TEACHERS GUIDE

Canada in a Changing Climate: The Living World

A Lesson Plan for Grade 7 and 8 Geography and Science Classes

Ingenium
Canada's Museums of Science and Innovation
Musées des sciences et de l'innovation du Canada

Canadian Geographic

Canada

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Overview

This teachers guide is designed to accompany the Natural Resources Canada report called Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (2014), available at www.nrcan.gc.ca/environment (Climate Change > Impacts and Adaptations). This report addresses current sensitivities to climate, as well as the risks and opportunities that climate change presents. The report also discusses adaptation options, approaches, and planning. It aims to inform the public and decision-makers about the importance of employing both adaptation and mitigation measures to significantly reduce the risks and magnitude of climate change.

By participating in activities like the ones in this module, students will develop a better understanding of the factors that contribute to climate change and of the effects of climate change on biodiversity and the living world. They will also explore the notion of adapting to climate change — both its existing effects and expected ones — to help maintain a healthy and balanced environment.

The activities in this module aim to develop a variety of 21st-century skills such as critical thinking, creativity, collaboration, and communication. Teachers can present the activities as a module or individually.

Teacher Backgrounder[1]

Climate Change: A Definition

What is climate change?

The term climate change refers to significant changes in average weather patterns (i.e., precipitation, temperature, wind, and other indicators) that persist within a climate system, caused directly or indirectly by human activity.[2] Climate change can involve both changes in *average conditions* and changes in *variability*, including extreme events. While there has always been variation in the Earth's climate, there is consensus in the scientific community that since the Industrial Revolution, human activity has increased the amount of greenhouse gases being released into the atmosphere; and that this is leading to a statistically significant increase in the Earth's temperature — hence the expression "global warming." **Climate change is happening now.**

It is this human-induced enhancement of the greenhouse effect that is of concern. Ongoing emissions of greenhouse gases have the potential to warm the planet to levels that have never been experienced in the history of human civilization.
Environment and Climate Change Canada www.climatechange.gc.ca/default.asp?lang=En&n=65CD73F4-1

[1] Most of the information contained in this section, unless otherwise noted, is taken from the report Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, F.J. Warren and D.S Lemmen, editors (2104); Government of Canada, Ottawa, ON. www.nrcan.gc.ca/environment

[2] The Intergovernmental Panel on Climate Change uses the term "climate variability" for changes in weather patterns due to natural causes, and reserves "climate change" for shifts due to direct or indirect human activity.

How does climate change affect us?

Researchers agree that we are seeing the impacts of climate change in Canada in various areas, including the following.

- **Natural resources development (forestry, energy, mining):** Climate change exacerbates climate extremes (e.g., extreme heat, cold, precipitation) and the resulting impacts and hazards. It also leads to gradual changes, such as permafrost degradation, sea level rise, and plant species migration — all of which affect the forestry, energy, and mining sectors. Climate change will also present new opportunities for the natural resource sectors, particularly in relation to northern economic development.
- **Industry**: Industrial activity is sensitive to variations in weather and to extreme events. The type of impacts and their extent depend o the industry, but production, operations, and revenue among and within sectors can be affected.
- **Human health:** Climate-sensitive diseases and disease vectors are moving northward into Canada (e.g., Lyme disease) and will likely continue to expand their range. In addition, new research suggests climate change will exacerbate health issues related to air pollution in some parts of Canada.
- **Water resources and infrastructure:** Well-maintained infrastructure is more resilient to a changing climate. This is especially true with respect to gradual changes in temperature and precipitation patterns. But there are key vulnerabilities associated with extreme weather events, which can overwhelm the capacity of water infrastructure.
- **Food production:** The impacts of climate change differ significantly between agriculture, fisheries, and non-commercial food supply, but common effects include increased losses from invasive pests and diseases, and risks to the transportation systems these sectors rely on.
- **Biodiversity:** Climate-related shifts in species distributions have already been documented for plants and animals in Canada. In many areas, shifts in species range are likely to result in novel ecosystems that have different species combinations, structural attributes, and ecological functions than existing ones.

Biodiversity

Biodiversity refers to the variety of species and ecosystems on Earth and the ecological processes which they are a part of. Biodiversity is the natural capital on which Canadians base most of their social and economic well-being. It plays a role in the purification of air and water, in climate regulation, in carbon capture and storage, in pollination, and in flood regulation. Humans take advantage of biodiversity directly and indirectly, for example, as a source of food and fibre, as a material resource for clothing manufacture, in forest products, and to facilitate recreational activities.

Climate Change Effects on Biodiversity

Climate is a key driver of ecosystem composition, structure, and function. It also interacts with other factors that influence biodiversity, such as pollution and land use change. Key conclusions related to biodiversity arising from ecological studies[3] include the following.

1. Climatically suitable ranges (or climate envelopes) for many species will likely shift northwards in response to warming temperatures. This will have major implications for people who rely on the current structure of ecosystem types.
2. Biodiversity may also be affected when species shifts are limited by physical conditions (barriers to movement) and biological processes (reduced access to food at critical times in the life cycle, such as breeding and rearing periods). Resulting changes in species composition can have varying consequences, such as disruptions in predator-prey and host-parasite relationships.
3. Although forest productivity could increase with higher atmospheric carbon dioxide concentrations and longer growing seasons, increases in the frequency and intensity of fires, insect outbreaks, drought, and icing events could offset potential gains. In addition, climate change impacts interact with other human-induced and natural stresses, including habitat loss and fragmentation, pollution, overharvesting, forest fire, and invasive species. The cumulative effects of these stresses could threaten many species.
4. Increased moisture stress in prairie ecosystems will likely decrease productivity in natural grasslands, although longer growing seasons and reduced competition from shrubs and trees (because of drier conditions) may partly offset the effects of reduced moisture.
5. Coastal and estuary ecosystems are at risk from increased erosion and "coastal squeeze," which could eliminate habitat for some species.
6. Climate change impacts on water quantity and quality are a concern for lakes and rivers across Canada. Higher temperatures are affecting the thermal habitat of many fish species, increasing potential habitat for invasive species and creating favourable conditions for unwanted algal blooms.
7. Climate change impacts on species distribution, abundance, physiology, and life cycle timing will alter interspecific relationships and habitats. The earlier onset of spring is changing the timing of growth and reproduction of many plant species that provide food and habitat for a variety of species. For example, the blossoming date of Trembling Aspen in Alberta has advanced by 26 days in the past 100 years. Such timing shifts can cause decoupling of species that have co-evolved.
8. Given that several pests and pathogens are currently limited by winter temperatures, the range and severity of diseases and pest outbreaks are likely to increase as winter temperatures rise. In addition, the harassment of insects can affect summer grazing, which will have physical consequences on animals.

[3] As outlined in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation *(Warren and Lemmen, 2014) and* From Impacts to Adaptation: Canada in a Changing Climate (Lemmen et al., 2008).

Adaptation and Mitigation Measures

A changing climate presents both risks and opportunities for Canada's regions and resource sectors. In this vast country with its diverse climate and economy, addressing climate change requires targeted and collaborative action that reduces greenhouse gas emissions (mitigation) and helps us adapt to climate impacts (adaptation).

Adaptation	**Mitigation**
Adaptation involves modifying our decisions, activities, and ways of thinking to adjust to a changing climate. Here are some examples of adaption measures in support of ecosystem resilience: • Protecting intact ecosystems and the diversity of species and processes that are part of them • Connecting protected areas through sustainably managed landscapes and waterscapes • Restoring degraded ecosystems, and supporting species recovery • Maintaining or restoring natural disturbance regimes to reflect the natural range of variability characteristic for a particular ecosystem • Including conservation measures that protect and manage range limits • Considering active management approaches, such as assisted migration, where appropriate	Mitigation aims to reduce the causes of climate change. It is designed to reduce greenhouse gas emissions at the source or to support "sinks" that absorb or eliminate greenhouse gases. Here are some examples of mitigation measures that deal with forests: • Limiting deforestation and reducing greenhouse gases connected with forestry development • Creating new forests, as well as improving energy efficiency in all economic sectors to reduce our dependence on fossil fuel consumption

There can be co-benefits, or synergies, between these two responses to climate change: in some cases, actions taken to adapt also serve to reduce greenhouse gas emissions, or mitigation actions also reduce vulnerability to climate change (see Figure 1). For example, green roofs — where vegetation is planted on the roofs of buildings — have adaptive benefits (e.g., moderated stormwater runoff, reduced urban-heat-island effect, and improved air quality) as well as mitigative value (e.g., reduced energy consumption, reduced greenhouse gas emissions, and increased carbon dioxide absorption). However, there is also the potential for conflict between adaptation and mitigation, where adaptation choices can increase greenhouse gas emissions. Using air conditioners to deal with higher temperatures, for example, means increased energy use and related emissions.

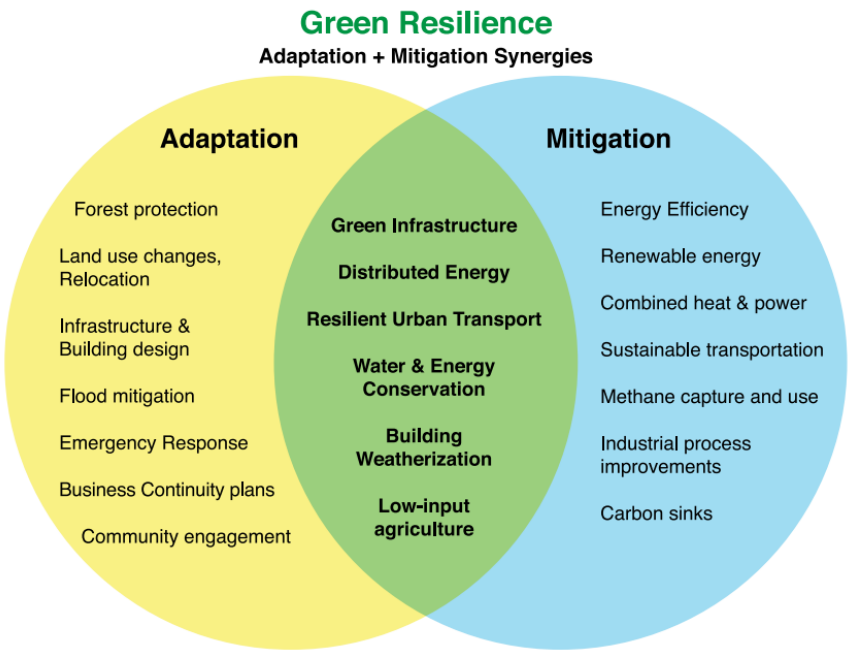


Figure 1. Examples of adaptation, mitigation, and overlap between the two approaches. Source: Canada's Marine Coasts in a Changing Climate, D.S. Lemmen, F.J. Warren, T.S. James, and C.S.L. Mercer, editors (2016); Government of Canada, Ottawa, ON, p. 257. (Image courtesy of the Centre for Clean Air Policy.)

Climate change is happening now, which is why government, industry, and social enterprises around the world are actively engaged in developing adaptive strategies to reduce the negative impacts to society and the environment.

Glossary and Key Vocabulary

Adaptation measure: Any action that reduces the negative impacts of climate change or allows us to take advantage of new opportunities resulting from climate change.

Biodiversity: The variety of species and ecosystems and the relationships between them.

Climate change: A significant change in the Earth's climate. The Earth is currently getting warmer because people are adding heat-trapping greenhouse gases to the atmosphere. The term "global warming" refers to warmer temperatures, while "climate change" refers to the broader set of changes that go along with warmer temperatures, including changes in weather patterns, the oceans, ice and snow, and ecosystems around the world. (epa.gov)

Crop management and planning: Planning and managing agricultural crops in order to optimize the use of soil nutrients.

Crop rotation: An agricultural term describing the rotation of plant crop locations to promote soil regeneration.

Ecological (or ecosystem) services: The variety of resources and processes that are supplied by ecosystems and benefit human societies. These include products like clean drinking water and processes such as the decomposition of wastes.

Ecosystems: Community of living organisms (plants, animals and microbes) that interact with the physical components of their environment (air, water, soil).

GHG sinks: Mechanism which is natural (e.g. photosynthesis) or man-made (e.g. underground carbon capture and storage) and which absorb atmospheric GHG (usually carbon or methane).

Greenhouse gas emissions (GHG): Gases that allow the Sun's rays to reach the Earth, but which absorb the infrared radiation reflected back by the surface of the Earth. They trap a portion of the solar energy, which reheats the planet's surface sufficiently to maintain life. The accumulation of greenhouse gas emissions due to human activity amplifies the natural "greenhouse effect" and is the main contributor to global warming. (NRCan)

Issues: Things that can be gained or lost in terms of money (economic), society (social), laws (political), or the environment (environmental).

Mitigation measure: Action designed to reduce greenhouse gas (GHG) emissions in the atmosphere or to support GHG sinks.

Pest: Organism that causes significant damage to vegetation. (NRCan)

Phenology: The study of plant and animal life cycles and how these are affected by variations in environmental factors.

Pollination: The action of transporting pollen in order to fertilize plants.

Vegetable garden: Plant, vegetable and fruit crops grown for culinary use.

Definitions by "NRCan" were taken or adapted from the Glossary of Natural Resources Canada, found at https://cfs.nrcan.gc.ca/terms

Suggested Resources

Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation
F.J. Warren and D.S. Lemmen, editors (2014); Government of Canada, Ottawa, ON
http://www.nrcan.gc.ca/environment

Canada's Marine Coasts in a Changing Climate
D.S. Lemmen, F.J. Warren, T.S. James, and C.S.L. Mercer Clarke, editors (2016); Government of Canada, Ottawa, ON
http://www.nrcan.gc.ca/environment

Climate Change: What Is Happening and How Do We Know?
Katherine Hayhoe (Nov. 12, 2016); Presentation at the Science Teachers Association of Ontario conference (start at 4:00 minutes)
http://youtu.be/-9LKaPWmaMc?t=246

Les changements climatiques: l'état des lieux
Radio-Canada television (in French)
http://ici.radio-canada.ca/emissions/decouverte/2013-2014/reportage.asp?idDoc=339313

Natural Resources Canada glossary
https://cfs.nrcan.gc.ca/terms

Adapting to climate change
Quebec Centre for Biodiversity Science website
http://qcbs.ca/research/research-contracts/adapting-to-cc/

Adaptation and Mitigation Options
Intergovernmental Panel on Climate Change – See most recent Synthesis Report (indicators, impacts, adaptation and mitigation)
https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

Climate change
Natural Resources Canada website, Forest Topics (effects, impacts, mitigation, and adaptation)
http://www.nrcan.gc.ca/forests/climate-change/13083

Adaptation Library: Resources for Climate Adaptation
http://www.adaptationlibrary.com

Impacts and Adaptation
Natural Resources Canada website, Climate Change
http://www.nrcan.gc.ca/environment/impacts-adaptation

Forest pest management
Natural Resources Canada website, Forest topics (includes videos)
http://www.nrcan.gc.ca/forests/fire-insects-disturbances/pest-management/13361

Le changement climatique: Ce qui va changer dans mon quotidien
Hélène Géli (2015), Éditions Quae (in French)

Facing the Change: 5 Canadian Communities Threatened by Climate Change Now
CBC Radio
http://www.cbc.ca/radio/day6/five-canadian-communities-threatened-by-climate-change-now-1.3776341

Strategic Planning by Province

AB	Climate Leadership Plan www.alberta.ca/climate-change.aspx
BC	Climate Leadership Plan climate.gov.bc.ca/
PEI	Prince Edward Island: Climate Change www.princeedwardisland.ca/en/topic/climate-change-0
MB	Climate Change and Air Quality www.gov.mb.ca/sd/climate/ (English only)
NS	Climate Change Nova Scotia climatechange.novascotia.ca/ (English only)
NB	New Brunswick: Climate Change www2.gnb.ca/content/gnb/fr/ministeres/egl/environnement/content/changements_climatiques.html
NV	Climate Change Centre www.climatechangenunavut.ca/ (English only)
ON	Ontario: Climate change www.ontario.ca/page/climate-change
QC	Quebec: 2013-2020 Climate Change Action Plan (French) www.mddelcc.gouv.qc.ca/changements/plan_action/stategie-adaptation2013-2020.pdf
SK	Climate Change Policy www.saskatchewan.ca/business/environmental-protection-and-sustainability/climate-change-policy (English only)
NFL	Climate Change www.ecc.gov.nl.ca/climate_change (English only)
NWT	Northwest Territories: Climate Change www.enr.gov.nt.ca/programs/nwt-climate-change
YK	Climate Change and Yukon www.env.gov.yk.ca/air-water-waste/climatechange.php (English only)

Learning Outcomes in Geography and Science

Canadian National Standards for Geography, Grades 7 and 8 (2001)[1]
(Physical Systems) Explain environmental phenomena using physical processes.
(Physical Systems) Explain ecosystem distribution, from a local scale to a global scale.
(Physical Systems) Explain ecosystem functions and dynamics as they relate to precipitation and the water cycle.
(Physical Systems) Predict the consequences of natural disasters on the Earth.
(Places and Regions): Analyze physical and human characteristics of places.
(Places and Regions) Explain how regions change in space and time.
(Environment and society) Analyze the environmental consequences of changes brought about by humans to their physical environment.
(Environment and society) Describe how humans prepare for natural disasters.
(Environment and society) Describe environmental factors that positively and negatively affect human activities.
(Environment and society) Identify and explain the consequences of changes brought about by humans in one region on the physical environment of another region.
(Human Systems) Analyze and evaluate the issues involved in the spatial distribution of economic activities.
Common Framework of Natural Science Training Outcomes, Grades 7 and 8 (1997)[2]
(Social and environmental contexts of science and technology) Give examples of how scientific and technological activities take place in a variety of individual or group settings
(Social and environmental contexts of science and technology) Propose a course of action on social issues related to science and technology, taking personal needs into account.
(Initiating and planning) Identify questions to investigate rising from practical problems and issues
(Initiating and planning) State a prediction and a hypothesis based on background information or an observed pattern of events
(Initiating and planning) Propose alternate solutions to a given practical problem, select one, and develop a plan
(Communication and teamwork) Work collaboratively on problems and use appropriate language and formats to communicate ideas, procedures and results
(Grade 7 Life sciences: Ecosystems) Describe conditions essential to the growth and reproduction of plants and microorganisms grown in an ecosystem and relate these conditions to various aspects of the human food supply
(Grade 7 Life sciences: Ecosystems) Describe interactions between biotic and abiotic factors in an ecosystem
(**Grade 7 Life sciences: Ecosystems)** Apply the system concept as a tool for interpreting the structure and interactions of natural and technological systems
(Grade 7 Earth and Space Sciences: The Earth's crust) Relate various metrological, geological and biological processes to the formation of soils
(Grade 8 Earth and Space Sciences: Salt water and fresh water) Analyze factors that affect productivity and species distribution in marine and fresh water environments
(Grade 8 Earth and Space Sciences: Salt water and fresh water) Describe factors that affect glaciers and polar icecaps and describe their consequent effects on the environment
(Grade 8 Earth and Space Sciences: Salt water and fresh water) Describe the interactions of the ocean currents, winds and regional climates

[1] Canadian National Standards for Geography: www.cangeoeducation.ca/resources/learning_centre/docs/Canadian_Geography_Standards.pdf

[2] Common Framework of Science Learning Outcomes: science.cmec.ca/index.en.htm

Activity 1: What do you know about climate change?

Activity Summary

This first brainstorming activity is designed to encourage students to activate their prior knowledge of climate change from an objective point of view and to get a better understanding of the overall knowledge shared by the group. It is important to remember that while more than 97% of scientists who publish work in academic journals agree that it is highly likely that human activity is responsible for global warming (and this number continues to rise), there will always be skeptics and those who deny this reality. To see a list of scientific groups that agree that humans are contributing to global warming, visit the NASA's climate change website at https://climate.nasa.gov/scientific-consensus/.

Duration: 60 minutes

Learning outcomes	**Competency outcomes**
• Describe the various ways that human activity and technology impact both balance and interactions in the environment • Describe the effect of human activity on greenhouse gas (GHG) emissions • Define the vocabulary associated with climate change	• Critical thinking • Research • Communication • Collaboration

Material:

- ❑ 3 packs of sticky notes in 3 different colours (e.g. 4 green, 4 yellow and 4 red per student)
- ❑ Sharpie-style markers (1 per student)
- ❑ Climate change infographic
- ❑ *Adapting to our Changing Climate in Canada* poster (also available on the Natural Resources Canada website > Climate change publications, at http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/assess/2016/adaptation_poster_e.jpg)
- ❑ Computer with Internet access and projector
- ❑ Internet access for students (optional)
- ❑ Copies of the **Student BLM: What are Greenhouse Gases (GHG) and what do they do?**

What to do:

1. In order to help students think objectively, ask them the following question:

   Over the last several years, we've seen that while there are many people who are concerned about the alarming effects of climate change and its impact on our environment, others still argue that climate change is an exaggerated phenomenon and that there is no reason to panic. What do you think about this?

2. In order to answer this question in detail, students must first answer the question: *What do you know about climate change?* (It is important that they give **their personal interpretations** regarding what they have seen or heard themselves).

3. Hand out 3 to 4 sticky notes in each colour to the students so that they can note down everything that they have seen or heard about climate change. They may note down as many statements about climate change as they like, but just one statement per sticky note:
   - Green sticky notes: "factual" statements (with explanations as to why they have no doubts about their veracity);
   - Yellow sticky notes: statements that they are not sure about or which are unproven (with explanations); and
   - Red sticky notes: statements about things they have seen or heard which they believe to be false (with explanations).

4. Divide the table or wall into three distinct sections (columns: the green column should contain "factual statements", the yellow column "unproven statements" and the red column "false statements"). Explain to the students that they can come up and stick their Sticky notes in the appropriate column once they've finished writing their climate change statement.

5. Once all students have finished writing down their statements and have stuck the sticky notes in the appropriate columns, take a look at the distribution of the colours on the table or wall and ask the students what their first impressions are.
   - Are there more yellow, green or red notes?
   - What do you notice?

6. **With the students**, try to create new categories for more sticky notes (e.g. causes, effects, consequences, actions). Assign a few sticky notes to groups of two students and ask them to put those notes into different categories.

7. Ask them to take it in turns to read some of the explanations given for the climate change statements and initiate a class discussion regarding the various explanations that the class has come up with for each category (green, red, yellow statements).

8. In order to connect the students' explanations to current information on climate change, hand out student notebooks to each student. Ask them to each note down 1 to 2 statements in each category that they would like to learn more about.

9. To help them with their research, show them:
   - The collection of infographics included in this kit
   - The *Adapting to our Changing Climate in Canada* poster (also available on the Natural Resources Canada website > Climate change publications, at http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/images/assess/2016/adaptation_poster_e.jpg)
   - A video illustrating what climate change is, such as *How does climate change affect biodiversity?* (California Academy of Sciences) https://www.youtube.com/watch?v=XFmovUAWQUQ
   - The website Skeptical Science (https://skepticalscience.com) which explores the concepts that people are skeptical about.
   - Copies of the **Student BLM: What are Greenhouse Gases (GHG) and what do they do?**

10. Finally, ask students the following: Based on your observations and explanations, what conclusions can we come to?

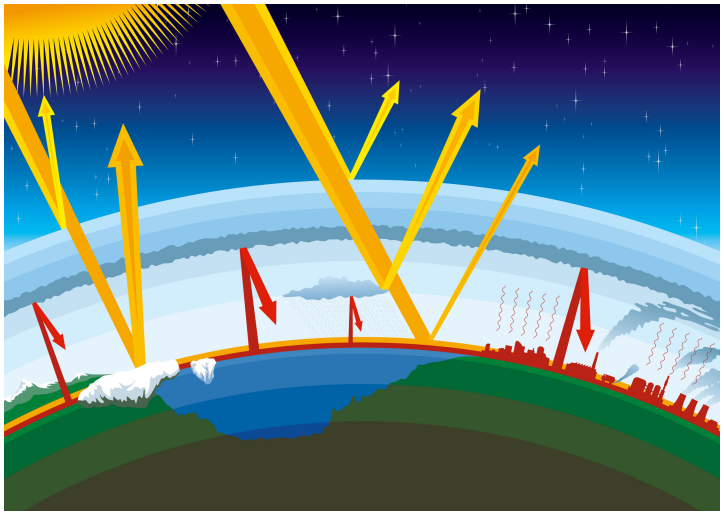
How are falsehoods spread? The Serengeti Strategy

In the same way that a group lions will attempt to isolate a zebra on the outskirts of its group so that they can capture it more easily, a scientist may be targeted by individuals who mobilize their resources to attack and weaken him or her. The fight to defend themselves will take up a lot of the scientist's energy and resources. The strategy succeeds not only in isolating a scientist from his or her colleagues (easier to attack an individual than to attack a group), but also serves as a warning to other scientists seeking to make their studies public. This strategy has been used to discredit Rachel Carson (effects of DDT on the environment) as well as the scientists who revealed the truth about the harmful effects of tobacco consumption.

Mann, M. E. (2015). The Serengeti strategy: How special interests try to intimidate scientists, and how best to fight back. *Bulletin of the Atomic Scientists*, *71*(1), 33-45. http://www.meteo.psu.edu/holocene/public_html/Mann/articles/articles/MannBullAtomSci15.pdf

Name: _____ **Date:** _____

Activity 1–Student BLM: What are Greenhouse Gases (GHG) and what do they do?



a) Look at the picture above. In your own words, describe the role played by greenhouse gases on the Earth.

b) Are GHGs good for life on Earth or not? Explain.

c) Research the following greenhouse gases and note where they come from.

	Natural sources	**Man-made/anthropogenic sources (caused by humans)**
Carbon dioxide (CO_2)		
Methane (CH_4)		
Water vapour		
Nitrous oxide (N_20)		
Chlorofluorocarbon (CFC)		

Activity 2: Climate Change Mind Map

Summary

In this activity, students will draw a conceptual map, or mind map to link together the physical impacts climate change has on the environment and the consequences these impacts have on biodiversity. Following an activity on **Adaptation and Mitigation** (p. 23), they will revisit the map to offer adaptation measures to address those consequences.

Duration: Two 60-minute sessions

Learning outcomes	**Competency outcomes**
After participating in the activity, students will be able to: • Identify physical impacts of climate change on the environment, and • Discuss the consequences of climate change on biodiversity	• Critical thinking • Collaboration • Communication

Set-up and materials

- ❑ Computer and projector (for videos)
- ❑ **Climate Change and Biodiversity** infographic
- ❑ **Climate Change and the Environment** infographic
- ❑ Copies of **Mind Map Rubric** (one per student)
- ❑ Copies of student BLM **Climate Change Mind Map —Biodiversity and the Living World** student worksheet
- ❑ Chart paper (one per team of two to three students)
- ❑ Coloured markers or pencils
- ❑ Sticky notes (optional)

Tip: Some students may find it easier to put their ideas on sticky notes so that they can move them around during the planning phase.

What to do

1. Following an introduction on climate change, discuss the implications of climate change on biodiversity.
2. Watch these videos to contribute to the discussion about biodiversity and climate change:
   a) *Can wildlife adapt to climate change?* (TEDEd) at www.youtube.com/watch?v=ZCKRjP_DMII
   b) *How does climate change affect animals?* (DW English) at www.youtube.com/watch?v=9h7P8gWpolQ
3. Brainstorm about some impacts of climate change and the consequences these impacts have on biodiversity.

4. Hand out a large sheet of chart paper to teams of two to three students and ask them to write “Climate Change and Biodiversity” at the centre of the sheet.
5. Ask each team to use their creativity and, starting from the centre of the map, build three distinct concept levels based on Climate Change and Biodiversity (show the students the figure below as an example).

Tip: Remind students to make a sketch of their ideas in their notebooks.

Level 1: Physical impacts of climate change, e.g., rising temperatures or increased precipitation (two per map)

Level 2: Consequences of these impacts on biodiversity and food production, e.g., infestation or competition (one or two per impact)

The next level will be filled out following the **Adaptation and Mitigation** activity (p. 23), so ask students to leave some room to add these later.

Level 3: Adaptation measures that could be taken to deal with these consequences, e.g., migration corridors or assisted migration (one or two per consequence)

6. Encourage students to unleash their creativity and represent the concepts with shapes, text, and drawings, using the connecting lines between concepts to justify their links.

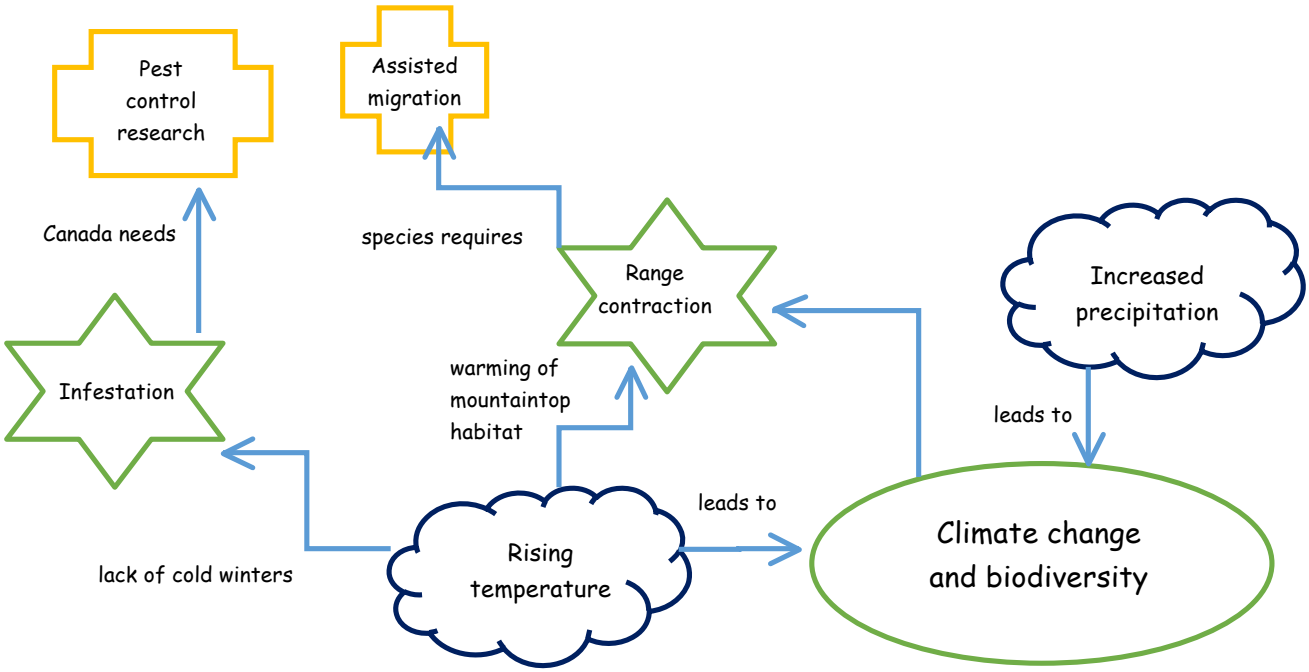
Tip: Students can use information from the videos, as well as the **Climate Change and the Environment** and **Climate Change and Biodiversity** infographics, as tools to complete their mind maps.

7. Ask students to present their conceptual maps to the class. Encourage dialogue by asking students with similar concepts to add their interpretations to the discussion.

Extension

Ask students to cut out their concepts to make a large classroom concept wall. Glue each level on a different cardboard backdrop to keep the hierarchy visible.

Mind Map Example



Activity 2–Vocabulary list

Adaptation

1. **Protect:** Create parks, wildlife reserves, and marine protected areas to provide safe habitat spaces
2. **Research:** Combine research from different disciplines (e.g., ecology, biology, chemistry, geology, and technology) to identify issues and plan accordingly
3. **Monitor species populations:** Involve citizens (schools, communities) in collecting data about climate change impacts on various species
4. **Restore:** Rebuild habitats or increase the variety of plant species in an area
5. **Connect:** Build migration corridors (e.g., a land bridge over a highway) or assist migration by physically moving an animal or plant species to new areas

Competition: Species competing for limited resources such as food, space, water or mates. Can result from other species migrating north or into new territories.

Ecological (or ecosystem) services: The variety of resources and processes that are supplied by ecosystems and benefit human societies. These include products like clean drinking water and processes such as waste decomposition.

Habitat destruction: Habitats can be destroyed due to an increase in fires, droughts, precipitation, ice storms, windstorms, rising sea levels, acidification, and higher water temperatures.

Habitat fragmentation: Natural landscapes can be broken up by human constructions like river dams and highways. This makes it difficult for species to move around and limits the resources they need to survive. For example, salmon migrating upstream can be impacted by dams.

Hybridization is the mixing of two different but similar species. The movement of species to new areas as they try to adapt to climate change can cause hybridization. Hybridization can result in rare species becoming extinct or, in other cases, can help species adapt by introducing new genes into the population. For example, Black-capped chickadees are interbreeding with Carolina chickadees, who might replace Black-capped chickadees in southern Ontario.

Infestation: Insect, disease, and parasite outbreaks are predicted to become bigger and more frequent because of climate change, as cold winters will no longer stop their spread. New diseases and parasites from the south can cause much damage for species that have not evolved defences against them. For example, the Mountain Pine Beetle has destroyed large parts of British Columbia's pine forests, and caribou have seen a decrease in health as a result of mosquitoes affecting their summer foraging.

Phenological mismatches happen when changes in the timing of life cycles between dependent species mean they fail to match up. For example, by the time migrating birds arrive at a feeding site, the best availability of the insect they eat may already have passed. The earlier arrival of spring also changes the life cycle of many plants that provide food and habitat for other species.

Phenology: The study of plant and animal life cycles and how these are affected by variations in environmental factors.

Range contraction is the shrinking of a species' habitat. Many arctic species found in mountain habitats are at risk of range contraction because there may be no opportunity for their habitats to expand upwards or northwards. For example, polar bears have their hunting grounds restricted by shrinking ice cover.

Names: _____ **Date:** _____

Activity 2–Student BLM: Climate Change Mind Map

Draw a sketch of your mind map, including the impacts of climate change and the consequences of these impacts biodiversity and the living world.

What I learned from my classmates' presentations:

Names: _____ **Date:** _____

Activity 2–Teacher BLM: Mind Map Rubric

	Highly effective	Effective	Satisfactory	Unsatisfactory
Concepts and terminology	Shows an understanding of the topic's concepts and principles and uses appropriate scientific terminology.	Makes some mistakes in terminology or shows a few misunderstandings of concepts.	Makes mistakes in terminology and shows a lack of understanding of some concepts.	Shows no understanding of the topic's concepts and principles.
Relationships between concepts	Provides highly relevant and original links between concepts.	Provides adequate links between concepts.	Provides some links between concepts.	Provides no links between concepts.
Adaptation solutions	Provides highly relevant and realistic solutions.	Provides relevant solutions.	Provides a few relevant solutions.	Provides no solutions.
Work ethic	Plans the concept map in a highly effective manner.	Plans the concept map in an effective manner.	Plans the concept map in an adequate manner.	Does not plan the concept map.
Communication	Presents the concept map in a highly effective manner and provides examples to support the analysis.	Presents the concept map in an effective manner.	Presents the concept map in an adequate manner.	Does not present the concept map in an effective manner
Design and layout	The design and layout contribute greatly to the flow and clarity of the map in a highly effective manner. An original and effective design is used to denote level hierarchy.	The design and layout contribute to the clarity of the map in an effective manner. The level hierarchy is evident.	The design and layout contribute to the clarity of the map in an adequate manner. The level hierarchy is present.	The design and layout do not contribute to the clarity of the map. Attention has not been paid to the level hierarchy.
Collaboration skills	Consistently works towards group goals and encourages people to work well together.	Frequently works towards group goals and encourages people to work well together.	Adequately works towards group goals and encourages people to work well together.	Rarely works towards group goals.

Activity 3: Adaptation and Mitigation

Summary

In this activity, students collaborate to define and identify the concepts of adaptation and mitigation as they pertain to climate change. They also further their understanding of how Canada is helping biodiversity adapt to climate change.

Duration*:* 60 to 75 minutes

Learning outcomes	**Competency outcomes**
After participating in the activity, students will be able to: • Define and differentiate between the concepts of adaptation and mitigation as they pertain to climate change, • Identify examples of adaptation and mitigation measures, • Discuss the importance of using both adaptation and mitigation measures to fight against climate change, and • Identify resources and processes that ecosystems provide (ecosystem services)	During this activity, students will develop or improve these abilities: • Collaboration • Inference • Research • Critical thinking

Set-up and materials

- ❑ Computer, tablet, or dictionary (one per team)
- ❑ Colour printout of teacher BLM **Adaptation and Mitigation Goals**, cut into strips
- ❑ Copies of student BLM **Adaptation or Mitigation?** student worksheet
- ❑ Copies of the **Climate Change: Adaptation and Mitigation** infographic
- ❑ **Adapting to Our Changing Climate in Canada** poster

Tip: Check out Natural Resources Canada's new poster, **Adapting to Our Changing Climate in Canada**. It will help students learn more about our changing climate, the impacts it's having, and how Canadians are adapting. Request your copy using the online order form or by calling 1-800-387-2000 (Product # M174-13/2016). Alternatively, you can download the web-accessible version.

What to do

1. Following the **Conceptual Map activity**, write this question on the board:

   Why should humans help biodiversity thrive and survive?

2. Launch a discussion on the ecological services that nature provides and invite students to put as many examples as possible on the board. Examples may include:
   - Resources such as timber, food, fuel, and bioproducts,

- Ecological processes such as carbon storage, nutrient cycling, water and air purification, erosion control, cooling, shade, pollination, seed dispersal, waste decomposition, and maintenance of wildlife habitat, and
- Social and cultural benefits such as recreation, traditional resource uses, and spirituality.

3. Synthesize the benefits of ecological services by proposing that it's in our best interests to do everything we can to help biodiversity thrive and survive in the face of climate change.

4. To launch the discussion on adaptation and mitigation, watch the video: Climate change adaptation: It's time for decisions now (GIZ online)–www.youtube.com/watch?v=FO46sPwm4xk.

5. On the blackboard or Smart Board, write "Adaptation Measures" (on one side) and "Mitigation Measures" (on the other side).

   Brainstorming phase: Ask students if they know what these words mean (synonyms, resemblances) and write their ideas under each heading.

   Research phase: Ask students to find two or three words related to these concepts using the Internet or the dictionary.

   Validation phase: Synthesize the results and work with students to define the concepts.

6. Provide students with the following examples of adaptation measures and mitigation measures with respect to biodiversity and nature. Work with students to refine their definitions further.

   Adaptation measures:

   - Plant different types of crops to respond to changing growing seasons and temperatures.
   - Research natural alternatives to deter any pests migrating northwards from attacking trees and crops.
   - Build alternative physical corridors to help fish migrate when rivers are reduced due to evaporation.

   Mitigation measures:

   - Increase the amount of food grown locally to reduce the greenhouse gas emissions caused by transporting food over long distances.
   - Plant millions of trees to absorb and trap carbon dioxide from the atmosphere.
   - Feed cattle seaweed instead of traditional hay and grains to reduce the methane content of cow belching and flatulence.

7. As a whole-class activity, ask students to help you classify the **Adaptation and Mitigation Goals** as either "Adaptation" or "Mitigation."

8. Hand out the **Adaptation or Mitigation?** student worksheet.

9. Assign two measures per pair of students and ask them to justify whether they fall under "Adaptation" or "Mitigation."

10. Ask each pair to join another group to compare answers.

11. As a class, decide where each example should be classified and why. Hand out the **Climate Change: Adaptation and Mitigation** infographic to compare answers.

Tip: Your class answers may vary from the **Climate Change: Adaptation and Mitigation** infographic. The important part for assessment purposes is that students are able to justify their choice based on the goals of adaptation and mitigation.

Extension

- Return to the Mind Map activity (p. 16) and ask students to assign adaptations to their consequences.
- Discuss with students: When it comes to adaptation or mitigation, is one more important than the other? Are there some measures that address both at the same time?
- Tap into any first-hand knowledge and make connections to their lives outside the classroom by inviting students to share their stories. Some students may have experienced climate change impacts, large or small (e.g., recurrent flooding; earlier spring smelt runs). They may also have witnessed adaptation measures (e.g., their village may have been relocated; they may go smelt fishing earlier in the season).
- Discuss the implications of assisted migration with respect to the disruption of the receiving ecosystem.
- Talk about whether fishers, like farmers, may be able to adapt their practices to adapt to climate change.
- Discuss whether genetic modification could help some species adapt. Watch the following video as an introduction:

  What can genomics do for Canada's forestry sector? (NRCan)
  www.nrcan.gc.ca/forests/video/17158

- Read the following article and justify whether this is an example of adaptation or mitigation:

  P.E.I. farmer assists in near-eradication of methane from cow farts
  www.cbc.ca/news/canada/prince-edward-island/pei-cow-farting-1.3856202

Activity 3–Teacher BLM: Adaptation and Mitigation Goals

Cut out the goals and work with students to assign each to either adaptation or mitigation.

Improve the ability of animals and plants to thrive under different climate conditions.

Build resilience to extreme weather and climate changes.

Increase the capacity of species to adapt.

Cut down greenhouse gas emissions.

Trap greenhouse gas emissions.

Name: _____ **Date**: _____

Activity 3–Student BLM: Adaptation or Mitigation?

What type of measure does each example below represent: adaptation or mitigation? Justify your answers.

	Adaptation	Mitigation
 Create or increase protected natural areas.		
 Connect protected areas by changing the landscape or waterscape to ease migration and movement.		
 Physically displace species within their range or move them to a new territory.		
 Restore damaged ecosystems.		
 Improve access to water.		
 Involve citizens in monitoring climate change impacts.		
 Invest in research on the biology and ecology of plants and animals.		
 Increase sources of renewable energy.		
 Improve industrial processes on nearby farms and industries.		
 Create community and home gardens for food production and to create habitat.		

Bear in Cage by Gan Khoon Lay from the Noun Project
Microscope by Akshar Pathak from the Noun Project
Wheat by Aleksandr Vector from the Nound Project

Activity 4: Impacts of Climate Change on Food Production in Canada

Summary

Although we tend to think of biodiversity in terms of natural settings such as forests and oceans, species variety and the ecosystems in which they interact play a key role in human food production. In small teams, students brainstorm and discuss climate change impacts on food production in Canada.

Duration: One 60-minute session (two sessions if students make sketches to illustrate their ideas)

Learning outcomes

After participating in the activity, students will be able to:

- Analyze the impacts of climate change on food production in relation to
  - crop production
  - pollinators
  - animal production
  - food processing
  - fish stocks
  - pests, diseases and invasive species
  - northern communities
  - trade, and
- Suggest adaptation measures to deal with the effects of climate change

Competency outcomes

During this activity, students will develop or improve these abilities:

- Collaboration
- Analysis
- Problem-solving
- Critical thinking

Set-up and materials

- ❑ Print a set of *"Impacts of Climate Change on Food Production in Canada"* cards, with the reflection questions on one side (p. 32 and 34) and the graphic on the other (p. 33 and 35)
- ❑ Copies of the **Climate Change and the Environment** infographic (one per student)
- ❑ Copies of the **Climate Change and the Economy** infographic (one per student)
- ❑ Copies of the **Student BLM Possible Impacts of Climate Change on Food Production in Canada**
- ❑ Set of cards entitled "Impacts of Climate Change on Food Production in Canada" (one card per group of three to four students), printed on both sides
- ❑ Large sheets of paper for display on flip chart, plus markers (enough for each team of three to four students)
- ❑ Copies of the **Teacher BLM**: **A Summary of Possible Impacts of Climate Change on Food Production in Canada—Key**

What to do

1. Review impacts caused by climate change using the "infographics entitled Climate **Change and the Environment** and **Climate Change and the Economy**.

Tip: Don't forget, in Canada, climate change has different impacts depending on location (e.g., more precipitation in British Columbia and less precipitation on the Prairies).

2. Use one sheet of paper per issue. Write the title of the issue followed by two columns with the heading "**Opportunities**" above one and "**Negative impacts**" above the other.

3. Give out one card per team and ask students to write ideas related to their particular issue on the sheet.

Alternative instructions tips:

- Give out cards according to team strengths
- Give students the option of expressing themselves through drawing
- Allow students to perform their results from the prospective of an animal or plant (e.g., from a bee's perspective

4. Invite students to share their ideas.

5. Synthesize the main points in the student BLM **Possible Impacts of Climate Change on Food Production in Canada.**

6. With the students, suggest measures that might be put in place to adapt to the repercussions of climate change (e.g., find ways of reducing water consumption or genetically engineer insect-/disease-resistant plants, etc.).

Extension

On the blackboard, draw a diagram representing how different issues are connected, in order to demonstrate their interdependency.

Move on to the vertical vegetable garden activity, which represents a practical adaptation to food production challenges, whether they are small-scale (at home) or large-scale (in industry). Ask students this key question: To which issue (of those discussed) could the vertical vegetable garden be a solution?

Tip: For more information on these repercussions and on the adaptation measures that Canada has already started to take, see *Food production* (chapter 4) in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (2014), on the Natural Resources Canada website at *http://www.nrcan.gc.ca/environment/impacts-adaptation10761*

1
Crop production

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographics to brainstorm about how climate change affects crop production.

Are there any positive impacts? Negative impacts?

Further questions

How will rising temperatures affect crop production (amount, quality)?

How will changes in water supply affect crop production?

How are crop locations affected?

2
Pollinators

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects pollinators.

Are there any positive impacts? Negative impacts?

Further questions

Which factors affect pollinators' activities and survival?

3
Animal production

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects animal production.

Are there any positive impacts? Negative impacts?

Further questions

Which factors affect animal production?

What do animals need?

4
Food processing (storage, transportation)

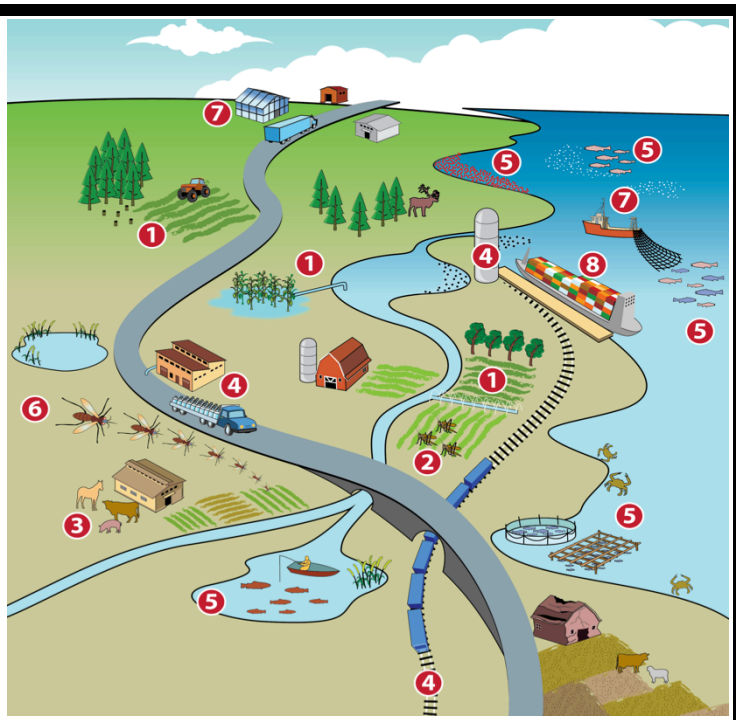
Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects food processing.

Are there any positive impacts? Negative impacts?

Further questions

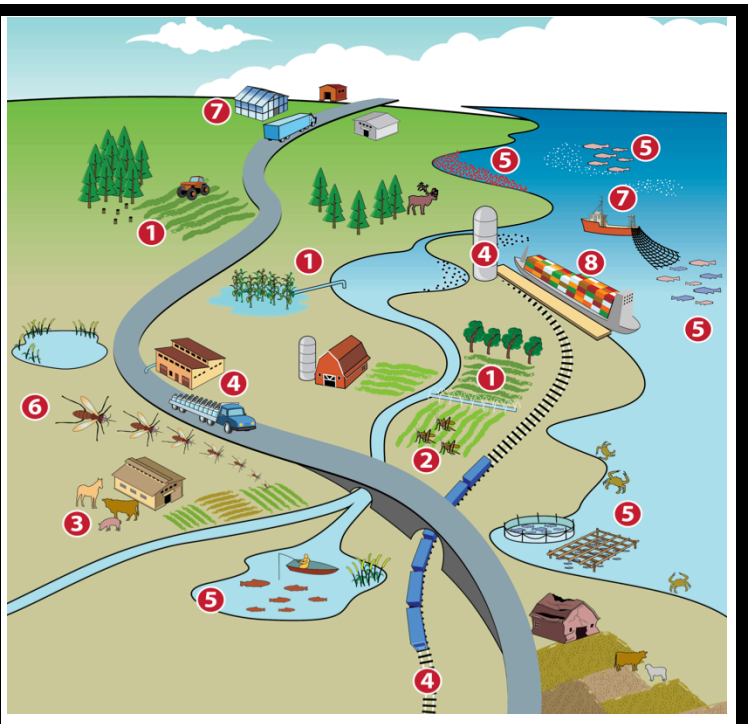
How will rising temperatures affect food storage?

How will transport disruptions (floods, violent storms) affect food transport?



Potential impacts of climate change on food production in Canada

1. Crop production 2. Pollinators 3. Animal production 4. Food processing 5. Fish stocks 6. Pests, diseases, and invasive species 7. Northern communities 8. Trade



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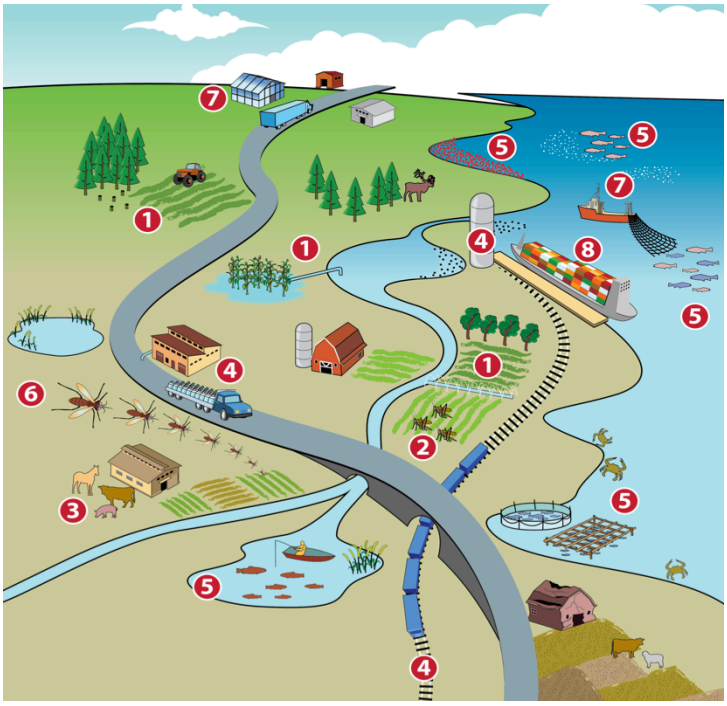

Potential impacts of climate change on food production in Canada

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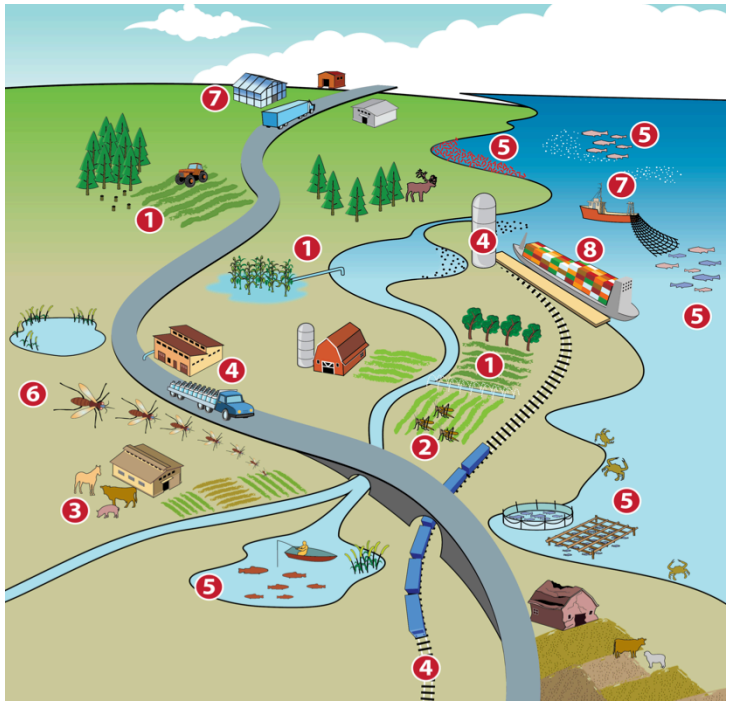


Potential impacts of climate change on food production in Canada

1. Crop production 2. Pollinators 3. Animal production 4. Food processing 5. Fish stocks 6. Pests, diseases, and invasive species 7. Northern communities 8. Trade

5

Fish stocks

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects fish stocks.

Are there any positive impacts? Negative impacts?

Further questions

Which factors affect fish stocks?

What are the effects on fishing?

6

Pests, diseases, and invasive species

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects pests, diseases, and invasive species.

Are there any positive impacts? Negative impacts?

Further questions

How will pests, diseases, and invasive species be affected?

What will the impact be?

7

Northern communities

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects northern communities.

Are there any positive impacts? Negative impacts?

Further questions

What is the impact on agricultural production in the Great North?

What is the impact on food grown in nature?

What is the impact of the reduction of sea ice on transportation?

8

Trade

Use the *Climate Change and the Economy* and *Climate Change and the Environment* infographic to brainstorm about how climate change affects trade.

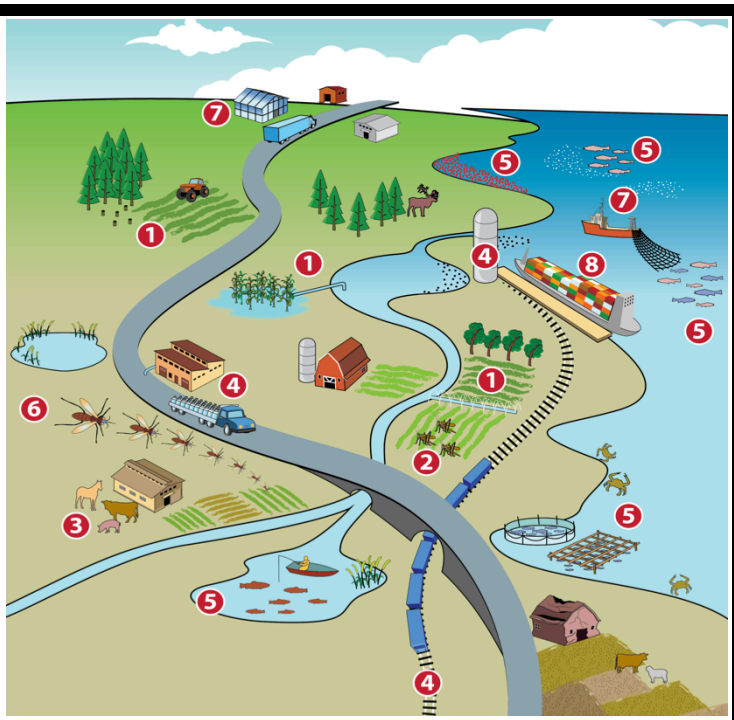
Are there any positive impacts? Negative impacts?

Further questions

What are the impacts on worldwide geographic distribution?

What are the impacts on transportation routes in northern Canada?

How are food prices affected?



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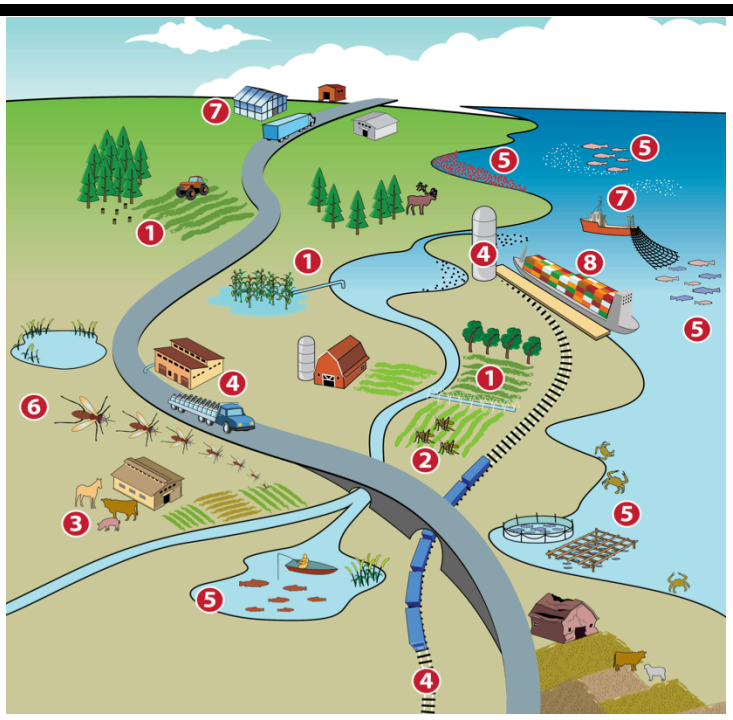

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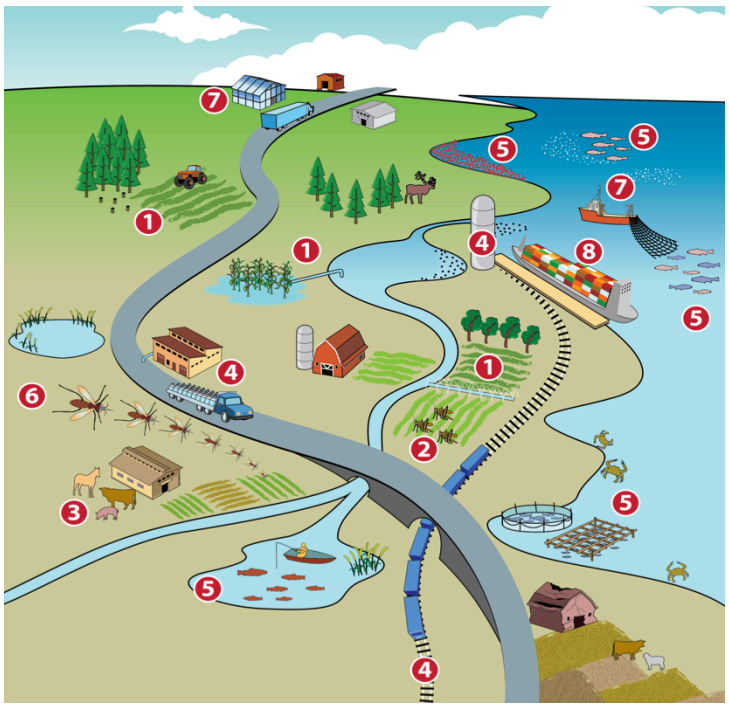

Potential impacts of climate change on food production in Canada

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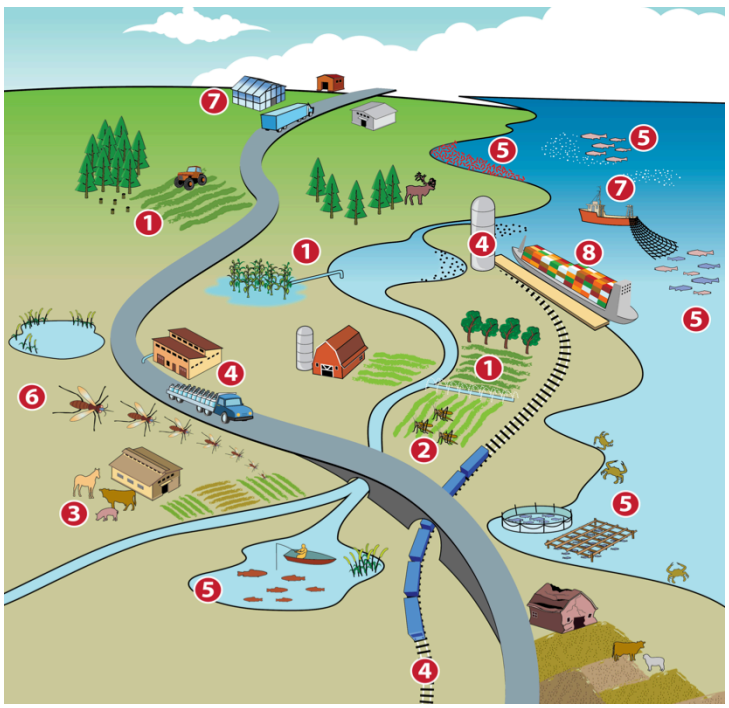


Potential impacts of climate change on food production in Canada

1. Crop production 2. Pollinators 3. Animal production 4. Food processing 5. Fish stocks 6. Pests, diseases, and invasive species 7. Northern communities 8. Trade

Name: _____ Date: _____

Activity 4–Student BLM: Possible Impacts of Climate Change on Food Production in Canada

Issue	Opportunities	Negative Impacts
1. **Crop production**		
2. **Pollinators**		
3. **Animal production**		
4. **Food processing (storage, transportation)**		

5. Fish stocks		
6. Pests, diseases, and invasive species		
7. Northern communities		
8. Trade		

Activity 4–Teacher BLM: A Summary of Possible Impacts of Climate Change on Food Production in Canada—Key

Issue	Possible positive impacts	Possible negative impacts
1) Crop production How will rising temperatures affect crop production (amount, quality)? How will changes in water supply affect crop production? How will these factors affect crop location?	• Production of new crops • Increase in local food production thanks to adaptation measures (e.g., greenhouses, *large-scale production of crops and cold-resistant fodder*)	• Soil toxins due to drought or floods • Decrease in nutritional value of plants • Increase in pesticide use • Increase in drainage needs • Increase in waterways contaminants due to heavy precipitation • Increase in irrigation needs
2) Pollinators How will climate change affect pollinators' activities and survival?	• Benefits of shorter and milder winters	• Increase in pest and disease activity • Changes in food source • Changes in the start of flowering seasons
3) Animal production How will climate change affect animal production?	• Diversification of cattle (different species) • Better resistance to diseases and pests • Increase in pasture production (higher temperatures and CO_2 levels) in certain regions	• Changes in crop production (soil toxins due to drought or floods, decrease in nutritional value of plants, increase in pesticide use) • Requirement for heating and cooling • Decrease in pasture production (temperature too high) in certain areas
4) Food processing (storage, transportation) How will rising temperatures affect food storage? How will transport disruptions (floods, extreme storms) affect food transportation?		• Challenges in food processing due to reduced or inconsistent water supply • Changes in storing food for cattle due to increasing temperatures • Increase in storage capacity (in certain places) to adapt to longer and more frequent transport disruptions

Issue	Possible positive impacts	Possible negative impacts
5) Fish stocks How will climate change affect fish stocks? How will it affect fishing?	• Ability to access fish species that are found in warmer waters	• Challenges related to changes related to water temperature and chemistry, food supply, algae proliferation, water flow, and oceanic currents • Changes to ecosystems of lakes and oceans (which may affect all types of fishing)
6) Pests, diseases, and invasive species How will climate change affect pests, diseases, and invasive species?		• Changes in pests, diseases, and invasive species (more aggressive and diverse) since milder winters reduce their mortality and certain species found in the south may move northwards
7) Northern communities How will climate change affect agricultural production in the North? How will it affect food grown in nature? How will the reduction in sea ice affect food transportation?	• Increase in local food production thanks to adaptation measures (e.g., greenhouses, *large-scale production of crops and cold-resistant fodder*) • Prolonged sailing season (allowing increased transport of goods to northern ports) due to reduction in sea ice	• Changes in access to food growing in nature since vegetation is directly impacted by climate change, and in species distribution due to rising temperatures • Decrease in some hunting and traditional fishing activities due to a reduction in sea ice
8) Trade How will climate change affect the distribution of food worldwide? How will it affect transportation routes in Canada's North? How will it affect food prices?	• Differences in types of products certain countries send due to changes in the distribution of food worldwide • Reduced transport time between the northern Pacific and the northern Atlantic with opening of the Northwest Passage	• More frequent disruption of food transportation worldwide due to extreme climatic events • Increase in food prices due to necessary adaptations — increase will impact low-income families even more

Based on Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation (2014, chapter 4) available on the Natural Resources Canada website at *http://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/assessments/2014/16309*.

Activity 5: Interior Vegetable Wall as Adaptation

Summary

In this activity, students implement an adaptation strategy aimed at reducing water consumption and countering the effects of plant diseases and harmful insects that are increasing due to a warmer climate. Together they will rethink the traditional vegetable garden by building an interior vegetable wall that maximizes space, reduces water consumption, and promotes crop diversity while keeping harmful insects out.

Duration: Four to five 60-minute sessions

Learning outcomes

After participating in the activity, students will be able to:

- Describe how vertical gardens can maximize space and reduce water consumption;
- Explain the relationship between a warming climate and the spread of plant diseases and pests;
- Demonstrate basic crop management and planning principles, including choosing plants based on conditions; and
- Explain the proportional relationship between surface area and water evaporation rate.

Competency outcomes

During this activity, students will develop or improve these abilities:

- Planning and design
- Collaboration
- Research
- Problem-solving

Set-up and materials

- ❑ Laptops, tablets, or computers with Internet access (one per team)
- ❑ Projector and screen for videos and visual examples
- ❑ **Teacher BLM: Vegetable Wall Rubric**
- ❑ **Student BLM: Design an Interior Vegetable Wall**
- ❑ **Teacher BLM: Advantages and Disadvantages of Vertical Vegetable Gardens**
- ❑ Materials from home, based on student designs or materials specific to garden pockets/garden bottles below

Materials for vegetable garden pockets

- ❑ Hanging shoe organizer or other solid/fabric pocket or bag stand (Home Depot, Ikea, Staples, Canadian Tire, etc.)
- ❑ Wall hooks and/or hanging bar
- ❑ Various seeds: lettuce, peas, parsley, herbs, cherry tomatoes, arugula, spinach, collards, etc.
- ❑ Gardening soil, compost
- ❑ Other materials from home (as needed)

Materials for vegetable garden bottles

- ❑ 6 to 15 plastic bottles with caps
- ❑ 1 to 3 pairs scissors or cutter knives
- ❑ Roll of fishing line or wire
- ❑ Hot glue (as needed)
- ❑ Ceiling hooks or hanging bar
- ❑ Various seeds: lettuce, peas, parsley, herbs, cherry tomatoes, arugula, spinach, collards, etc.
- ❑ Gardening soil, compost
- ❑ Other materials from home (as needed)

What to do

1. Launch the lesson by showing this video on a topic that affects everyone — our food supply:
   Some bugs like it hot: Climate change & agricultural pests (KQED Science)
   www.youtube.com/watch?v=1qaRQ0MoEmY
2. Discuss measures that could be put into place to adapt to the repercussions of climate change with respect to agricultural pests (e.g., plant indoors or in a greenhouse; rotate crops so that disease and pests do not persist from one generation of crops to another). Ask students about ways to reduce water evaporation and water consumption.
3. Ask students if they have vegetable gardens or if they know people who grow their own fruits and vegetables. Explain that over the next several lessons, they will be building their own vegetable wall. Discuss whether building a vertical garden counts as an adaptation measure.
4. Play these videos on the innovative, cost-effective, and ecologically friendly methods of growing vegetables:

   Bottle Towers at www.youtube.com/watch?v=JtbOREs2kIo

   Laundry Basket Turned Strawberry Planter at www.youtube.com/watch?v=a2QcU0wYuac

   The Green Wall — Vertical Educational Garden Bottle Project at www.youtube.com/watch?v=UCtAQOP3xuk

   Le Jardin en bouteilles - cultivez un jardin comestible chez vous, même en hiver! (Bottle gardens: Grow an edible garden at home, even in winter!), in French only, at www.youtube.com/watch?v=Ls7exuPuj1I
5. Show examples of vertical vegetable gardens (see p. 43).
6. Ask students to search the web to explore other vertical vegetable garden options.
7. In teams of three students, ask students to choose a vertical vegetable garden model they would like to build. In the student BLM **Design an Interior Vegetable Wall**, ask students to list the materials needed and sketch their design with clear labels. They should also list the type of seeds they plan to use depending on the model they have chosen, and be able to justify their choice.
8. Build the various vertical vegetable gardens and tend to them regularly. This stage is very important since students will have to give special attention to the plants throughout the school year. In order to make this environmentally friendly project a success and avoid loss of healthy seedlings, distribute the plants among the students at the end of the school year so that they can take them home and replant them outside during the summer.
9. In pairs, ask students to come up with a list of advantages and disadvantages of vertical gardening in the student BLM. Debrief with the class using the suggestions listed on the **Teacher BLM: Advantages and Disadvantages of Vertical Vegetable Gardens** on p. 48.

Extension

With the students, co-construct parameters for the garden. For example, the vertical vegetable garden must:

- Include a stand that can support a certain weight;
- Use as much recycled material as possible;

- Have an irrigation system that reduces water use (hint: reuse water or have a smaller exposed surface area so that the soil takes longer to dry out); and/or
- Have an automatic watering system (or one that requires less maintenance).

Perform an experiment to measure evaporation rate in relation to surface area exposure. Using two containers that start off with the same volume of water at the beginning of the week —but have different size openings — measure the amount of water at the end of the week to see which container retained the most water.

We'd love to see your creations! Send us photographs or short videos of your creations to the following email address:

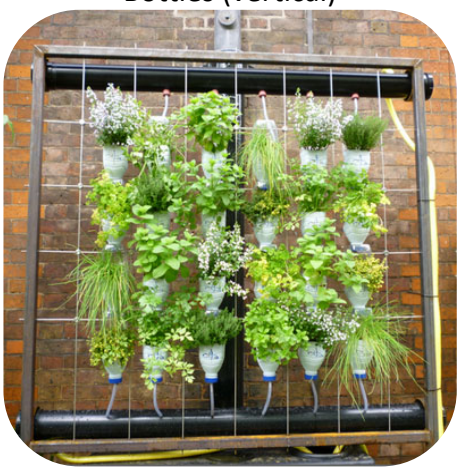
jarmstrong@IngeniumCanada.org

Activity 5–Examples of vertical vegetable gardens

Pockets

www.lecoinpotager.fr/jardin-potager-vertical-crop-ideale/

Bottles (vertical)



www.lecoinpotager.fr/realiser-jardin-vertical-exterieur-bouteilles-plastiques/

Pipes

www.ecole-enfants-precoces.fr/2012/10/le-potager-vertical.html

Bottles (horizontal)

designmag.fr/jardins-et-terrasses/jardin-vertical.html

www.amenagementdujardin.net/7-idees-pour-realiser-un-potager-vertical/

Name: _____ **Date:** _____

Activity 5–Student BLM: Design an Interior Vegetable Wall

1. Make a list of the materials you will need to build your vertical vegetable garden and make a sketch of the garden you intend to build.

Materials needed:

Seeds to plant:

Sketch of my vegetable garden

2. In what way(s) is building a vertical garden an adaptation measure to address climate change?

3. In what way(s) is building a vertical garden a **mitigation measure** to reduce greenhouse gas emissions?

4. In your opinion, what are the advantages and disadvantages of an interior vertical vegetable garden? Hint: water consumption, harmful insects, surface area, plant types, dependence on fossil fuels, maintenance.

Advantages of a vegetable wall	Disadvantages of a vegetable wall

5. What did you learn while designing your vegetable wall?

6. What did you enjoy most about this project?

7. What advice would you give next year's class?

Activity 5–Teacher BLM: Advantages and Disadvantages of Vertical Vegetable Gardens

Advantages	Disadvantages
You save space • You can add in X times as many levels but occupy the same ground space: do the math! **You save water** • Top-to-bottom irrigation means a water surplus benefits plants in the lower levels • Unused water can be recovered by plants in the lower levels **You provide a better nutrient supply** • Less space needs fertilizing • Less time is spent fertilizing **You limit nuisances** • There are few or no weeds • Less time is spent getting rid of weeds • Only the lower levels are affected by pests (e.g., earwigs and snails) and small rodents (e.g., rabbits) **Your soil is less dry** • The soil is less dry as you can place the vertical garden in an area protected from the sun **You save money** • As consumers, we are adapting to increasing prices of fruits and vegetables in shops **You reduce the ecological footprint** • Food produced in the vegetable garden needs no transporting • Deforestation is reduced	**You can't grow all types of plants** • Ideal types are: leafy vegetables that don't grow very tall • Unsuitable crops are: vegetables with long roots (potatoes); plants that require pollinators to produce fruit • The stand has limited space: vegetables (e.g., tomatoes and broad beans) can grow on top of each other may be limited **Your costs may be high** • Reasonable initial investment • An automated irrigation system is expensive

Activity 5–Teacher BLM: Vegetable Wall Rubric

Names:					Date:
Criteria	**Exemplary**	**Proficient**	**Satisfactory**	**Unsatisfactory**	**Comments**
Initiating and planning The sketch clearly illustrates the design and materials required to carry out the project. Carries out research on seed possibilities and provides reasons for seed choice and layout.					
Performing and recording Builds and tests the device according to the predetermined plan and makes adjustments to the original sketch to indicate changes and improvements.					
Design and function The vegetable garden construction is solid, well assembled and properly secured in place. Design reflects clear strategies for adaptation to climate change.					
Collaboration Team shows good organization and collaboration skills.					
Analysis Identifies and explains what changes could be made to improve the design to lessen or eliminate undesirable effects. Analyzes the efficiency of the device based on predetermined criteria as well as cost, materials, time, and space.					
Communication The students provide reasons for the choices made in the design of the wall that take into account functional, aesthetic, and environmental perspectives. All team members are able to clearly explain how the technology works and use grade-appropriate science and technology vocabulary correctly.					