SCHOOLS GO GREEN

Co-funded by the Erasmus+ Programme of the European Union

SCHOOLS GO GREEN

Project number: 2020-1-DE03-KA201-077258

M7: Climate change

Institute of Environmental Protection-National Research Institute

10.04.2022, Warsaw

TEACHERS HANDBOOK

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Project Information

PROJECT: Schools Go Green

PROJECT TITLE: DEVELOPING A WHOLE-SCHOOL APPROACH TO PROMOTE SOCIAL CHANGE AND SUSTAINABLE DEVELOPMENT AS A RESPONSE TO ENVIRONMENTAL CHALLENGES

ACRONYM: SCHOOLS GO GREEN

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Key Symbols

Symbols	Explanation
	Definitions
	Case study
	Additional Resources
	Tips
	Activities
	Reminder
	Video

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General Objective of the Module

The general aim of the module "Climate change" is to provide primary school students with information that is important to know and understand about climate change – what are its causes and impacts, and what are the solutions.

Based on this handbook for teachers, the module provides a presentation for students to be used in class, lesson plans for the age groups 6-10 and 10- 12 and a data bank with further resources.

Topics:

1) What is the difference between the weather and climate?
2) What is climate change?
3) What causes climate change?
4) What are the impacts of climate change?
5) What are the solutions to climate change?

Learning goals

- Students will understand what is climate change, how we know that it is changing, and why it is happening
- Students will be able to describe the impacts of climate change and will develop an awareness of and empathy for people and communities affected by climate change
- Students will understand their personal impact on the world's climate and consider different actions that individuals, communities and decision-makers can take to respond to climate change

1. Introduction

There is overwhelming scientific evidence to show that there have been changes in the global climate since the early 1900s, and that these climate changes and the future ones predicted are largely due to human activities releasing huge quantities of greenhouse gases, which are warming up the earth. Climate change is a global threat that is already having an impact on millions of people around the world – it has damaging effects on natural resources, land, food, and people, especially the poorest ones. These issues, which are expected to influence the lives of the students for decades to come, make climate change an important topic for the classroom.

The following material was prepared based on the:

- https://climatekids.nasa.gov/ and https://climate.nasa.gov/
- IPPC, Climate Change 2022. Impacts, Adaptation and Vulnerability. Summary for Policymakers.
- Zabel, I. H. H., D. Duggan-Haas, and R. M. Ross (eds.), 2017, The Teacher-Friendly Guide to Climate Change. Paleontological Research Institution, Ithaca, New York.

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2. What is the difference between weather and climate?

Weather describes short term changes in factors such as temperature, humidity and wind. Weather describes the conditions at any given moment in a specific place. For example, if it's raining outside right now, that's a way to describe today's weather. Rain, snow, wind, hurricanes, tornadoes — these all are weather events.

Climate, on the other hand, is more than just one or two rainy days. Climate describes the weather conditions that are expected in a region at a particular time of year. Is it usually rainy or usually dry? Is it typically hot or typically cold? Climate describes the long-term pattern of weather in a particular place, typically over 30 years or more.

3. What is climate change

Climate change is the large-scale, long-term shift in the planet's weather patterns and average temperatures across the world. Climate change describes a change in the typical weather for a region — such as high and low temperatures and amount of rainfall — over a long period.

3.1. Greenhouse effect

The greenhouse effect is a process that occurs when gases in Earth's atmosphere trap the Sun's heat. This process makes Earth much warmer than it would be without an atmosphere. The greenhouse effect is one of the things that makes Earth a comfortable place to live.

Version for younger students

The greenhouse effect works … like a greenhouse! A greenhouse is a building with glass walls and a glass roof. A greenhouse stays warm inside, even during the winter. That's because the glass walls of the greenhouse trap the Sun's heat. In the daytime, sunlight shines into the greenhouse and warms the plants and air inside. At nighttime, it's colder outside, but the greenhouse stays pretty warm inside. Greenhouses are used to grow plants, such as tomatoes and tropical flowers.

The greenhouse effect works much the same way on Earth. During the day, the Sun shines through the atmosphere. Earth's surface warms up in the sunlight. At night, Earth's surface cools, releasing heat back into the air. Gases in the atmosphere, such as carbon dioxide, trap heat and stop it from escaping into space similar to the glass roof of a greenhouse.

Paxi – The Greenhouse effect; movie for kids (different language versions)

https://www.esa.int/esatv/Videos/2018/05/Paxi_-_The_Greenhouse_Effect

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Version for older students

When short-wave radiation from the sun reaches Earth, most of it passes straight through and hits the surface. The Earth absorbs most of this radiation and gives off longer-wavelength infrared radiation.

The greenhouse gases absorb some of this infrared radiation, instead of it passing straight out into space. The atmosphere then emits radiation in all directions, sending some of it back to the surface, causing the planet to heat up. This process is known as the 'greenhouse effect'.

NASA – Graphic: The Greenhouse Effect

https://climate.nasa.gov/climate_resources/188/graphic-the-greenhouse-effect/

The greenhouse effect keeps our Earth warm at 58 degrees Fahrenheit (14 degrees Celsius), on average. The greenhouse effect is critical to our survival. In fact, without greenhouse gases, Earth would be about 30 degrees colder than it is today. Without greenhouse gases and their warming effect, we wouldn't be able to survive.

These heat-trapping gases, called greenhouse gases, come from both human and natural sources. Greenhouse gases like carbon dioxide, methane, and nitrous oxide naturally occur in the atmosphere. Others, such as halocarbons, are only produced by human activity.

Carbon dioxide originates from animal respiration, plant decay, volcanic eruptions, and the burning of fossil fuels. Carbon dioxide is produced by such human activities as the burning of fossil fuels, land-use change and deforestation.

Methane originates from the decomposition of organic matter and it can be found in the gas and coal mines, and in wetlands. The majority of methane emissions come from such human activities as mining (coal, natural gases, oil) and agriculture (rice cultivation and stomach fermentation in animals).

Nitrous oxide originates from the bacterial decomposition of the earth's soils and oceans. Humans increase the amount of nitrous oxide in the atmosphere through land-use change (e.g. cutting down trees to make space for farming), the use of fertilizers and the burning of fossil fuels.

Halocarbons are produced only by human activities. Chlorofluorocarbons (CFCs), a type of halocarbons, were widely used in spray cans, cleaners, air conditioners, and refrigerators. After regulating CFCs, which caused the depletion of the ozone layer, the substitute – hydrofluorocarbons (HFCs), another type of halocarbons, were introduced. While HFCs do not cause depletion of the ozone layer, they are greenhouse gases and contribute to the greenhouse effect.

3.2. How do we know the climate is changing

Earth's climate has constantly been changing — even long before humans came into the picture. Most of these climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy Earth receives.

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Scientists use weather stations, ocean buoys, and remote sensing instruments to collect many types of information about Earth's land, atmosphere, ocean and ice which show the changes in the climate.

Scientists study:

- trees (the colour and width of tree rings provide information on how old a tree is and what the weather conditions were like during each year of that tree's life; eg. tree rings usually grow wider in warm, wet years and they are thinner in years when it is cold and dry)
- ice cores drawn from Greenland, Antarctica, and tropical mountain glaciers (layers of ice give clues about every year of Earth's history back to the time the deepest layer was formed – the ice contains bubbles of the air from each year; scientists analyze the bubbles in each layer to see how much CO2 they contain)
- sediment cores from the bottoms of lakes or the ocean floor (they provide evidence of climate variation over time; eg. the composition of the sediment – for example, the amount of iron it carries – differs between wet and dry periods)

This ancient, or paleoclimate, evidence reveals that current warming is occurring roughly ten times faster than the average rate of ice-age-recovery warming. Carbon dioxide from human activity is increasing more than 250 times faster than it did from natural sources after the last Ice Age.

This body of data, collected over many years, reveals the signals of a changing climate[1].

Global temperature rise

The planet's average surface temperature has risen about 1 degree Celsius since the late 19th century. Most of the warming occurred in the past 40 years, with the seven most recent years being the warmest.

This animation in the form of a colour-coded map shows a progression of changing global surface temperatures between 1884 and 2021. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.

https://climate.nasa.gov/interactives/climate-time-machine

Warming Ocean

The ocean has absorbed much of this increased heat, with the top 100 meters of the ocean showing warming of more than 0.33 degrees Celsius since 1969. The graph in the figure shows the change in the heat content of the world's ocean.

[1] https://climate.nasa.gov/evidence/

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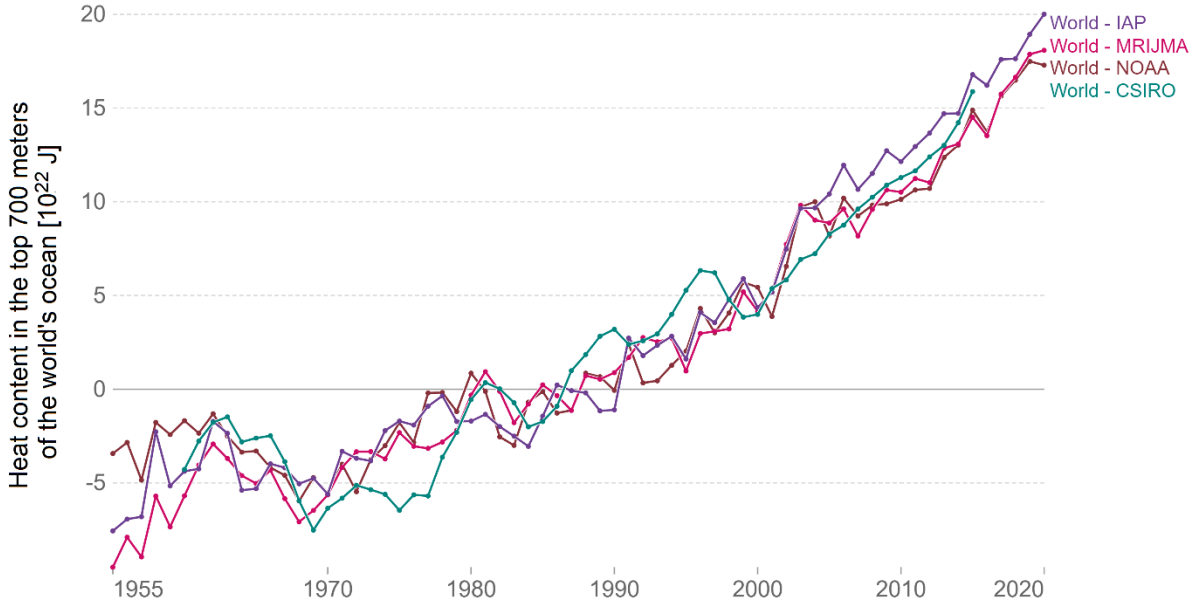

Figure. Heat content in the top 700 meters of the world's oceans (measured relative to the 1971–2000 average).

Source: EPA; https://ourworldindata.org/explorers/climate-change?facet=none&Metric=Ocean+heat+content+%28top+700m%29&Long-run+series%3F=false&country=~OWID_WRL

Rising ocean levels

Rising temperatures are causing glaciers and ice sheets to melt, adding more water to the oceans. Oceans absorb 90% of the extra heat from global warming: warmer water expands, and so our oceans are taking up more space. Both processes are causing the ocean level to rise (figure).

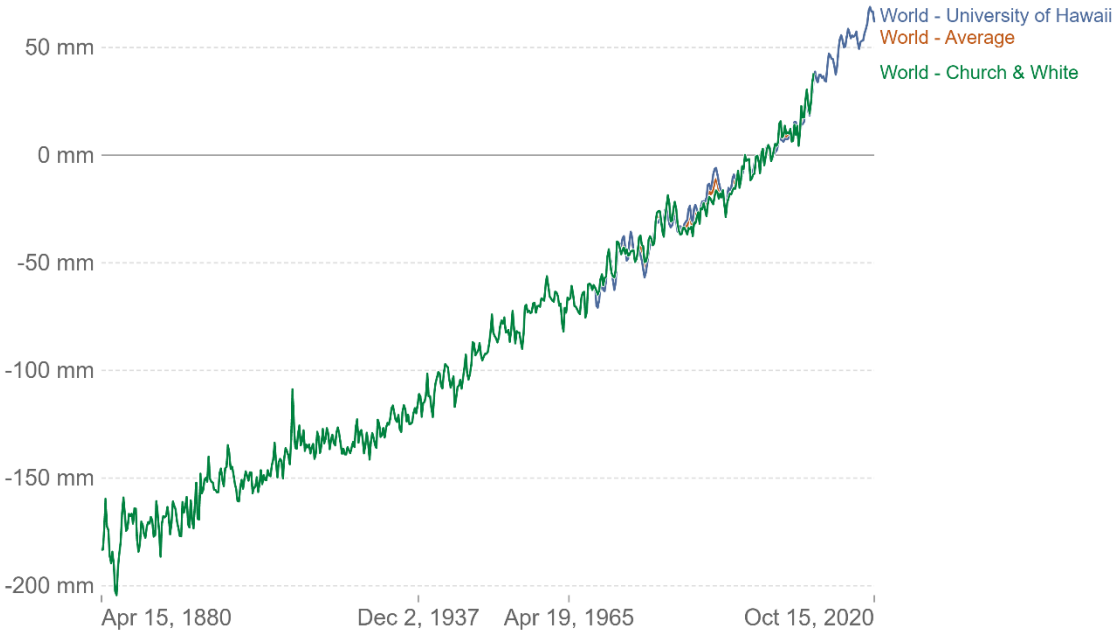

Figure. Global mean sea level rise measured relative to the 1993-2008 average sea level.

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Source: NOAA, https://ourworldindata.org/explorers/climate-change?facet=none&Metric=Sea+level+rise&Long-run+series%3F=false&country=~OWID_WRL

Why Melting Glaciers Matter to the Coasts

https://www.youtube.com/watch?v=lDZWWcAfn-c&list=PLr8uf42JALwcbQVGKFTCGFQ9se9komUm7&index=1

How Warming Leads to Sea Level Rise

https://www.youtube.com/watch?v=y8db-KFj6k0&list=PLr8uf42JALwcbQVGKFTCGFQ9se9komUm7&index=2

Shrinking Ice Sheets

The Greenland and Antarctic ice sheets together store over 99% of the Earth's freshwater. Due to the Earth's warming, the Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost an average of 279 billion tons of ice per year between 1993 and 2019, while Antarctica lost about 148 billion tons of ice per year.

What are ice sheets, and how do they work? What effects do glacial processes in Antarctica have upon the continent itself and on the rest of the world?

https://discoveringantarctica.org.uk/oceans-atmosphere-landscape/ice-land-and-sea/ice-sheets-and-glaciation/

Declining Arctic Sea Ice

Both the extent and thickness of Arctic sea ice have declined rapidly over the last several decades (figure). Arctic sea ice reaches its minimum each September. September Arctic sea ice is now declining at a rate of 13% per decade, relative to the 1981 to 2010 average. This graph shows the annual Arctic sea ice minimum each September since 1979, derived from satellite observations.

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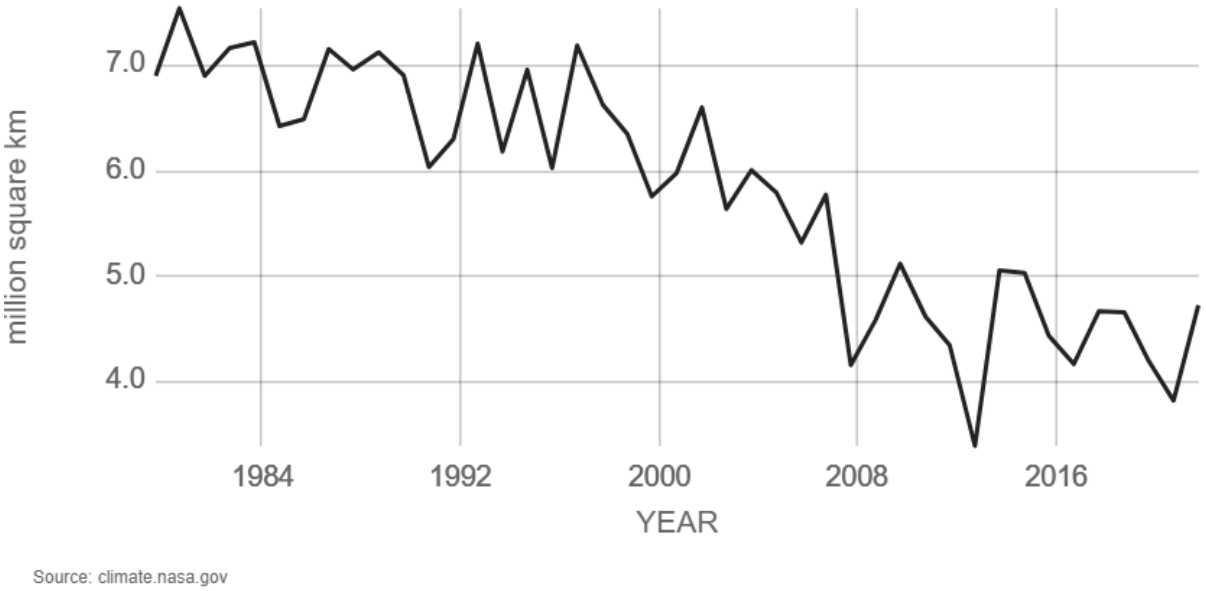

Figure. Annual September minimum extent

Data source: Satellite observations. Credit: NSIDC/NASA

Version for younger students

This visualization shows the annual Arctic sea ice minimum since 1979. At the end of each summer, the sea ice cover reaches its minimum extent, leaving what is called the perennial ice cover. The area of the perennial ice has been steadily decreasing since the satellite record began in 1979.

https://climatekids.nasa.gov/time-machine/

Version for older students

The animated time series below shows the annual Arctic sea ice minimum since 1979, based on satellite observations. The 2012 sea ice extent is the lowest in the satellite record.

https://climate.nasa.gov/interactives/global-ice-viewer/#/3/7

Glacial Retreat

Mountain glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska, and Africa, although a few glaciers are holding steady or growing in mass. Generally, however, the trend is overwhelmingly towards glacial retreat and loss.

Decreased Snow Cover

Satellite observations reveal that the amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and the snow is melting earlier.

Extreme Events

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The number of extreme events such as heatwaves, droughts, flooding, hurricanes, and intense rainfall events is increasing.

4. What causes climate change?

The climate on Earth has been changing since it formed 4.5 billion years ago. Over the past one million years, the Earth has experienced a series of ice ages, including cooler periods (glacials) and warmer periods (interglacials). Glacial and interglacial periods cycle roughly every 100,000 years, caused by changes in Earth's orbit around the sun. For the past few thousand years, Earth has been in an interglacial period with a constant temperature. Until recently, natural factors have been the cause of these changes.

Even though these natural causes contribute to climate change, we know based on scientific evidence that they are not the primary cause. Since the Industrial Revolution in the 1800s, human activity has become the leading cause of changes to the climate. By burning fossil fuels such as coal, oil, and natural gas, industrialisation, and changing how we use the land, we've been adding more and more greenhouse gases into the air, trapping more heat. Instead of keeping Earth at a warm, stable temperature, the greenhouse effect is heating the planet at a much faster rate.

4.1. Natural changes to the climate

The leading cause of climate change is human activity and the release of greenhouse gases. However, there are lots of natural causes that also lead to changes in the climate system. Some of these natural cycles include:

Milankovitch cycles

As Earth travels around the sun, its path and the tilt of its axis can change slightly. These changes, called Milankovitch cycles, affect the amount of sunlight that falls on Earth. This can cause the temperature of Earth to change. However, these cycles take place over tens or hundreds of thousands of years and are unlikely to be causing the changes to the climate that we are seeing today.

El Niño Southern Oscillation (ENSO)

ENSO is a pattern of changing water temperatures in the Pacific Ocean. In an 'El Niño' year, the global temperature warms up, and in a 'La Niña' year, it cools down. These patterns can affect the global temperature for a short amount of time (months or years) but cannot explain the persistent warming that we see today.

Natural forcings that can contribute to climate change include:

Solar irradiance

Changing energy from the sun has affected the temperature of Earth in the past. However, we have not seen anything strong enough to change our climate. Any increase in solar energy would make the entire atmosphere of Earth warm, but we can only see warming in the bottom layer.

Volcanic eruptions

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Volcanoes have a mixed effect on our climate. Eruptions produce aerosol particles that cool Earth, but they also release carbon dioxide, which warms it. Volcanoes produce 50 times less carbon dioxide than humans do, so we know they are not the leading cause of global warming. On top of this, cooling is the dominant effect of volcanic eruptions, not warming.

Natural climate cycles can change the temperature of Earth, but the changes we are seeing are happening at a scale and speed that natural cycles cannot explain.

4.2. Human causes of climate change

Greenhouse gases trap the Sun's heat in Earth's atmosphere. It's normal for there to be some greenhouse gases in our atmosphere. They help keep Earth warm enough to live on. But too many greenhouse gases can cause too much warming.

When looking at all the evidence, there is a large scientific consensus that humans are the leading cause of climate change. In their latest report, the Intergovernmental Panel on Climate Change stated unequivocally that human activity is the cause of global warming[2].

Extra greenhouse gases emitted by humans into the atmosphere are the main reason that Earth is getting warmer. We produce greenhouse gases in lots of different ways.

Burning fossil fuels

Fossil fuels such as oil, gas, and coal contain carbon dioxide that has been 'locked away' in the ground for thousands of years. When we take these out of the land and burn them, we release the stored carbon dioxide into the air.

Global Carbon Atlas 2021 is a platform to explore and visualize the most up-to-date data on carbon fluxes resulting from human activities and natural processes

http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas

Today, there is more carbon dioxide in the atmosphere than there ever has been in at least the past 2 million years. During the 20th and 21st centuries, the level of carbon dioxide rose by 40%. The graph in figure shows the monthly mean carbon dioxide measured at Mauna Loa Observatory, Hawaii. The carbon dioxide data on Mauna Loa constitute the longest record of direct measurements of CO2 in the atmosphere – they were started in 1958.

[2] IPCC, The Intergovernmental Panel on Climate Change (IPCC) - The latest IPCC report is the global go-to source for the latest research on climate change: https://www.ipcc.ch/report/sixth-assessment-report-cycle/

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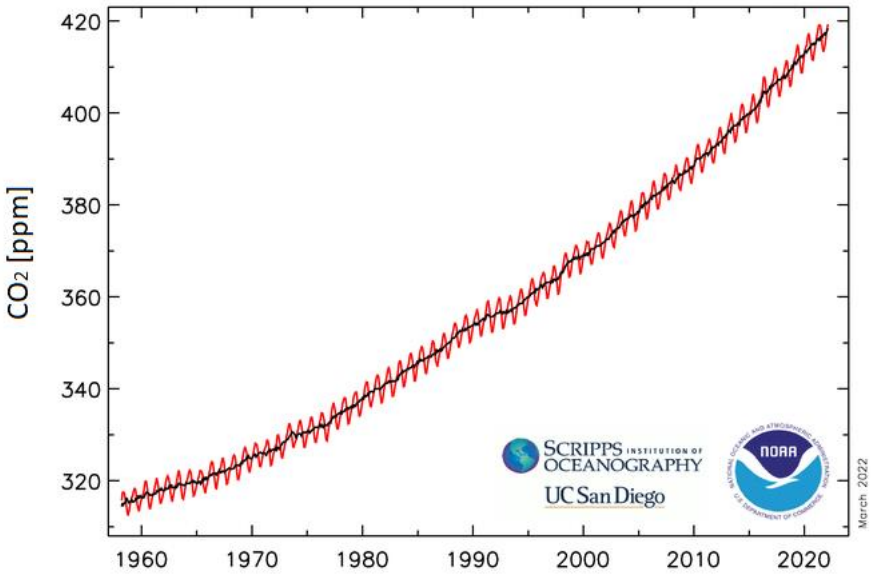

Figure. The monthly mean of atmospheric carbon dioxide measured at Mauna Loa Observatory, Hawaii

Source: Scripps Institution of Oceanography; NOAA Global Monitoring Laboratory.

The red lines and symbols represent the monthly mean values, centred on the middle of each month. The black lines and symbols represent the same, after correction for the average seasonal cycle.

History of atmospheric carbon dioxide from 800,000 years ago until 2021:

https://youtu.be/Mr84tEbCQSg

Deforestation

Forests remove and store carbon dioxide from the atmosphere. Cutting down forests to create farms or pastures or for wood production means that carbon dioxide builds up quicker since there are no trees to absorb it. Moreover, when burned, trees release the carbon they stored.

Agriculture

Planting crops and rearing animals releases many different types of greenhouse gases into the air. For example, animals produce methane, which is 30 times more powerful than carbon dioxide as a greenhouse gas. The nitrous oxide used for fertilisers is ten times worse and is nearly 300 times more potent than carbon dioxide.

Cement

Producing cement is another contributor to climate change, causing 2-5% of our entire carbon dioxide emissions.

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5. What are the impacts of climate change

Human activity – from releasing greenhouse gases and aerosols into the atmosphere, to changing the use of land – is the main driver of climate change.

Climate change impact people around the world in different ways. The level of impact depends on the climate of the area and the wealth of the country. Climate change is causing many extreme weather events to become more intense and frequent, such as heatwaves, droughts, floods, hurricanes, winter storms, and coastal storm surges. Extreme weather can be highly destructive and life-threatening. Climate change effects are 'stress multipliers', which means that they often make existing problems more severe.

The climate system is finely balanced, and small changes can have significant consequences (Figures).

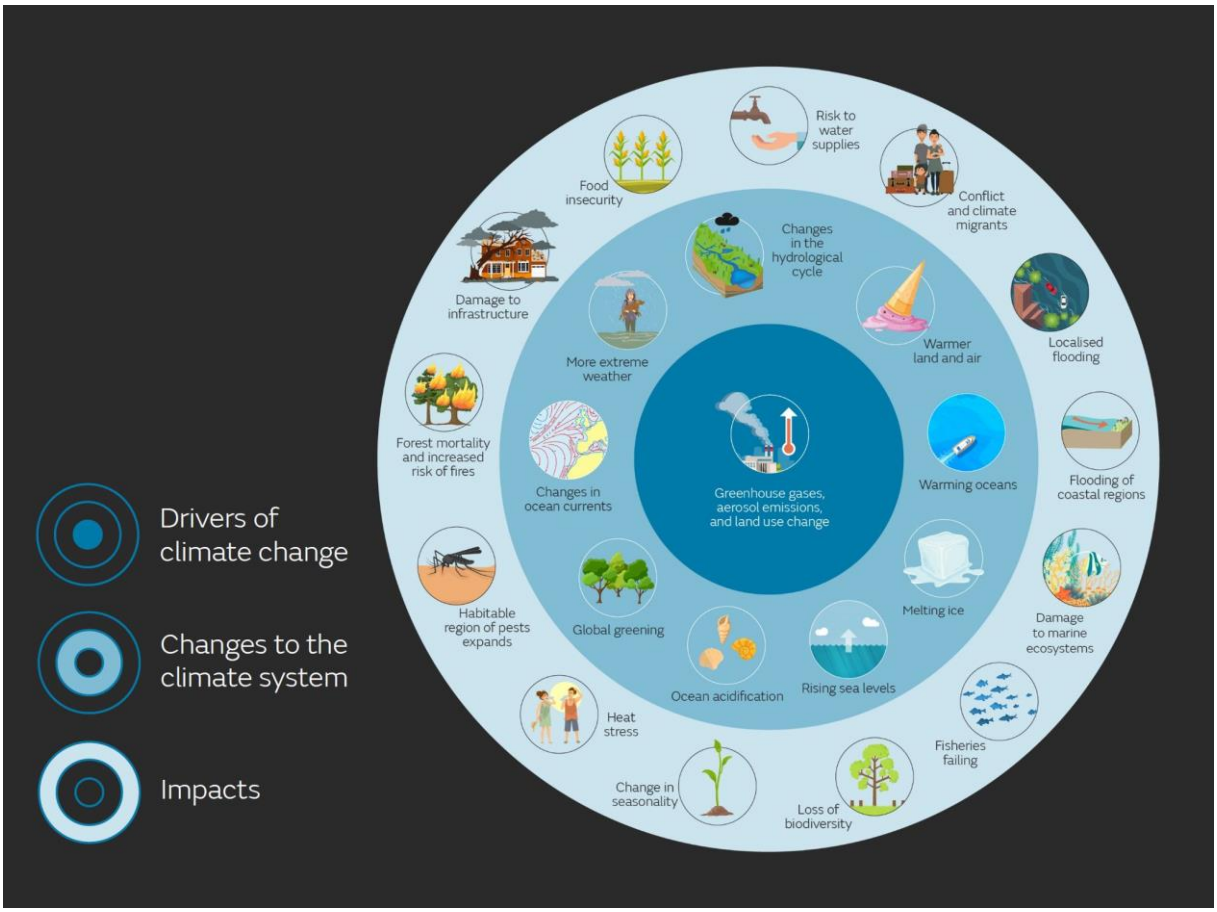

Figure. Impacts of climate change.

Source: https://www.metoffice.gov.uk/weather/climate-change/effects-of-climate-change

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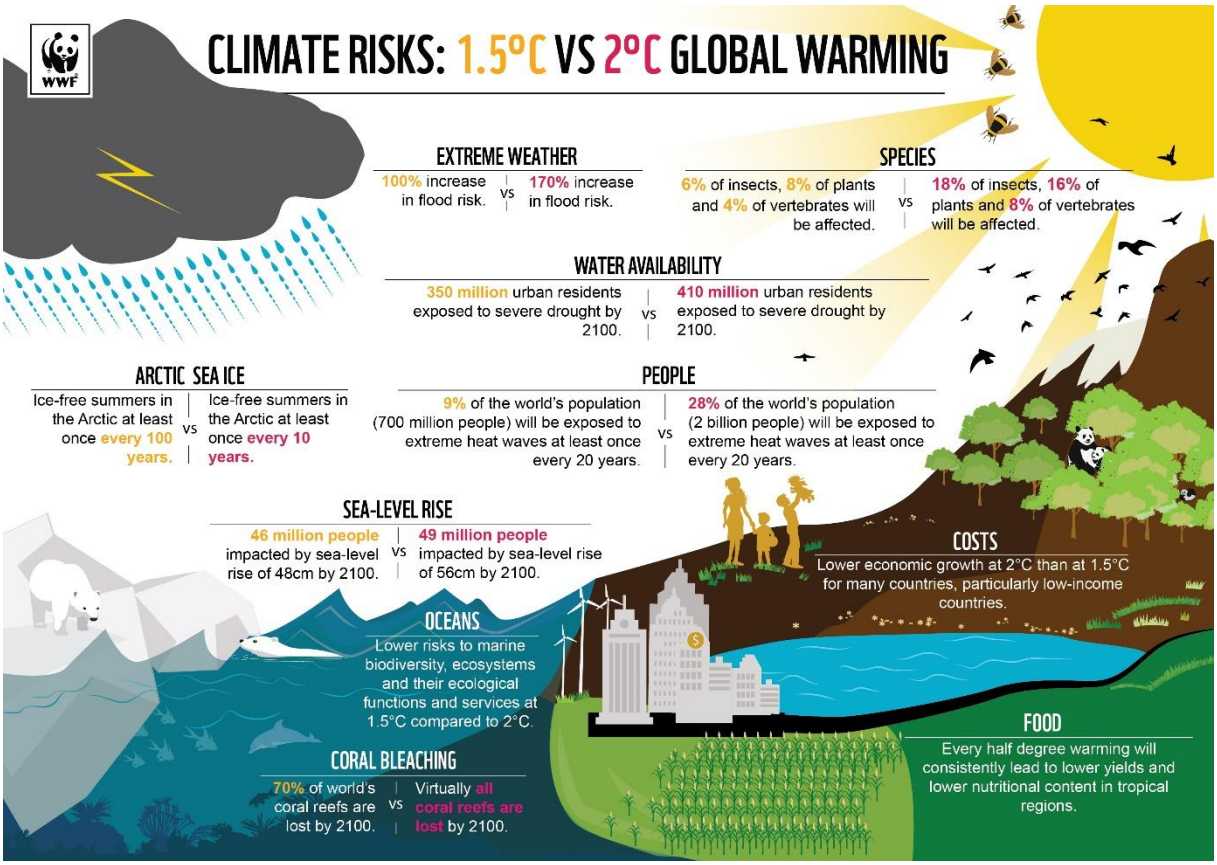

Figure. What are the differences in impacts if the temperature rises to 2°C versus 1.5°C.

https://wwfint.awsassets.panda.org/downloads/1_5c_infographic___final__high_res__final.jpg

Changes in Earth's climate have different effects in different areas of the world. Some places will warm much more than others, some regions will receive more rainfall, while others are exposed to more frequent droughts. Regional changes in temperature and precipitation are having impacts on people, natural ecosystems, biodiversity, and the economy.

Climate Visuals is a website and image library – a unique and trusted source of evidence and images for over 350 climate change and environmental groups, journalists, educators and businesses catalysing a new visual language for climate change. This resource offers seven core principles for effective visual communication, plus a library of images relating to different aspects of climate change.

https://climatevisuals.org/

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Conflict and climate migrants

Climate change is a stress multiplier – it can take existing problems, such as lack of food or shelter, and make them worse. This can cause people to fight over resources (food, water, and shelter), or to migrate.

If our climate continues to change, many parts of the world will become more challenging places to live. People may have to leave their homes. Climate is just one of many factors that influences human migration, but it will play an increasing role in the future.

Flooding of coastal regions

Rising sea levels cause problems for people around the world. Many people will have to leave their homes, but the number will vary depending on how we act, by reducing global emissions and improving flood defences.

Nearly 4 in 10 people (39%) live within 100 kilometres from a shoreline and are at risk of flooding if sea levels continue to rise. 600 million of these people live in a 'low-level coastal zone', and 200 million on a coastal flood plain.

Much of coastal Bangladesh is very close to sea level. Thus, sea-level rise is expected to cause widespread flooding as the climate continues to change. This low-lying area, vulnerable to flooding, is home to 18 million people.

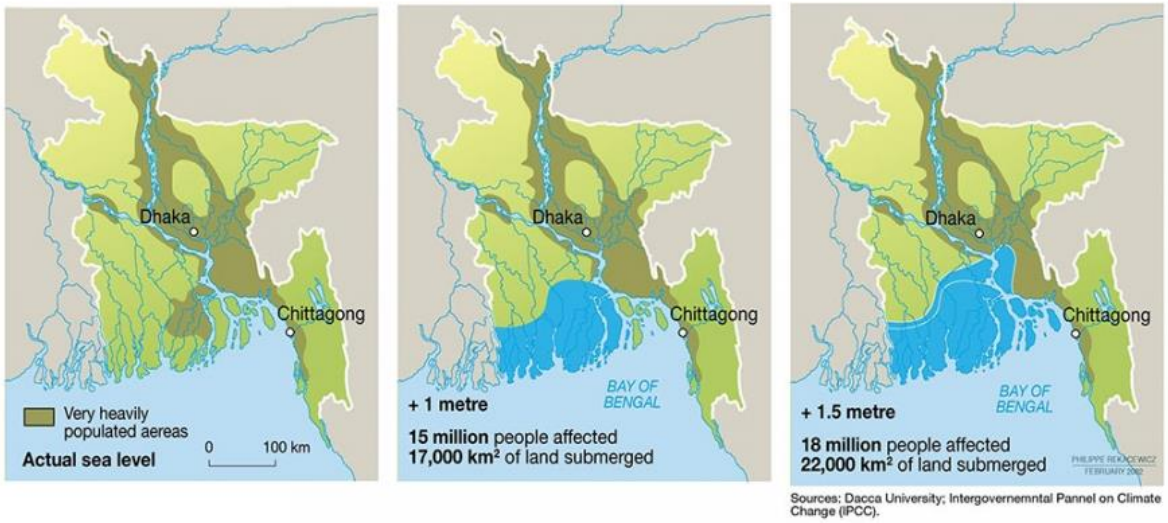

Figure. Sea Level Change in Bangladesh; source: https://scied.ucar.edu/image/sea-level-change-bangladesh

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Heavy rains

Warmer air can hold more water vapour, so under a warming climate, the average global amount of precipitation will increase and heavy rains are expected to increase. A large amount of rain falling in a short time can overwhelm stormwater management and sewer systems and lead to dangerous, destructive flooding and mudslides. In heavily concreted urban areas and cities, the effect is more severe because the water cannot sink directly into the soil. Flooding causes severe damage to buildings and transportation, which can be very costly and hard to recover. It can also wash nutrients from farms and pollutants into sensitive ecosystems and drinking water reservoirs.

Flooding

An increase in flooding is another danger.

Countries that flood regularly, such as Bangladesh, are expected to see even more regular floods, putting more communities at risk.

Damage to marine ecosystems

Warming temperatures, rising seas, melting ice, and other impacts of climate change can threaten the habitat of many plants and animals. Some species are moving to new habitats, but others may struggle to adapt and become endangered or extinct.

Rising ocean temperatures, ocean acidification, and ocean anoxia (lack of oxygen) are damaging to marine life such as fish and coral reefs.

Ocean acidification occurs when the ocean absorbs carbon dioxide and becomes more acidic. This can make it difficult for corals and organisms that form shells to survive, which can threaten the survival of the entire food web of which they are part.

How does climate change affect coral reefs?

https://oceanservice.noaa.gov/facts/coralreef-climate.html

Loss of biodiversity

A changing climate means changing habitats. This in turn further intensifies the effects of climate change, which cause biodiversity loss. Biodiversity loss describes the decline in the number, genetic variability, and variety of species, and the biological communities in a given area. This loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where the decline has happened[3].

Biodiversity, also called biological diversity, is the variety of life found in a place on Earth or, often, the total variety of life on Earth. A common measure of this variety, called species richness, is the count of species in an area. Biodiversity also

[3] https://www.britannica.com/science/biodiversity-loss

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encompasses the genetic variety within each species and the variety of ecosystems that species create[4].

Change in seasonality

Climate change is affecting the patterns and duration of the seasons. As an effect of climate change, the Northern Hemisphere's seasons are changing. Between 1952 and 2011, the average length of summer in Northern latitudes has already increased from 78 to 95 days, while the length of winter has shrunk from 76 to 73 days. Even small seasonal shifts such as this can disrupt ecosystems and also lead to serious health hazards. The change in seasonality can negatively affect crop production or increase the occurrence of mosquito-borne diseases. Longer summers can increase the length of heatwaves and the occurrence of wildfires[5].

Heat stress

Heatwaves are defined as a series of consecutive days with exceptionally high air temperatures. As the Earth warms, more areas will be at risk for hotter and more common extreme heatwaves.

Extreme heat causes heat-related illnesses, such as cardiovascular and respiratory complications and kidney disease, and mortality. The groups particularly vulnerable to heat stress include older adults, infants and children, people with chronic health conditions, outdoor workers, and people who have low incomes.

Heatwaves also stress ecosystems, livestock, and infrastructure. Dairy cows produce less milk and crop growth can slow during periods of intense heat, and paved roads can buckle. Energy systems are strained during heat waves when electricity demand for air conditioning rises, sometimes leading to brownouts and blackouts. These power disruptions in turn put a strain on communications and emergency response systems. Heatwaves combined with drought can increase the likelihood of wildfires.

In the urban areas, the prolonged periods of heat cause buildings, roads, and infrastructure to absorb heat, leading to an increase in the temperature compared to outlying areas – a phenomenon known as the urban heat island effect. This impact is most intense during the day, but the slow release of heat overnight can keep cities much hotter than surrounding areas.

Food insecurity

Climate change affects agricultural systems in complex ways. Rising atmospheric CO2 concentrations, higher temperatures, changes in precipitation patterns, extreme weather events, flooding, and droughts affect the quantity, quality and stability of food production. Farming, more than many other industries, is feeling the effects of changing weather patterns with more frequent and severe weather events. Many farmers around the world have suffered increased flooding which ruins their crops and soil or faced wildfires that wiped out not only crops and livestock but businesses, homes and wildlife

[4] https://www.britannica.com/science/biodiversity

[5] Changing Lengths of the Four Seasons by Global Warming, https://doi.org/10.1029/2020GL091753

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too. Increased temperatures and lack of rain can result in severe droughts. In all these cases, the food supplies are threatened and food becomes more expensive and not so readily available.

Wildfires

These are fires that burn large amounts of forests and brush. When they are not controlled, wildfires can destroy homes and be deadly. The number of large wildfires and the length of the season when they're most likely and threatening have been increasing in recent years.

6. What are the solutions to climate change?

Even though climate change sounds scary, we still have time to avoid some of the worst impacts. Everyone can play a part, including government, businesses, and you.

There are two main things we need to do:

1) We need to reduce the greenhouse gas emissions responsible for climate change (prevention and mitigation)
2) We need to prepare for life in a changing climate (adaptation)

The annual "Conference of the Parties" (COP) was set up by the United Nations to coordinate the global response to climate change. Limiting global temperature rises to 1.5°C is widely agreed as the limit to prevent very serious and damaging climate change. The objective of the 2015 COP Conference, which took place in Paris, was to achieve a legal and universal agreement from all the countries of the world to reduce greenhouse gases so we don't go above a 2°C rise, and to reduce the impacts even this will have across the world, especially on poorer people.

At the longest COP conference on record, COP26 which took place in Glasgow, countries agreed to the goal of climate neutrality, increased funding for vulnerable developing countries, and less money for new fossil fuel projects. They did not reach a common response to phasing out the use of coal.

In July 2021 the European Climate Law entered into force. It is the EU's first climate law that makes reaching climate neutrality by 2050 law. It also aims to achieve negative emissions after 2050 and sets an intermediary climate target of a reduction of net greenhouse gas emissions of at least 55% by 2030.

Interactive timeline: A GUIDE TO CLIMATE CHANGE NEGOTIATIONS

https://www.europarl.europa.eu/infographic/climate-negotiations-timeline/index_en.html#event-2019-12-12

6.1. Prevention and mitigation

The most crucial step to limiting climate change is to make big and rapid reductions in global greenhouse gas emissions. There are many different ways this can be done and governments, businesses, organisations and individuals around the world can all contribute. A successful mitigation pathway will likely involve combinations of strategies on all these levels.

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By choosing cleaner ways to power our homes, offices, and cars, and being more efficient and less wasteful, we can produce fewer greenhouse gas emissions.

Energy production and use

Energy production and use are by far our biggest contributors to greenhouse gases emissions. By transforming how we produce the energy we could reduce greenhouse gas emissions (see Module 3 Energy Resources and Management).

Transport

The transportation sector is a big contributor to greenhouse gases emissions. The transportation sector also is a primary source of other kinds of emissions that degrade air quality and threaten human health. Reducing transportation emissions will both mitigate future climate change and improve air quality and human health. Such benefits that go beyond reducing emissions are sometimes referred to as co-benefits.

On a larger scale, we can make societal decisions to reduce our transportation energy use. For example, cities can choose to build public transportation networks so we use less energy driving individual cars, or cities can build infrastructure that makes it easier to ride a bicycle. Communities can choose to develop neighbourhoods where jobs and stores are close to where people live. Businesses can create incentives and mechanisms for employees to telecommute and carpool. Governments can set fuel efficiency standards for vehicles.

At the individual level, we can save energy by driving less: carpooling, combining errands into fewer trips, and walking, biking, or taking public transportation instead of cars. We can also choose to buy products that involve less transportation, such as buying locally- or regionally-grown produce instead of imported fruits and vegetables. When we do drive, we can use less energy by not idling, driving at lower speeds on the highway, keeping tires properly inflated, and doing regular maintenance. We can choose to buy more fuel-efficient cars. Sometimes we can choose to live in neighbourhoods where employers, services, and activities are close by and require less driving. Sometimes some of us can choose to work from home.

Buildings

Buildings are one of the sectors with the biggest potential for energy savings. Buildings use energy for heating, cooling, lighting, and other electrical systems.

There are many ways to increase the energy efficiency of buildings, including installing more efficient lighting and better insulation. Greenhouse gas emissions can be reduced by making power on-site with renewables and other climate-friendly energy resources. Examples include rooftop solar panels, solar water heating, small-scale wind generation, fuel cells powered by natural gas or renewable hydrogen, and geothermal energy.

The use of green infrastructure is a mitigation strategy for buildings and communities because green infrastructure helps to reduce energy use. Green infrastructure refers to structures that use plants, soil, and other natural features to perform functions such as providing shade, absorbing heat, blocking wind, or absorbing stormwater.

Carbon sequestration

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Plants and soils sequester (hold) carbon when left untouched by large-scale human activity. Plants take in carbon through photosynthesis, release some to the atmosphere through respiration and some to the soil through their roots, and store the remainder in their tissues. A tree's dry weight is almost half from carbon. The soil takes in carbon when plants die and decompose.

When people burn forests or till the soil, carbon is released into the atmosphere. The practices used in managing forests and land can have a big impact on carbon emissions.

Some forestry options for mitigating the release of carbon are afforestation, reforestation, reducing deforestation, and planting forests that grow rapidly.

Agriculture

The large contribution to greenhouse gas emissions comes from food production. Emissions come from crop agriculture, such as rice or corn, and livestock. Emissions can be reduced by changing the way crops and livestock are grown and managed:

- reducing the use of heavy chemicals and petroleum-based fertilizers
- reducing the dependence on livestock as food and improving feeding management as livestock (especially cows) emit large amounts of methane
- implementing innovative solutions to manage manure which is byproduct of livestock

Waste management

The ways we manage waste products in society have significant environmental impacts, including on greenhouse gas emissions. Waste management techniques that mitigate climate change indirectly include recycling and material reuse (see Module 2 Waste Management and Circular Economy).

6.2. Adaptation

Even if we could stop creating greenhouse gases tomorrow, the climate would still change some because of our past emissions. So we need to make sure our buildings, roads, businesses, and communities are ready for the climate changes that we can't avoid. Climate change is happening now and will get more serious in the future, even if global efforts to reduce greenhouse gas emissions prove effective. Climate change leads to adverse impacts on ecosystems, economic sectors, and human health and well-being. Therefore, minimising the risks from global climate change requires targeted actions to adapt to the impacts of climate change, in addition to actions to reduce greenhouse gas emissions. Adaptation must be tailored to the specific circumstances in different regions[6].

Sea level rise

Strategies to protect coasts and communities from sea-level rise include building structures that break or attenuate waves, maintaining and enhancing natural protective coastline features, setting restrictions and rules on whether and how coastal land can be developed, and relocating infrastructure and communities to higher ground. The effective solutions include the implementation of nature-based approaches such as:

[6] https://experience.arcgis.com/experience/5f6596de6c4445a58aec956532b9813d

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- building dunes
- nourishing (i.e., adding sand to) beaches
- maintaining and enhancing wetlands, coastal forests, barrier islands, and oyster reefs which help to prevent erosion, break waves offshore, and reduce the energy of incoming waves

Communities can set restrictions on where buildings can be built, limiting development extremely close to the coast where beaches and buildings are at the greatest risk.

Communities need to create effective flood and storm warning and preparedness programs, to keep residents safe in place or to evacuate them when necessary.

Some communities will need to consider relocation which can involve moving critical infrastructures such as hospitals, wastewater treatment plants, and bridges, but it can also involve moving entire communities or neighbourhoods farther inland to higher ground.

Heavy rains

One way that cities are addressing the increased risk of heavy rainfall is through the use of green infrastructure. Conventional or “gray” ways of managing heavy rainfall in cities involve capturing the rain with gutters and storm sewers and moving it away through pipes to nearby streams, rivers, or lakes. With the increasing intensity of heavy rains, many stormwater systems will need to be redesigned and rebuilt to an appropriate size which is costly. On the other hand, green infrastructure incorporates soil and plants and uses them to absorb and filter rainwater. The absorption reduces the amount of stormwater that could potentially flood streets and neighbourhoods, and any excess water is cleaner after being filtered.

Examples of green infrastructure:

- rain garden which collects and absorbs rainwater, reducing pollution and preventing flooding
- a bioswale, a type of rain garden built as a channel along a street or parking lot which absorbs and filters water, and also slow water down as it moves along the channel, reducing the risk of flooding
- using the permeable pavement on paved areas such as parking which allows water to drain into the soil below

A final strategy to adapt to the increasing frequency of heavy rainfall is to relocate key infrastructure out of flood-prone areas and to site new construction away from these areas.

Heat stress

Strategies to build resilience to extreme heat can include:

- identifying vulnerable populations and creating heat preparedness plans with all residents in mind
- pursuing energy efficiency to reduce demand on the electricity grid, especially during heatwaves

Strategies to reduce the effects of heatwaves and urban heat islands often focus on reducing the absorption of sunlight. Examples include:

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- planting trees along city streets and in open spaces as plants cool the air through evapotranspiration
- building living roofs – rooftops covered with living plants instead of asphalt or other materials
- painting roofs with reflective paint where living roofs are not feasible helps keep buildings cool
- using lighter coloured paving materials for streets

Extreme Weather

Adapting to storm surges is a difficult challenge for those who live on the coast, especially since storm surges can rise over 30 feet in an intense hurricane. Houses can be raised above the land surface by being built on piles (vertical structures), which allow water to flow beneath the house. Communities can set regulations that require new buildings to be set back from flood-prone areas. They can also protect and revitalize natural features that provide buffers against storms surges, such as dunes and beach vegetation.

Adaptation strategies for high winds include using building practices that strengthen structures, designing building sites with high winds in mind, protecting power lines and other infrastructure, and providing education on safety in the face of severe winds.

Winter storms can include high winds and storm surges (if along the coast), but they bring the additional hazards of snow, ice, and cold temperatures. A loss of power following a winter storm can lead to a lack of heat for buildings, putting people at risk and causing water pipes to freeze and burst. Implementing and enforcing building codes can help reduce the risk of weak roofs that collapse under heavy snow, and can reduce heat loss through the use of insulation.

Utility lines can be protected from ice and snow damage through similar measures as described above for protection from high winds, and communities can install snow fences or rows of trees to prevent snow from drifting and building upon roads.

Drought

Adapting to more frequent and severe drought can involve monitoring and planning, restricting water use and grazing, improving and upgrading water supply and delivery infrastructure, developing and encouraging the use of drought-tolerant plants for gardens and crops, and educating the public and farmers on water conservation practices.

Ecosystems also experience stress during times of drought, but people can take action to help plants and wildlife adapt. One example is by creating fish passages. When streams and rivers dry out because of drought, fish find it much more difficult to travel upstream to spawn. Even if they are able to spawn, low stream flows can threaten the viability of their eggs and young. Fisheries managers can help fish by building channels with sufficient stream flow to allow fish to pass, and by removing barriers such as dams.

Agriculture

Farmers can limit the adverse impacts and enhance the beneficial impacts of climate change through suitable adaptation measures, such as adapting crop varieties, changing sowing dates and improving irrigation.

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Transportation, telecommunications, and energy distribution

For activities such as transportation, telecommunications, and energy distribution, many of the adaptation strategies for extreme heat involve technological solutions. For example, power lines may need upgrading with wiring and transformers that work well at higher temperatures. Bridge and road materials may also need upgrading, and public transportation systems such as subways and buses may need more and better air conditioning. In addition, if large-scale systems that use energy can be made more energy-efficient, it will reduce the strain on electrical systems during heat waves when demand is high.

Students use a card sort activity to explore different actions we can take to reduce the risks of climate change and learn to recognize different types of climate solutions: mitigations and adaptations.

https://scied.ucar.edu/activity/mitigation-or-adaptation

7. Additional Resources

Movies that teach kids about climate change

https://www.commonsensemedia.org/lists/movies-that-teach-kids-about-climate-change

Guidance in Teaching About Climate and Energy

https://cleanet.org/clean/literacy/index.html

Education for Sustainable Development

https://en.unesco.org/themes/education-sustainable-development

SDG Resources for Educators - Climate Action

https://en.unesco.org/themes/education/sdgs/material/13

8. Additional Guidelines

How to talk to change thinking[7]:

• Encourage diverse thinking. Encourage young people to recognise that different communities need different actions and we can't assume a blanket action for everyone. For example, whilst using a reusable water bottle might work in your classroom, for others where clean running water isn't an option, plastic bottles might be the only source of clean water.

• Collective action & systems change learning is important. When thinking about tackling climate change, we often feel that it is up to individuals to make behaviour changes that will

[7] World's Largest Lesson. How to talk to children and young people about climate change, https://worldslargestlesson.globalgoals.org/resource/talking-to-young-people-about-climate-change/

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help tackle the crisis. However, it's important to think about how collective action also plays a vital role in solving this crisis. Writing to business leaders, local elected officials and community leaders should be encouraged amongst young people as a way of bringing in larger, systemic change.

• Encourage children to get involved in their local communities; they'll feel more connected to local issues

• Acknowledge student emotions. Young people can often find climate change overwhelming and leads to "eco-anxiety", with many youth feeling isolated in their concern for climate change. Try and make your classroom or learning environment a space where young people can voice their opinions and feelings on climate change a reality. We suggest using emoji or scenario cards to help students communicate these.

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