National Collaborating Centre
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Tools and Methods for Integrating Health into Climate Change Adaptation and Mitigation Policies and Strategies

Report | January 2021

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National Collaborating Centre
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About the National Collaborating Centre for Healthy Public Policy

The National Collaborating Centre for Healthy Public Policy (NCCHPP) seeks to increase the expertise of public health actors across Canada in healthy public policy through the development, sharing and use of knowledge. The NCCHPP is one of six centres financed by the Public Health Agency of Canada. The six centres form a network across Canada, each hosted by a different institution and each focusing on a specific topic linked to public health. The National Collaborating Centre for Healthy Public Policy is hosted by the Institut national de santé publique du Québec (INSPQ), a leading centre in public health in Canada.

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Summary

This paper presents the results of a scoping review of the literature on existing tools and methods for integrating health concerns into climate change adaptation and mitigation policies and strategies. It is intended for public health actors who may be involved in the development of such policies and strategies. It may also be of interest to other actors who would like to further integrate the health dimension into their actions aimed at combating climate change.

The review of the scientific and grey literature identified thirteen tools and methods, which were classified into five categories:

1. Impact assessment tools;
2. Tools for integrating health into adaptation policies and strategies;
3. Models;
4. Conceptual frameworks;
5. Other methodological approaches.

This document briefly describes these tools and methods and provides hyperlinks for stakeholders interested in maximizing the health benefits of climate change mitigation or adaptation scenarios and wishing to learn more.

Introduction

Climate change poses a major risk to human health (Costello et al., 2009; Chastonay, Zybach, Simos, & Mattig, 2015; World Health Organization [WHO], 2018; Wight & Middleton, 2019). The potential health effects of climate change are quite well documented in the scientific literature. They can be direct: for example, risks related to heat waves, increased exposure to pollens, and extreme weather events such as storms, forest fires, floods or drought (Watts et al., 2015). They can also be indirect, resulting from the effects of climate change on ecosystems: for example, changes in the geographic distribution of vector-borne diseases, water availability and quality, and access to food. (Watts et al., 2015; Levy & Patz, 2015). To these should be added consequences related to the economy and to social structures, such as migration and conflicts (McLeman, 2019; Woodhall, Landeg, & Kovats, 2019). To avoid the most significant impacts on human health and reduce inequalities, the Intergovernmental Panel on Climate Change advises limiting warming to 1.5°C (Intergovernmental Panel on Climate Change [IPCC], 2018; Maibach, Sarfaty, Mitchell, & Gould, 2019).

Thus, the health sector has a role to play in the fight against climate change (Flahault, Schütte, Guégan, Pascal, & Barouki, 2015). The Paris Climate Accord encourages countries to take ambitious action to mitigate climate change and find ways to adapt to it (Hoegh-Guldberg et al., 2019). In this context, mitigation refers to strategies for reducing greenhouse gas emissions (Ebi & Paulson, 2010; Harlan & Ruddell, 2011). It corresponds to primary prevention (Frumkin, Hess, Luber, Malilay, & McGeehin, 2008). Adaptation refers to policies, measures and strategies designed to reduce the impacts of climate change and support resilience (Austin et al., 2015). It corresponds to strategies aimed at enhancing a system's ability to adjust and to reduce vulnerability to the effects of climate change (Harlan & Ruddell, 2011). These two types of strategies are complementary, and a combination of both is required to meet global health needs (Hobbhahn, Fears, Haines, & Ter Meulen, 2019).

Adaptation and mitigation policies and strategies should, in general, help improve health by achieving their ultimate goal (reducing the effects of climate change); but they are also intrinsically a means of positively affecting population health, to a greater or lesser degree, and of increasing or decreasing health inequalities. Therefore, the potential exists for maximizing the health benefits of these policies and strategies.

With this in mind, the National Collaborating Centre for Healthy Public Policy undertook to complete a scoping review of the grey and scientific literature on the subject. The objective was to identify existing tools and methods for integrating health concerns into climate change adaptation and mitigation policies and strategies.

This document presents the results of this exploratory literature review. It is intended for public health actors who may be involved in the development of such policies and strategies. It may also be of interest to other actors who would like to further integrate the health dimension into their actions aimed at combating climate change. The document presents and describes thirteen tools and methods classified into five categories:

1. Impact assessment tools;
2. Tools for integrating health into adaptation policies and strategies;
3. Models;
4. Conceptual frameworks;
5. Other methodological approaches.

Hyperlinks to examples of the tools and methods presented in this document are included for those interested in learning more.

1 Methodological approach

Thethirteen tools and methods were identified through a scoping review of the scientific and grey literature. To this end, a search strategy for identifying articles and reports related to the topic was developed with support from the documentation services of the Institut national de santé publique du Québec (INSPQ) and the library services of Université Laval. Keywords and their combinations[1] were proposed for the bibliographic search. The review of the scientific literature was conducted using three databases: PubMed, Elsevier, and Web of science. The review of the grey literature was conducted using the following tools:

- Université Laval's database: doctoral and master's theses and conference proceedings;
- The websites of the following international organizations: World Health Organization (WHO), Intergovernmental Panel on Climate Change, United Nations Environment Programme, World Meteorological Organization, United Nations Framework Convention on Climate Change;
- The websites of environment and health ministries in Canada, the United States and France, including state and provincial websites.

The inclusion criteria for this literature search were as follows:

- The study clearly presents the link between a health issue and a meteorological factor that is likely to be modified by climate change or that has already been modified by climate change;
- The purpose of the study is to assess the health effects of one or more policies/strategies aimed at adapting to the consequences of climate change or at reducing greenhouse gas emissions;
- The tools/methods are presented and described.

The exclusion criteria for this literature search were as follows:

- The study only examines the health impacts or health system impacts of climate change (no strategies/tools are examined) in qualitative or quantitative terms;
- The study presents tools for assessing the health impacts of extreme climatic events (drought, heat waves, floods, hurricanes);
- The study presents tools/methods that assess the health benefits of implementing a policy or strategy that is not aimed at climate change adaptation or mitigation;
- Commentaries, editorials, synthesis reviews, systematic reviews, speeches, testimonials, press releases;
- The study is published in a language other than English or French.

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[1] In French: (Outil*[TIAB] OR Method[TIAB] OR Cadre[TIAB] OR "Évaluation d'impact sur la santé"[MeSH])
AND ("Changement Climat"[Mesh] OR " Réchauffement climat"[TIAB] OR "Effet de serre"[MeSH:NoExp] OR "Gaz à effet de serre"[MeSH:NoExp] OR "Changement climatique"[TIAB] OR "Évènements extrêmes"[TIAB]) AND ("Santé publique"[Mesh:NoExp] OR "Politique publique"[MeSH:NoExp] OR "Planification en santé"[MeSH:NoExp] OR "Politique de santé"[MeSH:NoExp] OR "Pollution de l'air" OR Aéroallergènes OR Canicules OR "Ilot de chaleur" OR "Maladies vectorielles" OR "Maladies hydriques" OR "Approvisionnement en eau et en nourriture" OR "Santé mentale" OR "Refugies environnementaux")
In English: (Tool*[TIAB] OR Method[TIAB] OR framework[TIAB] OR "Health Impact Assessment"[MeSH])
AND ("Climate Change"[MeSH] OR "Climate Change"[TIAB] OR "Climatic change"[TIAB] OR "Global warming"[TIAB] OR "Greenhouse Effect"[MeSH:NoExp] OR "Extreme Events"[TIAB]) AND ("Public Health"[MeSH:NoExp] OR "Public Policy"[MeSH:NoExp] OR "Health Planning"[MeSH:NoExp] OR "Health Policy"[MeSH:NoExp] OR "Air Pollution" OR Aeroallergens OR "Heat waves" OR "Urban Heat island effect" OR "Vector-borne diseases" OR "Water-borne diseases" OR "Water & food supply" OR "Mental health" OR "Environmental Refugees")

The review of scientific and grey literature was conducted between February and March 2019. The bibliographic search considered the period from January 1990 to January 2019. It should be noted that no restrictions were placed on geographic location for the scientific literature search.

It should also be noted that action plans, generally defined at the national level, were not included in the literature review. These usually constitute a compilation of measures organized by activity sector and do not allow for identification of tools or a method as such. For example, plans specifically for the management of heat waves do not necessarily incorporate a climate change component. However, in some cases, these documents advocate choosing solutions that do not aggravate the climate change problem, by avoiding those that increase greenhouse gas emissions, for example (WHO Regional Office for Europe [WHO-ROE], 2008)

2 Principal results of the literature review

2.1 Scientific literature

A synthesis of the results of the review of the scientific literature is presented in Table 1.

Table 1 Number of articles generated by the scientific literature review

	Total (with duplicates)	Total (without duplicates)	Excluded	Retained	Included in the final review
Number of articles	2082	1718	1617	101	28

The scientific literature review generated 1718 articles without duplicates. A preliminary selection was made, based on titles and keywords, as well as on abstracts in case of doubt. It should be noted that the results included a large number of studies that used models to assess the health impacts of different climate change scenarios, but did not, however, present adaptation and/or mitigation strategies, or tools and/or methods. These studies were excluded from the review.

Following application of the exclusion criteria, 101 articles were downloaded for more in-depth reading. After these were consulted, **28 were retained** on the basis of the inclusion criteria. These articles were published between 2008 and 2018.

2.2 Grey literature

A synthesis of the results of the review of the grey literature is presented in Table 2.

Table 2 Number of reports generated by the grey literature review

	Total	Included in the final review
Number of reports	43	7

A preliminary selection was made, based on titles and keywords, as well as on abstracts. Forty-three reports were selected and downloaded for an in-depth review. After application of the inclusion criteria, **seven were retained** for final analysis.

3 Brief description of the tools and methods identified

The methods and tools identified by the review of the scientific and grey literature were classified into five main categories:

- Impact assessment tools;
- Tools for integrating health into adaptation policies and strategies;
- Models;
- Conceptual frameworks;
- Other methodological approaches.

3.1 Impact assessment tools

3.1.1 HEALTH IMPACT ASSESSMENT

Health impact assessment (HIA) is most often defined as "a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (WHO, 1999, p. 4). HIA identifies appropriate measures for managing these effects (Quigley et al., 2006). It is a decision-support tool that aims to minimize negative and strengthen positive health effects, and reduce health inequalities, prior to completion of the decision-making process. The HIA approach as defined by the Gothenburg Consensus often consists of five steps[2] (St-Pierre, 2009):

1. *Screening:* decide whether a policy, program or project should be the subject of an HIA;
2. *Scoping:* define the scope and terms of reference for the HIA, i.e., how the HIA will be carried out;
3. *Appraisal:* determine the extent to which the policy, program or project will affect health, the nature of those effects, and the population groups that will be impacted by those effects;
4. *Recommendations and report:* formulate recommendations for minimizing the negative effects and maximizing the positive effects of a policy, program or project, and present the results of the HIA in a report;
5. *Evaluation and monitoring:* evaluate the HIA process carried out and its influence on decision making, and monitor the implementation of proposed changes.

In 2011, the United Nations Framework Convention on Climate Change published a document presenting an HIA approach that can be used to assess the potential impacts of climate change and to develop adaptive responses with the aim of guiding government decision making. This process was detailed and documented by various actors including the WHO and the WHO Collaborating Centre for Environmental Health Impact Assessment located at Curtin University in Perth, Australia (The Curtin University WHO Collaborating Centre for Environmental Health Impact Assessment).

[2] Free online course offered by the National Collaborating Centre for Healthy Public Policy - Health Impact Assessment, step by step: https://ncchpp.ca/hia

It consists of seven steps (United Nations Framework Convention on Climate Change [UNFCCC], 2011):

1. Laying the groundwork for application of the process;
2. Identification of climate variables relevant to the country or region and the environmental impacts resulting from climate change;
3. Identification of potential health impacts and existing means of control;
4. Risk identification and prioritization (comparative risk assessment is proposed as a method [see section 4.1.2]);
5. Development of adaptation responses (measures);
6. Development of strategies required for the implementation of adaptation measures;
7. Formulation of recommendations for decision makers.

HIA can be used to analyze the potential health impacts of climate change policies or strategies. For example, this tool was used to assess the health impact of climate change mitigation policies at the local level in Geneva, Switzerland (Diallo, Cantoreggi, & Simos, 2016; Diallo, Cantoreggi, Simos, & Christie, 2017). It was also used to estimate the health co-benefits of three different land-use scenarios, with potential for climate change adaptation and mitigation, in the city of Houston in the United States. These three scenarios were: downtown office building renovation; urban infill; and a university campus sustainability plan (Houghton, 2011). This approach was also used to analyze the health impacts of four transport scenarios tied to local climate change mitigation policies in Basel, Switzerland (Perez et al., 2015). Similar work has been carried out in Rotterdam, in the Netherlands, using HIA to assess the health co-benefits of greenhouse gas reduction policies in the transportation sector (Tobollik et al., 2016). These applications of HIA helped identify which of the proposed climate change mitigation scenarios was most beneficial to health and the actions required to optimize the resulting health co-benefits.

A study produced in the United States analyzed twelve HIAs conducted in six states and applied to proposed climate change policies. This study concluded that the HIA process can facilitate intersectoral collaboration, help optimize the health co-benefits of climate change policies and raise awareness among decision makers about the health impacts of proposed policies (Dannenberg, Rogerson, & Rudolph, 2019).

HIA provides a means of involving health professionals in decision making related to proposed climate change plans, policies and projects, which should lead to better informed choices in the long term (Dannenberg in Levy & Patz, 2015).

To learn more about this tool, go to:
http://www.ncchpp.ca/54/Health_Impact_Assessment.ccnpps

To learn more about some examples of HIA being used in relation to climate change policies and strategies, go to:

Diallo and colleagues, 2016 (available in French only, paywall):
https://doi.org/10.1684/ers.2016.0890

Diallo and colleagues, 2017 (paywall):
https://doi.org/10.1177/1757975916686920

Houghton, 2011:
https://meridian.allenpress.com/jgb/article/6/2/66/199325/Health-Impact-Assessments-A-Tool-for-Designing

Perez and colleagues, 2015 (paywall):
https://doi.org/10.1016/j.envint.2015.08.002

Tobollik and colleagues, 2016 (paywall):
https://doi.org/10.1016/j.envres.2016.01.014

3.1.2 COMPARATIVE RISK ASSESSMENT

The WHO has defined comparative risk assessment (CRA) as "the systematic evaluation of changes in population health which result from modifying the population distribution of exposure to a risk factor or a group of risk factors" (Ezzati, 2000, p. 31). CRA is structured into four steps (adapted from Campbell-Lendrum & Woodruff, 2006):

1. Identification of health risks associated with exposure;
2. Quantification of the dose-response relationship for an established baseline period;
3. Definition of future exposure scenarios;
4. Estimation of the burden of disease attributable to a risk factor and the burden avoidable by plausible reductions in the risk factor.

Comparative risk assessment has been used to inform decisions related to climate change mitigation (Campbell-Lendrum & Woodruff, 2006). For example, it has been used to quantify the co-benefits in terms of reduced mortality associated with the implementation of a rapid transit system in Kuala Lumpur, Malaysia. This process revealed that the implementation of such a transport system could provide significant health benefits to both the general population and to users (Kwan, Tainio, Woodcock, & Hashim, 2016).

CRA was also used, in the context of climate change mitigation strategies, to compare the health effects of alternative urban transport scenarios in two cities: London, UK, and New Delhi, India. Its application in this context demonstrated that policies aimed at increasing the acceptability, attractiveness and safety of active urban travel, and at discouraging travel in private motor vehicles would offer greater health benefits than policies focused solely on promoting low-emission motor vehicles (Woodcock et al., 2009).

CRA has also been applied in the power generation sector in the European Union, China and India. It has been used to assess the effect of particulate matter on air pollution levels, and the health effects resulting from measures aimed at reducing greenhouse gas emissions. This work made it possible to document net health gains resulting from the decarbonization of electricity generation and to highlight additional information regarding the magnitude of these gains (Markandya et al., 2009).

To learn more about two examples of using the CRA process, go to:

Kwan and colleagues, 2016:
https://www.repository.cam.ac.uk/bitstream/handle/1810/266077/642%20-%20Kwan_Reviews%20on%20Environmental%20Health%202016%20%28pbc%20conference%29.pdf?sequence=1

Woodcock and colleagues, 2009: https://www.researchgate.net/profile/James_Woodcock/publication/40035431_Health_and_Climate_Change_2_Public_health_benefits_of_strategies_to_reduce_greenhouse-gas_emissions_urban_land_transport/links/5b97ed23299bf14ad4ce9514/Health-and-Climate-Change-2-Public-health-benefits-of-strategies-to-reduce-greenhouse-gas-emissions-urban-land-transport.pdf

3.1.3 ENVIRONMENTAL ASSESSMENTS

The purpose of environmental assessments is to identify and evaluate the potential consequences for the environment of policies and projects. In this context, environmental impact assessment (EIA) is used to assess the environmental impacts[3] of projects, whereas strategic environmental assessment (SEA) is applied to policies, plans or programs. SEA allows for a comparative analysis of different policy, plan or program options, including the "do nothing" option. The EIA and SEA processes are quite similar to the HIA process, in particular because they are composed of a series of steps. An EIA consists of the following steps (International Association for Impact Assessment [IAIA], 1999):

1. *Screening:* determine if an EIA is necessary;
2. *Scoping:* determine the content and scope of the EIA;
3. *Impact analysis:* assess the effects of the project on the environment;
4. *Impact mitigation and management:* propose measures to prevent, reduce and potentially offset adverse environmental effects; prepare plans needed to manage mitigation measures and other risks associated with the project.
5. *Report:* prepare the EIA report;
6. *Environmental monitoring:* ensure that mitigation measures and the proposed environmental management plan are properly implemented.

A SEA consists of the following generic steps (Crowley & Risse, 2011):

1. *Preliminary screening:* determine whether it is necessary to undertake a SEA;
2. *Scoping:* define the content and scope of the SEA;
3. *Evaluation, comparison and recommendations:* Evaluate and compare the effects of different policy, plan, or program options to select the most environmentally, socially, and economically beneficial option(s); formulate appropriate measures for reducing the negative impacts or maximizing the positive impacts of the selected option(s); and produce a SEA report;
4. *Revision:* verify the quality of the SEA report produced and assess the environmental, social and economic acceptability of a proposed or revised policy, plan or program;
5. *Decision making:* submit the SEA report containing the results and conclusions of the assessment to the competent authority for decision making;
6. *Implementation and monitoring:* monitor the implementation of the measures proposed in the SEA and their adequacy.

The SEA process is accompanied by public consultations as required.

[3] It should be noted that psychosocial impacts are increasingly taken into account in these analyses.

EIA can be used to identify adaptation and mitigation measures that benefit both the environment and health. This implies the explicit inclusion of human health concerns among the topics to be included within the scope of its investigation. Similarly, SEA can be used to assist in the selection of climate change adaptation or mitigation options that support both environmental protection and health promotion. To achieve this, the SEA must incorporate human health issues within the scope of its analysis.[4] All stages of the SEA can integrate health concerns (Kemm, 2013). In Canada, the passage in 2019 of Bill C-69, a major reform of the federal environmental assessment regime, along with the creation of a new agency, broadened the scope of impact assessments required by federal authorities.[5] These changes also helped solidify the place of human health in these impact assessments. In addition, the practitioner's guide associated with the Impact Assessment Act requires the consideration of health issues, as well as compliance with the recommendations of the Public Health Agency of Canada regarding the application of the social determinants of health approach (Freeman, 2019; Diallo & Freeman, 2020).

EIA and SEA can be applied to policies, plans, programs and projects developed in sectors such as land use planning, transport and energy, and in relation to climate change mitigation (Diallo et al., 2017; WHO, 2011). Effectively integrating health concerns when applying these tools would make it possible to limit health risks and identify important opportunities for promoting health.

To learn more about the use of EIA and SEA in the context of land use planning interventions related to climate change issues, go to:

Diallo and colleagues, 2017 (paywall):
https://doi.org/10.1177/1757975916686920

3.1.4 INTEGRATED ENVIRONMENTAL HEALTH IMPACT ASSESSMENT

The objective of integrated environmental health impact assessment (IEHIA) is to assess health problems arising from the environment, as well as the health impacts of policies and other interventions that affect the environment, such that the complexities, interdependencies and uncertainties of reality are taken into account (Briggs, 2008). According to Briggs (2008), IEHIA derives from risk assessment, EIA, HIA and CRA. It is a response to the need for a more inclusive and integrated approach to the assessment of health risks related to the environment. The IEHIA process is structured into four steps (Briggs, 2008):

1. *Issue framing*: define the problem or issue to be examined and agree on the scope of the assessment. This step involves the construction of a conceptual model of the issue to be examined, which then provides a framework for the assessment.
2. *Design*: convert the conceptual model developed in the previous step into a detailed protocol for the assessment. This step includes definition of the key variables and their relationships, the policy scenarios to be evaluated, and the data and tools to be used.

[4] In Québec, the Institut national de santé publique offers an environmental assessment toolbox that includes grids that facilitate taking into account the climatic and health dimensions. Several of the items in this toolbox are applicable to other contexts: https://www.inspq.qc.ca/boite-outils-en-evaluation-environnementale-au-quebec-meridional

[5] Related initiatives also exist at the provincial and territorial levels. In Québec, for example, the Environment Quality Act also allows for the assessment of social and health impacts in environmental impact studies. http://legisquebec.gouv.qc.ca/en/showdoc/cs/q-2

3. *Execution*: this step is at the heart of the IEHIA process. As in traditional risk assessment, it involves hazard identification, exposure assessment and risk characterization. This step involves modeling and analyzing different scenarios with respect to exposure and health effects and comparing the results of the assessment.
4. *Appraisal*: synthesize and interpret the results. This involves assessing outcome measures for different scenarios and ranking different policy options based on their acceptability or effectiveness.

Although in Briggs' (2008) article the description of this tool is not accompanied by a concrete example of its application to climate change issues, the author discusses these issues and the need for an inclusive and integrated approach to addressing them. An example of the use of the tool in this context is found in the study of the effects of climate change on heat- and cold-related mortality in the Netherlands. Scenarios with and without adaptation strategies were analyzed. Application of the tool made it possible to compare the different scenarios and to provide an estimate of the order of magnitude of these effects for each scenario studied (Huynen & Martens, 2015).

To learn more about this tool, go to:

Briggs and colleagues, 2018:
https://doi.org/10.1186/1476-069X-7-61

3.2 Tools for integrating health into adaptation policies and strategies

3.2.1 Vulnerability and adaptation assessment

Vulnerability and adaptation assessment (V&A) was developed by the WHO. It is a process aimed at furthering understanding of the current and future health risks associated with climate change and at developing measures, policies and strategies for better managing these risks (Ebi, Anderson, Berry, Paterson, & Yusa, 2016). This is a way to support the involvement of the health sector in climate change adaptation efforts (Berry, Enright, Shumake-Guillemot, Villalobos Prats, & Campbell-Lendrum, 2018). The objective of a V&A assessment is to help decision makers understand the health risks attributable to climate change, manage those risks, and prioritize policies and programs aimed at improving population health in the context of a changing climate. This assessment can be conducted at the local or the national level (Ebi et al., 2016). The application process comprises the following five basic steps (WHO 2013):

1. Frame and scope the assessment;
2. Conduct the vulnerability and adaptation assessment;
3. Enhance understanding of future impacts on health;
4. Prioritize and implement health protection strategies within a climate change adaptation context;
5. Establish an iterative process to manage and monitor the health risks of climate change.

The Ontario Ministry of Health and Long-Term Care has developed a Climate Change and Health Toolkit to address public health challenges related to climate change in Ontario (Ebi et al., 2016). The objective is to support an adaptive and resilient public health system, enabling it to anticipate, mitigate and respond to the emerging risks and impacts of climate change. This kit contains, among other things, guidelines and a workbook for assessing V&A in relation to climate change.

The methodological approach proposed for the V&A assessment is based on that which the WHO defined, with an added sixth step that examines the potential advantages and disadvantages of adaptation and mitigation solutions implemented in other sectors (Ebi et al., 2016).

Another example of a tool linked to climate change vulnerability is the Geospatial Emergency Management Support System (GEMSS). This tool developed by the Texas Water Development Board is a platform for integrating data and metadata available on the internet. It allows for information concerning different indicators to be combined and represented visually in the form of various maps that integrate data on climatic events (heat waves, heavy rains), mortality, vulnerability indicators, and mitigation policies. The GEMSS is a useful tool for identifying and reaching out to populations vulnerable to climate risks, for mobilizing resources and for informing local climate policies such that health risks can be reduced. This tool[6] was used by the City of Austin in the United States to assess health vulnerability to climate change. Based on this use, it appears that the GEMSS tool has the potential to support several objectives, including: monitoring and assessing climate-related vulnerability through visualization; providing decision makers with an open-access tool for understanding how vulnerable populations and the environment could be affected by proposed climate policies; monitoring the progress of climate change policies in reducing socio-environmental vulnerability; raising public awareness of the links between climate change and public health; and providing a basis for epidemiological research (Houghton, Prudent, Scott III, Wade, & Luber, 2012).

For more information on the vulnerability and adaptation assessment tool, go to:

WHO: https://www.who.int/globalchange/publications/vulnerability-adaptation/en/

Ontario:
http://www.health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_health_va_guidelines.pdf

To learn more about the GEMSS tool, go to:

Houghton and colleagues, 2012:
https://www.academia.edu/2402738/Climate_change-related_vulnerabilities_and_local_environmental_public_health_tracking_through_GEMSS_A_web-based_visualization_tool

3.2.2 HEALTH NATIONAL ADAPTATION PROCESS

The health national adaptation process (HNAP) was developed by the WHO as part of the Climate Change Adaptation Programme of the United Nations Framework Convention on Climate Change. Its aim is to ensure that the process of iteratively managing the health risks resulting from climate change is integrated into the overall national adaptation planning process to achieve the goal of a healthy population in healthy communities. The HNAP consists of four components, each comprising several steps. The four components and eleven steps of the HNAP are as follows (WHO, 2014):

The first component focuses on *laying the groundwork and addressing gaps relative to the HNAP process.* This component comprises three steps:

[6] It has been used in relation to both climate change adaptation and mitigation policies.

1. Align the health adaptation planning process with the national process of developing a national adaptation plan;
2. Take stock of the available information;
3. Identify approaches to addressing gaps in the capacity to advance adaptation planning and weaknesses in undertaking the HNAP.

The second component concerns the *preparatory elements of the HNAP*. This component comprises three steps:

4. Conduct a health V&A assessment, including an assessment of short- to long-term adaptation needs with reference to development priorities;
5. Examine the impact of climate change on health-related development goals, legislation, strategies, policies and plans;
6. Develop a national health adaptation strategy that identifies priority adaptation options.

The third component focuses on *implementation strategies* and consists of two steps:

7. Develop an implementation strategy for operationalizing HNAPs and integrating climate change adaptation into all levels of health-related planning processes, including the enhancement of capacity for conducting future HNAPs;
8. Promote coordination and synergy with the NAP process (particularly with sectors affecting health), and with multilateral environmental agreements.

The fourth component concerns *reporting, monitoring and review*. It comprises three steps:

9. Monitor and review the HNAP to assess progress, effectiveness and gaps;
10. Update the health component of national adaptation plans in an iterative manner;
11. Establish periodic communication regarding the implementation of the HNAP, with reporting on progress and effectiveness.

The HNAP was developed in a global context to help countries' health sectors participate in developing climate change adaptation plans. In Canada, for example, the Ontario Ministry of Health and Long-Term Care has included templates in its “Ontario Climate Change and Health Toolkit” to support its public health system in developing climate change health adaptation plans (Ebi et al., 2016).

To learn more about HNAPs, go to:

WHO: https://www.who.int/globalchange/publications/guidance-health-adaptation-planning/en/

For more information about the Ontario Climate Change and Health Toolkit, go to:

Ebi and colleagues, 2016:
http://www.health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_toolkit.aspx

3.2.3 TOOL TO ESTIMATE HEALTH AND ADAPTATION COSTS

The WHO Regional Office for Europe has developed an economic analysis tool to support adaptation planning aimed at protecting health in member states from the adverse effects of climate change. This tool estimates health and adaptation costs across three dimensions (WHO Regional Office for Europe [WHO-ROE], 2013):

1. Costs associated with health damage caused by climate change;
2. The costs of adaptation in various sectors to protect health from such damage;
3. The efficiency of adaptation measures, including averted health costs.

There are four steps in the health and adaptation cost assessment process:

1. Define the scope of the assessment: determine the type of analysis and specify the following: the level of application of the tool, the types of diseases to be included, the population groups concerned, and the period of analysis;
2. Identify methods, data, and sources and conduct analyses: this step consists of estimating both the costs of health damage and the costs of adaptation. This involves taking into account methodological considerations, identifying data and sources, collecting the data and inserting it into Excel spreadsheets, conducting a sensitivity analysis (optional[7]), and analyzing the results;
3. Compare the costs of damage with those of adaptation: this amounts to carrying out a cost-benefit analysis;
4. Present results: this step involves considering the target audience and communication needs (WHO-ROE, 2013).

The tool takes the form of Excel spreadsheets.

For more information on the tool for estimating health and adaptation costs, go to:

WHO-ROE, 2013:
https://www.euro.who.int/en/publications/abstracts/climate-change-and-health-a-tool-to-estimate-health-and-adaptation-costs

3.3 Models

The models identified by this literature review were mainly used to assess the health effects of greenhouse gas emission reduction policies in various sectors (transportation, energy, industry or construction), as well as for urban planning (e.g., greening policies [Chen et al., 2014]). The energy sector is the most represented and has been studied at the regional level in various countries, including China (Cai et al., 2018; Markandya et al., 2009), Europe (Markandya et al., 2009; Williams et al., 2018) and the United States (Buonocore, Luckow, Fisher, Kempton, & Levy, 2016). Other applications of the models focus on building emissions (Abel et al., 2018; Tuomisto et al., 2015), municipal public transportation (Sarigiannis et al., 2017) or the cement industry (Zhang et al., 2016). Finally, some models have been used to assess the overall effects of national or sub-national carbon policies (Garcia-Menendez, Saari, Monier, & Selin, 2015; Thomson, Rausch, Saari, & Selin, 2016; Wolkinger et al., 2018).

[7] Given the uncertainty inherent in various data inputs used in the models (e.g., estimates of mortality and morbidity due to climate change), a sensitivity analysis is recommended to assess the likely range of results that will be obtained.

These types of tools have the same general structure and comprise a series of linked models that simulate different mitigation scenarios: a model that projects changes in greenhouse gas emissions for the scenarios; a model that estimates the resulting air pollutant concentrations; and a model that estimates the health effects of air pollution, such as the *Benefits Mapping and Analysis Program* (Abel et al., 2018). These sets of models also include some existing tools such as HIA, CRA or the *Health Economic Assessment Tool*, developed by the WHO to estimate the economic and health benefits of different policies.

To learn more about the various models, go to:

Abel and colleagues, 2018: https://doi.org/10.1371/journal.pmed.1002599

Buonocore and colleagues, 2016: https://doi.org/10.1088/1748-9326/11/7/074019

Cai and colleagues, 2018: https://doi.org/10.1016/S2542-5196(18)30050-0

Chen and colleagues, 2014: https://doi.org/10.1016/j.envpol.2014.05.002

Garcia-Menendez and colleagues, 2015: https://doi.org/10.1021/acs.est.5b01324

Markandya and colleagues, 2009: https://doi.org/10.1016/S0140-6736(09)61715-3

Sarigiannis and colleagues, 2017: https://doi.org/10.1016/j.scitotenv.2016.11.142

Thomson and colleagues, 2016: https://doi.org/10.1080/10962247.2016.1192071

Tuomisto and colleagues, 2015: https://doi.org/10.1186/s12940-015-0082-z

Williams and colleagues, 2018: https://doi.org/10.1016/S2542-5196(18)30067-6

Wolkinger and colleagues, 2018: https://doi.org/10.3390/ijerph15050880

Zhang and colleagues, 2016: https://doi.org/10.1016/j.apenergy.2016.10.030

3.4 Conceptual Frameworks

3.4.1 The eDPSEEA conceptual framework

Chiabai and colleagues (2018) used the DPSEEA approach, i.e., Driver, Pressure, State, Exposure, Effect, Action, to develop an ecosystems enriched conceptual framework (eDPSEEA) that makes it possible to identify the health impacts of modifying green spaces through climate change adaptation measures. In the eDPSEEA model, the driver is represented by the climate change resulting from greenhouse gas emissions. The pressure is represented by temperature and precipitation patterns, extreme weather events, and heat and air pollutants. The pressure leads to a potential change in the size/quantity/quality of a green space (its state), producing alterations in the functioning of the ecosystem; this change will then affect the terrestrial distribution of natural areas, as well as the flow of the ecosystem services that these natural areas provide in the short and medium term. The state is characterized by six types of ecosystem services that can affect the use or perception of a site through exposure. These services impact urban heat islands, air pollution, water regulation, the social environment, recreation and tourism, and the microbiome. Depending on a range of contextual factors (socio-economic characteristics, health status, culture, attitudes, beliefs, and environmental

factors), these changes can have direct or indirect, and positive or negative impacts on health (*effect*). Actions here refer to any intervention affecting green spaces and population exposure that may ultimately have an impact on human health.

To learn more about the eDPSEEA conceptual framework, go to:

Chiabai and colleagues, 2018:
https://doi.org/10.1016/j.scitotenv.2018.03.323

3.4.2 A RISK MODELING CONCEPTUAL FRAMEWORK

The goal of the study by Smith and colleagues (2015) is to develop an integrated approach able to evaluate, and provide scientific assessments of, climate change adaptation measures, so as to assist in the management of risk related to climate and weather events. To this end, the authors developed a conceptual framework based on risk modeling. This conceptual framework integrates three components:

1. Knowledge synthesis;
2. Data storage and access;
3. Stochastic modeling using the QMRA approach (quantitative microbial risk assessment).

The framework was used to estimate and compare outcomes of adaptation strategies aimed at reducing the risks of food- and waterborne diseases associated with climate change. Analyses of these strategies have shown that implementing intervention measures to adapt to the effects of climate change could mitigate future public health risks. This framework has demonstrated the potential to assist in decision making by comparing several options for adapting to and managing risk associated with the impacts of climate change on food and water security (Smith et al., 2015).

For more information about this conceptual framework, go to:

Smith and colleagues, 2015:
https://doi.org/10.1016/j.foodres.2014.07.006

3.4.3 CLIMATE, HEALTH AND EQUITY VULNERABILITY ASSESSMENT

Climate, health and equity vulnerability assessment (CHEVA) is a conceptual framework for assessing climate and health vulnerabilities. It consists of four components:

1. Current and future physical threats related to climate change;
2. Population vulnerabilities, including the social determinants of health;
3. “Adaptive capacity” which reflects the individual and community resources that could mitigate the negative effects of climate change;
4. Health impact projections (Rudolph, Harrison, Buckley, & North, 2018).

A list of indicators was developed to support the use of this conceptual framework. These indicators focus on climate threats, population vulnerability, adaptive capacity and resiliency (Rudolph et al., 2018).

For more information about this conceptual framework, go to: Rudolph and colleagues, 2018:
https://www.apha.org/topics-and-issues/climate-change/guide

3.5 Other methodological approaches

3.5.1 Participatory approaches

As part of the health component of Québec's climate change action plan (2006-2012), the Institut national de santé publique du Québec (INSPQ) was mandated by the Ministère de la Santé et des Services sociaux du Québec to support projects that reduce the impact of climate change on the health of vulnerable populations. One focus of the INSPQ's efforts involved combating urban heat islands as a climate change adaptation measure. In the context of this work, the participatory approach was used to mobilize the community and involve it in the implementation of urban heat island reduction strategies. This approach served to assess the effects on the quality of life and well-being of residents and users of several urban heat island reduction pilot projects in the Montreal area. The assessment was based on four criteria: attractiveness, comfort, coolness and safety. Stakeholders were invited to participate in the process of developing the approach, implementing it and interpreting the results. The tools used include interviews, questionnaires (online and paper-based), and focus group discussions (Beaudoin & Gosselin, 2016). For more information about this approach, go to:

Beaudoin & Gosselin, 2016:
https://iris.paho.org/handle/10665.2/31230

3.5.2 Mixed methods

Mixed methods refer to methods that combine different analytical approaches. Haluza and colleagues (2012) applied a mixed-method approach in the energy sector to estimate the health impact of switching from light fuel to wood-burning for residential heating in Upper Austria, one of the nine federal states of Austria. The methodological approach combined modeling, used to estimate air pollutant emissions, with a review of epidemiological studies, used to assess health impact (based on a literature review).

In the transportation sector, Lindsay, Macmillan, and Woodward (2011) used a combination of survey data and tools to study the effects on health, air pollution, and greenhouse gas emissions of a shift from taking short trips (less than 7 km) by car to using bikes instead, in New Zealand. In this study, several tools and models drawn from the literature were used:

- The New Zealand Household Travel Survey (NZHTS) for data on reasons for travel, distance and average speed;
- A Vehicle Emissions Prediction Model to predict vehicle emissions in terms of carbon monoxide, CO_2, nitrogen oxides (NO_x), volatile organic compounds (VOC) and fine particulate matter (PM_{10});
- The Health Economic Assessment Tool (HEAT) developed by the WHO to estimate the health and economic benefits of increased cycling and walking;
- Application of the results of the Health and Pollution in New Zealand (HAPiNZ) study to vehicle-related air pollution data;
- Data on bicycle-related injuries and deaths and energy expenditure (due to car to bike switch) from the literature.

Finally, Smith and Haigler (2008) present a set of scoping methods for conducting a rapid health co-benefit assessment of greenhouse gas emission reduction measures in the energy sector.

To learn more about the approach proposed by Haluza and colleagues (2012), go to: https://doi.org/10.1038/jes.2012.27

For more information on the method used by Lindsay and colleagues (2011), go to: https://doi.org/10.1111/j.1753-6405.2010.00621.x

For more information on the approach proposed by Smith and Haigler (2008), go to: https://doi.org/10.1146/annurev.publhealth.29.020907.090759

3.6 Synthesis

Table 3 provides an overview of the different tools and methods presented in this report and drawn from the scoping review of the scientific and grey literature. However, when interpreting this information it is necessary to keep in mind the context in which the tools and methods were used, and the context of their analysis in the studies included in this literature review. HIA, for example, has been used to assess adaptation and, especially, mitigation strategies at the municipal level, but this type of tool could also be applied at other levels of government. In addition, environmental assessments have been considered in relation to climate change mitigation policies and strategies; however, they can also be applied to climate change adaptation policies, programs or projects.

Table 3 Overview of the different tools and methods identified by the scoping review of scientific and grey literature

Type of tool/method	Name of tool/method	Type of strategy (adaptation/ mitigation)	Scale of application (country, province, region, city, etc.)	To learn more about the different tools and methods
Impact assessment tools	Health impact assessment	Adaptation and mitigation	City	Diallo and colleagues, 2016: https://doi.org/10.1684/ers.2016.0890 Diallo and colleagues, 2017: https://doi.org/10.1177/1757975916686920 Houghton, 2011: https://meridian.allenpress.com/jgb/article/6/2/66/199325/Health-Impact-Assessments-A-Tool-for-Designing Perez and colleagues, 2015: https://doi.org/10.1016/j.envint.2015.08.002 Tobollik and colleagues, 2016: https://doi.org/10.1016/j.envres.2016.01.014
	Comparative risk assessment	Mitigation	City, country	Kwan and colleagues, 2016: https://www.repository.cam.ac.uk/bitstream/handle/1810/266077/642%20-%20Kwan_Reviews%20on%20Environmental%20Health%202016%20%28pbc%20conference%29.pdf?sequence=1 Woodcock and colleagues, 2009: https://www.researchgate.net/profile/James_Woodcock/publication/40035431_Health_and_Climate_Change_2_Public_health_benefits_of_strategies_to_reduce_greenhouse-gas_emissions_urban_land_transport/links/5b97ed23299bf14ad4ce9514/Health-and-Climate-Change-2-Public-health-benefits-of-strategies-to-reduce-greenhouse-gas-emissions-urban-land-transport.pdf
	Environmental assessments (EIA; SEA)	Mitigation	City	Diallo and colleagues, 2017: https://doi.org/10.1177/1757975916686920
	Integrated environmental health impact assessment	Not indicated	Not indicated	Briggs and colleagues, 2008: https://doi.org/10.1186/1476-069X-7-61

Type of tool/method	Name of tool/method	Type of strategy (adaptation/ mitigation)	Scale of application (country, province, region, city, etc.)	To learn more about the different tools and methods
Adaptation tools	Vulnerability and adaptation assessment	Adaptation	Country, province	WHO: https://www.who.int/globalchange/publications/vulnerability-adaptation/en/ Ontario: http://www.health.gov.on.ca/en/common/ministry/publications/reports/climate_change_toolkit/climate_change_health_va_guidelines.pdf For the GEMSS tool,[8] see Houghton and colleagues, 2012: https://www.academia.edu/2402738/Climate_change-related_vulnerabilities_and_local_environmental_public_health_tracking_through_GEMSS_A_web-based_visualization_tool
	National health sector adaptation process	Adaptation	Country	WHO: https://www.who.int/globalchange/publications/guidance-health-adaptation-planning/en/
	Tool for estimating health and adaptation costs	Adaptation	Country	WHO-ROE, 2013: https://www.euro.who.int/en/publications/abstracts/climate-change-and-health-a-tool-to-estimate-health-and-adaptation-costs
Models	Twelve models identified	Mitigation	Country, province, region, city	Abel and colleagues, 2018: https://doi.org/10.1371/journal.pmed.1002599 Buonocore and colleagues, 2016: https://doi.org/10.1088/1748-9326/11/7/074019 Cai and colleagues, 2018: https://doi.org/10.1016/S2542-5196(18)30050-0 Chen and colleagues, 2014: https://doi.org/10.1016/j.envpol.2014.05.002 Garcia-Menendez and colleagues, 2015: https://doi.org/10.1021/acs.est.5b01324 Markandya and colleagues, 2009: https://doi.org/10.1016/S0140-6736(09)61715-3 Sarigiannis and colleagues, 2017: https://doi.org/10.1016/j.scitotenv.2016.11.142 Thomson and colleagues: https://doi.org/10.1080/10962247.2016.1192071 Tuomisto and colleagues, 2015: https://doi.org/10.1186/s12940-015-0082-z Williams and colleagues, 2018: https://doi.org/10.1016/S2542-5196(18)30067-6 Wolkinger and colleagues, 2018: https://doi.org/10.3390/ijerph15050880 Zhang and colleagues, 2016: https://doi.org/10.1016/j.apenergy.2016.10.030

[8] It has been used in relation to both climate change adaptation and mitigation policies.

Type of tool/method	Name of tool/method	Type of strategy (adaptation/ mitigation)	Scale of application (country, province, region, city, etc.)	To learn more about the different tools and methods
Conceptual frameworks	eDPSEEA conceptual framework	Adaptation	Not indicated	Chiabai and colleagues, 2018: https://doi.org/10.1016/j.scitotenv.2018.03.323
	Conceptual framework based on risk modeling	Adaptation	Region	Smith and colleagues, 2015: https://doi.org/10.1016/j.foodres.2014.07.006
	Climate, health and equity vulnerability assessment	Not indicated	Not indicated	Rudolph and colleagues, 2018: https://www.apha.org/topics-and-issues/climate-change/guide
Other methodological approaches	Participatory approach	Adaptation	City, urban agglomeration	Beaudoin & Gosselin, 2016: https://iris.paho.org/handle/10665.2/31230
	Mixed methods	Mitigation	Country, region	Haluza and colleagues, 2012: https://doi.org/10.1038/jes.2012.27 Lindsay and colleagues, 2011: https://doi.org/10.1111/j.1753-6405.2010.00621.x Smith & Haigler, 2008: https://doi.org/10.1146/annurev.publhealth.29.020907.090759

4 Principal findings

The majority of the tools identified in the scientific literature are models. Twelve out of the twenty-eight articles[9] consulted refer to them. These models were used in relation to climate change mitigation strategies. They appear to be tools that are able to produce a useful prediction of the effects of different mitigation strategies on health, although these strategies are often theoretical (the concrete details of their achievement are not always made explicit).

A significant number of HIAs, in particular, was also identified by this literature review, both in the scientific literature (5 articles out of 28)[10] and in the grey literature (1 report out of 7).[11] However, this result should be qualified, as the term “health impact assessment” appears among the keywords used in the search strategy. The contexts in which HIA was applied relate to alternative transportation, urban planning or the building sector.

The conceptual frameworks identified were not accompanied by a concrete example of application in the articles, but are of interest as tools for integrating health into adaptation/mitigation policies.

It is also important to note that the HIA and CRA approaches can be used to estimate potential health impacts within the context of applying certain models or of using certain mixed methods.

In the grey literature, most of the approaches identified concern adaptation to climate change: four of the seven reports consulted focus specifically on this issue.[12] These tools are not always accompanied by concrete examples of application and are primarily intended to support climate change adaptation planning in the health sector within governments, health agencies, or other institutions (environmental, meteorological). The vulnerability and adaptation assessment tool is found in three out of seven documents.[13]

[9] Abel et al., 2018; Buonocore et al., 2016; Cai et al., Chen et al., 2014; Garcia Menedez et al., 2015; Markandya et al., 2009; Sarigiannis et al.;2017; Thomson et al., 2016; Tuomisto et al., 2015; Williams et al., 2018; Wolkinger et al., 2018; Zhang et al., 2016.

[10] Diallo et al., 2016; Diallo et al., 2017; Houghton, 2011; Perez et al., 2015; Tobollik et al., 2016.

[11] UNFCCC, 2011.

[12] WHO, 2003; WHO-ROE, 2013; WHO, 2014; Ebi et al., 2016.

[13] WHO, 2003; WHO, 2013; Ebi et al., 2016.

5 Limitations

This literature review, as is often the case with bibliographic research, has its limitations. Despite a rigorous methodological approach, relevant articles may have been overlooked.14 There are three possible reasons for this: 1) the keywords selected for the search were not included in the titles or abstracts of the documents; 2) publications in languages other than English and French were excluded; and 3) this literature review focused only on documentation available online and thus excluded any other documents that were not published online.

In addition, it should be noted that the effectiveness of the tools and methods presented in this work has not been evaluated. Furthermore, their "transferability" to Canadian jurisdictions was not analyzed. In other words, factors that may facilitate or impede their application in various jurisdictions in Canada were not assessed.

Despite these limitations, we believe this work serves to highlight many existing tools and methods for integrating health concerns into the development of climate change adaptation and mitigation policies and strategies.

[14] For example, articles on cost-benefit analyses.

Conclusion

The review of the scientific and grey literature resulted in the selection of 35 relevant articles and reports and the identification of a large number of tools and methods classified into five categories: 1) impact assessment tools; 2) tools for integrating health into adaptation policies and strategies; 3) models; 4) conceptual frameworks; and 5) other methodological approaches. These tools and methods can be used to better integrate health issues into climate change adaptation or mitigation strategies and thereby contribute to climate protection and health promotion.

What these tools and methods have in common is that they all seek to support decision making related to policies and strategies for combating climate change. They can also be used to help maximize the health benefits of climate change mitigation or adaptation scenarios.

Moreover, an interdisciplinary and intersectoral scientific approach appears to be required to assess the health benefits of climate change mitigation and adaptation policies and strategies. Some of the tools and methods proposed in this document could help facilitate intersectoral work.

The hyperlinks accompanying the descriptions of these tools and methods will allow actors in public health and in other sectors who wish to learn more to continue reading and to assess the usefulness of the application of a tool or its adaptation to their context.

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