N. J., J. Blythe, S. Tyler, and N. C. Ban. 2015. Communities and change in the anthropocene: understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. Regional Environmental Change:1-20.

Carraro, C., Campagnolo, L., Eboli, F. and L. Farnia. 2015. Assessing sustainable development goals. A paper prepared for the SDSN Conference on Implementing the Sustainable Development Goals (SDGs): Getting Started, New York, 23-24 September 2015.

Damassa, T., and T, Fransen. 2015. Canada's proposed climate commitment lags behind its peers. World Resources Institute. Published online at http://www.wri.org/blog/2015/05/canadas-proposed-climate-commitment-lags-behind-its-peers

DARA. 2012. A guide to the cold calculus of a hot planet. DARA International, DARA and the Climate Vulnerable Forum, Climate Vulnerability Monitor 2nd Edition, Geneva. 342 pp.

Folke, C., Å. Jansson, J. Rockström, P. Olsson, S. R. Carpenter, F. S. Chapin III, A.-S. Crépin, G. Daily, K. Danell, and J. Ebbesson. 2011. Reconnecting to the biosphere. Ambio 40:719-738.

GCEC. 2015. Seizing the global opportunity: Partnerships for better growth and a better climate: The 2015 new climate economy report. The Global Commission on the Economy and the Climate, Washington DC and London UK. 76 pp.

Glavovic, B. C. 2015. On the frontline of the anthropocene: Adapting to climate change through deliberative coastal governance. Pages 51-99 In B. C. Glavovic, M. Kelly, R. Kay, and A. Travers, editors. Climate change and the coast: Building resilient communities. CRC Press, Taylor & Francis Group, Boca Raton FL.

GOV/CAN. 2016. Achieving a sustainable future: A federal sustainable development strategy for Canada 2016-2019: Fall 2017 Update. Environment and Climate Change Canada, Cat. No.: En4-136/1-2017E-PDF, Cat. No.: En4-136/1-2017E-PDF Ottawa. 51 pp.

GOV/CAN. 2016. Planning for a sustainable future: A federal sustainable development strategy for Canada 2016-2019. Environment and Climate Change Canada Ottawa. 69 pp.

GOV/USA/EPA. 2015. Climate change in the United States: Benefits of global action. United States Protection Agency, Office of Atmospheric Programs. 96 pp. 016-2019. Environment and Climate Change Canada, Ottawa. 69 pp.

GRCI. 2012. Annual Global Review 2012 Global ciites. 978-0-9870988-3-2, Global Cities Research Institute, RMIT University, Melbourne, Australia. 233 pp.

Griggs, D., M. Stafford-Smith, O. Gaffney, J. Rockström, M. C. Öhman, P. Shyamsundar, W. Steffen, G. Glaser, N. Kanie, and I. Noble. 2013. Policy: Sustainable development goals for people and planet. Nature 495:305-307.

Håkanson, L., and T. Blenckner. 2008. A review on operational bioindicators for sustainable coastal management: Criteria, motives and relationships. Ocean & Coastal Management 51:43-72.

IPCC. 2007. Fourth assessment report: Working Group II Report: Impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, (Eds.), Cambridge University Press, Cambridge UK. 987 pp. Glossary, pp. 869-883.

Kanuri, C., A. R., J. Espey, and H. Kuhle. 2016. Getting started with the SDGs in cities: A guide for stakeholders. Sustainable Development Solutions Network, A global initiative for the United Nations. 121 pp.

Lambin, E. F., B. L. Turner, H. J. Geist, S. B. Agbola, A. Angelsen, J. W. Bruce, O. T. Coomes, R. Dirzo, G. Fischer, and C. Folke. 2001. The causes of land-use and land-cover change: Moving beyond the myths. Global Environmental Change 11:261-269.

Leichenko, R. 2012. Climate change, globalization, and the double exposure challenge to sustainability: Rolling the dice in coastal New Jersey. Sustainability Science:315-328.

Milligan, J., and T. O'Riordan. 2007. Governance for sustainable coastal futures. Coastal Management 35:499-509.

Newton, A. 2012. A systems approach for sustainable development in coastal Zones. Ecology and Society 17.

PEW. 2011. Ocean Earth: How RIO+20 can and must turn the tide: Policy recommendations. The Pew Environment Group. Pew Oceans Commission, Arlington VA. 28 pp.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, E. F. Lambin, T. M. Lenton, M. Scheffer, C. Folke, and H. J. Schellnhuber. 2009. A safe operating space for humanity. Nature 461:472-475.

Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. J. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sorlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and F. J. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society.

RSC. 2012. Sustaining Canada's marine biodiversity: Responding to the challenges posed by climate change, fisheries and aquaculture. An Expert Panel Report of the Royal Society of Canada: The Academies of Arts, Humanities and Sciences of Canada, Ottawa. 315 pp.

Seitzinger, S. P., U. Svedin, C. L. Crumley, W. Steffen, S. A. Abdullah, C. Alfsen, W. J. Broadgate, F. Biermann, N. R. Bondre, and J. A. Dearing. 2012. Planetary stewardship in an urbanizing world: Beyond city limits. Ambio 41:787-794. Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, and C. A. de Wit. 2015. Planetary boundaries: Guiding human development on a changing planet. Science:1259855.

Sherman, K., M. Sissenwine, V. Christensen, A. Duda, G. Hempel, C. Ibe, S. Levin, D. Lluch-Belda, G. Matishov, and J. McGlade. 2005. A global movement toward an ecosystem approach to management of marine resources. Marine Ecology Progress Series 300:241-296.

Smit, B., and O. Pilifosova. 2003. Adaptation to climate change in the context of sustainable development and equity. Pages 881-906 in O. F. C. James J. McCarthy, Neil A. Leary, David J. Dokken, Kasey S. White, editor. Climate Change 2001: Impacts, adaptation and vulnerability. Cambridge University Press, Cambridge UK.

Snelgrove, P., P. Archambault, K. Juniper, P. Lawton, A. Metaxas, C. McKindsey, P. Pepin, D. Schneider, and V. Tunnicliffe. 2009. Scientific criteria for conservation and sustainable usage of marine biodiversity in Canada's oceans. Pages 1-8. IEEE.

Steffen, W., and M. S. Smith. 2013. Planetary boundaries, equity and global sustainability: why wealthy countries could benefit from more equity. Current Opinion in Environmental Sustainability 5:403-408.

Steffen, W., P. J. Crutzen, and J. R. McNeill. 2007. The Anthropocene: are humans now overwhelming the great forces of nature. AMBIO: A Journal of the Human Environment 36:614-621.

Steffen, W., J. Grinevald, P. Crutzen, and J. McNeill. 2011. The Anthropocene: Conceptual and historical perspectives. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 369:842-867.

Steffen, W., Å. Persson, L. Deutsch, J. Zalasiewicz, M. Williams, K. Richardson, C. Crumley, P. Crutzen, C. Folke, and L. Gordon. 2011. The Anthropocene: From global change to planetary stewardship. Ambio 40:739-761.

Steffen, W., K. Richardson, J. Rockström, S. E. Cornell, I. Fetzer, E. M. Bennett, R. Biggs, S. R. Carpenter, W. de Vries, and C. A. de Wit. 2015. Planetary boundaries: Guiding human development on a changing planet. Science:1259855.

Steffen, W., J. Rockström, and R. Costanza. 2011. How defining planetary boundaries can transform our approach to growth. Solutions 2 (3):59-65.

Steffen, W., A. Sanderson, P. D. Tyson, J. J., P. A. Matson, B. Moore, F. Oldfield, K. Richardson, H. J. Schellnhuber, B. L. Turner, and R. J. Wasson. 2004. Global change and the earth system: A planet under pressure. Springer, New York. 336 pp.

Sustainable Canada Dialogues. 2015. Acting on climate change: Solutions from Canadian scholars. An initiative under the UNESCO-McGill Chair for Dialogues on Sustainability and the Trottier Institute for Science and Public Policy, Montréal QC. 58 pp.

Suthren, V. J. H. 2009. The island of Canada: How three oceans shaped our nation. Thomas Allen Publishers, Toronto.

UN. 2012. The future we want: Resolution adopted by the General Assembly on 27 July 2012. The United Nations General Assembly, Sixty-sixth session. Agenda Item 19, Rio de Janeiro. 53 pp.

UN. 2015. Transforming our world: The 2030 Agenda for Sustainable Development. The United Nations General Assembly, Seventieth session Agenda items 15 and 116, Draft resolution referred to the United Nations summit for the adoption of the post-2015 development agenda by the General Assembly at its sixty-ninth session Rio de Janeiro. 35 pp.

UN. 2015. Open Working Group proposal for sustainable development goals. United Nations General UN. 2012. The future we want: Resolution adopted by the General Assembly on 27 July 2012. The United Nations General Assembly, Sixty-sixth session. Agenda Item 19, Rio de Janeiro. 53 pp.

UNEP. 2009. Sustainable coastal tourism: An integrated planning and management approach. United Nations Environment Programme, Sustainable Consumption and Production Branch, Priority Actions Programme, Paris. 87 pp.

UNEP. 2011. Ready, willing and able: Empowering countries to meet the climate challenge. United Nations Environment Programme, Nairobi. 52 pp.

UNEP. 2011. Towards a green economy: Pathways to sustainable development and poverty eradication. United Nations Environment Programme, UNEP/GRID-Arendal, Nairobi, Kenya. 631 pp.

UN. 2012. The future we want: Resolution adopted by the General Assembly on 27 July 2012. The United Nations General Assembly, Sixty-sixth session. Agenda Item 19, Rio de Janeiro. 53 pp.

UNEP. 2014. Measuring the environmental goods and services sector: Issues and challenges. United Nations Environment Programme, Nairobi, Kenya. 34 pp.

Wilbanks, T. J., and R. W. Kates. 1999. Global change in local places: How scale matters. Climatic Change 43:601-628.Assembly Open Working Group. 24 pp.

RE-FRAMING THE DISCUSSION

Allen, C. R., and L. H. Gunderson. 2011. Pathology and failure in the design and implementation of adaptive management. Journal of environmental management 92:1379-1384.

Barnett, J., and S. O'Neill. 2010. Maladaptation. Global Environmental Change 20:211-213.

Bours, D., C. McGinn, and P. Pringle. 2014. Monitoring and evaluation for climate change adaptation and resilience: A synthesis of tools, frameworks and approaches: Second edition. Sea Change Community of Practice and UKCIP, Phnom Penh and Oxford UK

Camare, H. M. 2011. Multicriteria decision evaluation of adaptation strategies for vulnerable coastal communities. University of Ottawa. 331 pp.

Davis, B. C. 2004. Regional planning in the US coastal zone: a comparative analysis of 15 special area plans. Ocean & Coastal Management 47:79-94.

EcoAdapt. 2011. The state of marine and coastal adaptation in North America: A synthesis of emerging ideas: Final report. A report prepared for the Gordon and Betty Moore Foundation Marine Conservation Initiative.

GOV/CAN/NRTEE. 2012. Reality check: The state of climate progress in Canada. Government of Canada: National Round Table on the Environment and the Economy, Ottawa. 176 pp.

Godschalk, D. R., R. Norton, C. Richardson, and D. Salvesen. 2000. Avoiding coastal hazard areas: best state mitigation practices. Environmental Geosciences 7:13-22.

Kling, D., and J. N. Sanchirico. 2009. An adaptation portfolio for the United States coastal and marine environment. A report of Resources for the Future. 70 pp.

Macintosh, A. 2013. Coastal climate hazards and urban planning: how planning responses can lead to maladaptation. Mitigation and Adaptation Strategies for Global Change 18:1035-1055.

Needham, H., D. Brown, and L. Carter. 2012. Impacts and adaptation options in the Gulf coast. Louisiana State University, Center for Climate and Energy Solutions. 41 pp.

Nicholls, R. J. 2007. Adaptation options for 2 coastal areas and infrastructure: 3 An analysis for 2030. A report to the UNFCCC, Bonn, by the School of Civil Engineering and the Environment, University of Southampton, UK. 35 pp.

Niven, R. J., and D. K. Bardsley. 2013. Planned retreat as a management response to coastal risk: A case study from the Fleurieu Peninsula, South Australia. Regional Environmental Change 13:193-209.

ProAct Network. 2008. The role of environmental management and eco-engineering in disaster risk reduction and climate change adaptation. Government of Finland, the ProAct Network, GAIA, and the United National International Strategy for Disaster Reduction (ISDR). 68 pp.

Spalding, M. D., S. Ruffo, C. Lacambra, I. Meliane, L. Z. Hale, C. C. Shepard, and M. W. Beck. 2014. The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management 90:50-57.

Turner, R. K., D. Burgess, D. Hadley, E. Coombes, and N. Jackson. 2007. A cost–benefit appraisal of coastal managed realignment policy. Global Environmental Change 17:397-407.

RESOURCES ON THE WEB

ARCTIC ADAPTATION EXCHANGE

http://arcticadaptationexchange.com/

The Arctic Adaptation Exchange is for individuals and organizations to: explore how others in the Arctic region have responded to the challenges and opportunities presented by climate change; share experiences and information on climate change impacts and adaptation initiatives and tools; ant to connect with others who have experience and knowledge. Information contained in the portal is user-submitted.

ATLANTIC CLIMATE ADAPTATION SOLUTIONS ASSOCIATION (ACASA)

https://atlanticadaptation.ca/

The Atlantic Climate Adaptation Solutions (ACASA) Project is a partnership among the provincial governments of Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and New Brunswick, and regional stakeholders including non-profits, tribal governments, and industry. ACASA applied for and received a grant from Natural Resources Canada (NRCan) as part of the Regional Adaptation Collaborative (RAC) Program to build a collaborative effort to address regional climate change impacts. This site primarily provides access to ACASA's projects, publications, and other research outputs that help Atlantic Canadians better prepare for, and adapt to, climate change.

CIRCLES OF SUSTAINABILITY

http://www.circlesofsustainability.org/about/

Circles of Sustainability is an approach that supports cities, communities and organizations seeking to understand and act upon basic issues relevant to sustaining positive and vibrant social life. The site offers an integrated method for deciding on the critical issues associated with responding actively to complex problems. Circles takes a city, community or organization through the difficult process of deciding on the terms of its approach.

COMMUNITY INFORMATION DATABASE

http://www.cid-bdc.ca/welcome-bienvenue

The CID is a free internet-based resources developed to provide communities, researchers, and governments with access to consistent and reliable socio-economic information and demographic data and information for all communities across Canada.

THE EUROPEAN CLIMATE ADAPTATION PLATFORM (CLIMATE-ADAPT)

http://climate-adapt.eea.europa.eu/about

CLIMATE-ADAPT, a partnership between the European Commission (DG CLIMA, DG Joint Research Centre and other DGs) and the European Environment Agency, aims to support Europe in adapting to climate change by helping users to access and share data and information on: expected climate change in Europe; current and future vulnerability of regions and sectors; EU, national and transnational adaptation strategies and actions; adaptation case studies and potential adaptation options and tools that support adaptation planning

ICLEI CANADA ADAPTATION LIBRARY

http://adaptationlibrary.com/#/options/

The Library is a publicly accessible and searchable collection of community, forestry, and energy related adaptation products. The goal of the Library is to connect community and industry users with relevant information related to climate change adaptation in Canada and abroad.

ICLEI USA

http://icleiusa.org/

ICLEI USA builds and serves the movement of local governments pursuing deep reductions in carbon pollution and tangible improvements in sustainability and resilience. For over 25 years, they have achieved results that have helped communities reduce emissions and become healthier, stronger, and more prepared

ONTARIO CENTRE FOR CLIMATE IMPACTS AND ADAPTATION RESOURCES

CLIMATE CHANGE ADAPATATION COMMUNITY OF PRACTICE (CCACoP)

http://www.climateontario.ca/p_ccac.php

The Ontario Centre for Climate Impacts and Adaptation Resources is an interactive online community that provides a space where researchers, experts, policy makers and practitioners can come together to ask questions, generate ideas, share knowledge and communicate with others who are also working in the field of climate change adaptation. CCACoP emails regular notices of new publications, workshops and webinars free of charge to subscribed members.

THE NATIONAL CLIMATE CHANGE ADAPTATION RESEARCH FACILITY

https://www.nccarf.edu.au/

The National Climate Change Adaptation Research Facility (NCCARF) works to support decision makers throughout Australia as they prepare for and manage the risks of climate change and sea-level rise.

UNITED NATIONS SUSTAINABLE DEVELOPMENT KNOWLEDGE PLATFORM

https://sustainabledevelopment.un.org/post2015/transformingourworld

The United Nations Sustainable Development Knowledge Platform presents Transforming our World: the 2030 Agenda for Sustainable Development. The Agenda is a plan of action for people, planet and prosperity that seeks to strengthen universal peace in larger freedom.

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

http://bigpicture.unfccc.int/

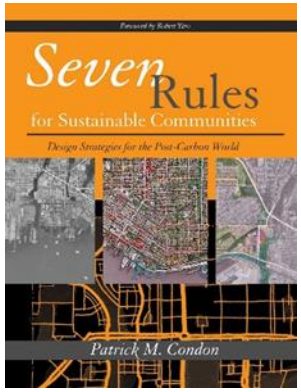
The United Nations Framework Convention on Climate Change. Climate – Get the Big Picture. A web-based interactive guide for newcomers to help them understand the 'big picture' of the United Nations climate change regime, which is at the forefront of international action to combat climate change. It guides the newcomer through the various issues covered by the regime, such as mitigation, adaptation and finance, in order to gain a better understanding of the global efforts to combat climate change

KNOWLEDGE PLATFORM OF THE UNITED NATIONS SUSTAINABLE DEVELOPMENT PROGRAMME

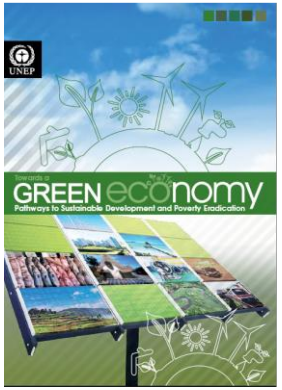
https://sustainabledevelopment.un.org/

The Knowledge Platform of the United Nations Sustainable Development programme provides access to recent publications and updates on current initiatives towards formulation and implementation of sustainability,

KEY REPORTS

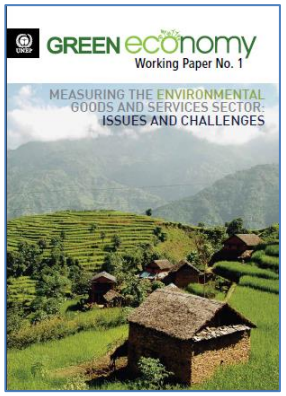


Condon, P. M. 2010. Seven rules for sustainable communities: Design strategies for the post-carbon world. Island Press, Washington DC. 241 pp.



UNEP. 2011. Towards a green economy: Pathways to sustainable development and poverty eradication. United Nations Environment Programme, UNEP/GRID-Arendal, Nairobi, Kenya. 631 pp.

Available at: http://www.unep.org/greeneconomy/Portals/88/documents/ger/ger_final_dec_2011/Green%20EconomyReport_Final_Dec2011.pdf



UNEP. 2014. Measuring the environmental goods and services sector: Issues and challenges. United Nations Environment Programme, Nairobi, Kenya. 34 pp.

Available at: http://www.unep.org/greeneconomy/portals/88/documents/WorkingPaperEGSSWorkshop.pdf

NATURAL RESOURCE CANADA ASSESSMENT REPORTS ON CLIMATE CHANGE

All NRCan publications are available in digital format, free of charge at: http://www.nrcan.gc.ca/environment/resources/publications/10766