• Geography E-learning Package about •

Climate Change

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Geography E-learning Package about Climate Change

Preface

Climate change is an environmental issue of global concern. We need to face up to its impacts and come up with a solution with no hesitation.

This package is sponsored by the Quality Education Fund, and jointly compiled and published by Ho Koon Nature Education cum Astronomical Centre (Sponsored by Sik Sik Yuen), and the Hong Kong Observatory. We aim to allow teachers and students in Geography or related disciplines to have a deeper understanding of climate change and to clarify common misunderstandings through the presentation of the latest scientific evidence and professional analysis.

Aside from providing a wealth of knowledge, this package can accommodate the senior secondary education as a desirable teaching tool. The teaching materials include: (1) teaching kit (text and figures, CD, and webpages, etc.); (2) mobile application about climate change; (3) board game learning set. All materials are developed based on the latest version of Geography Curriculum and Assessment Guide (Secondary 4 - 6): "(7) Climate change - Long term fluctuation or irreversible trend?" published by the Curriculum Development Institute of the Education Bureau and are divided in five chapters:

7.1 Is the climate changing?
7.2 What are the causes of global warming?
7.3 Climate change in Hong Kong?
7.4 What are the impacts of climate change?
7.5 How can we respond to the impacts of climate change?

The ample and comprehensive materials allow students to gain a basic knowledge of global and local climate change, and to further understand the mutual interactions and influences between human activities and the natural environment. These diversified educational information and digital resources will enhance the interaction between teaching and learning at the same time and boost the interest in learning and the effectiveness of the curriculum, enabling students to appreciate the importance of environmental conservation and to promote relating messages, and raising public awareness on climate change.

The successful completion of this package relied on the professional scientific advices from the experts at the Hong Kong Observatory, the partnership and guidance of the Curriculum Development Institute of the Education Bureau, involvement of teachers and students in the pilot program, as well as different parties from educational institutions around the world. We would like to thank all the individuals and organizations for their effort and contribution.

Contents

Download teaching kit

Climate change webpage of the Hong Kong Observatory

Source of figures and data of teaching kit

7.1 Is the climate changing?

7.1 The unquestionable truth – Is the climate changing?

Summary

To know more about climate change, first we need to understand the difference between weather and climate. Weather describes the conditions of the atmosphere within a short period of time, while climate describes the average meteorological conditions over a long period of time.

Weather and climate vary from region to region. After a brief discussion of the global climate, this chapter goes on to introduce the climates in China and Hong Kong specifically.

To better understand the ongoing climate change, we need to examine the scientific evidence such as the increasing global surface temperature, increasing ocean heat content, shrinking sea ice, retreating glaciers and ice sheets as well as rising sea level.

7.1.1 Weather and climate

Weather describes the conditions of the atmosphere in a place within a short period of time (e.g. several hours, a few days). Climate on the other hand describes the average meteorological conditions in a place over a long period of time. Therefore, climate can be interpreted as the "average weather". According to the definition given by the World Meteorological Organization (WMO), the reference period for compiling climate statistics should be at least 30 years.

What is climate?

More information

What are conditions of the atmosphere?

Conditions of the atmosphere refer to the meteorological elements such as temperature, relative humidity, precipitation, air pressure, wind direction and wind speed.

Example of weather

Fig1.1a shows the regional temperatures of Hong Kong in the afternoon on 26 November 2018. Fig1.1b shows that the temperature of Tsuen Wan Ho Koon station was 19°C and the relative humidity was 90%. Fig 1.1c is the image of radar echoes showing that there was rain around Hong Kong.

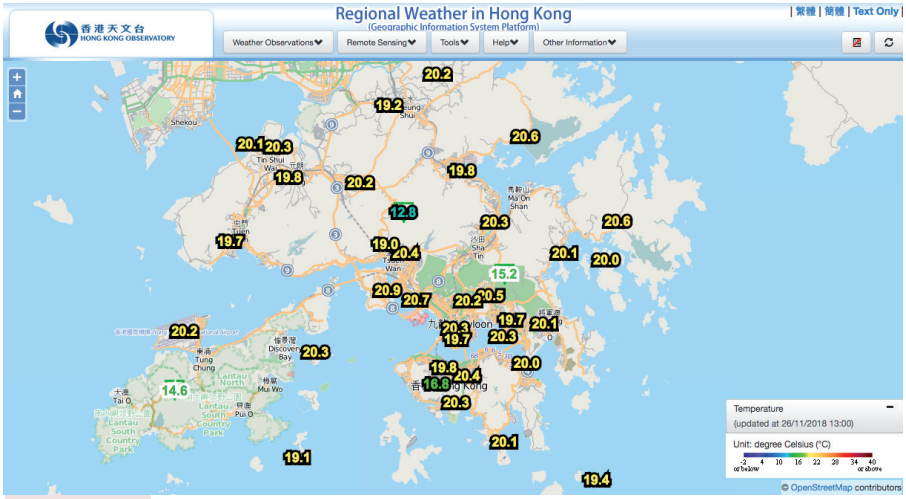


Fig 1.1a Regional temperatures of Hong Kong

Source: Hong Kong Observatory (HKO)

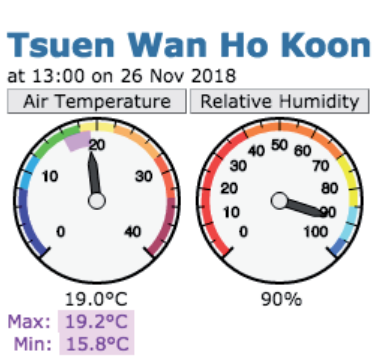


Fig 1.1b Weather conditions at Tsuen Wan Ho Koon station

Source: HKO

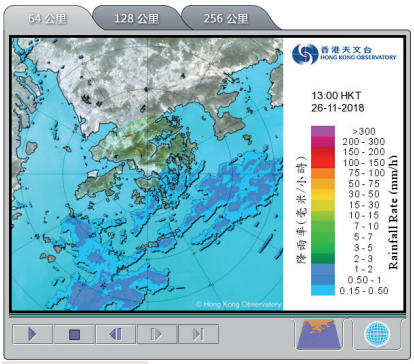


Fig 1.1c Image of radar echoes

Source: HKO

Current weather conditions

More information

The ABC's of Climate

More information

Educational Resources (climate and climate change)

More information

Example of climate

Using long records of meteorological data, we can calculate the climatological values.

Monthly mean of temperature and atmospheric pressure recorded at the Observatory (1981 to 2010)

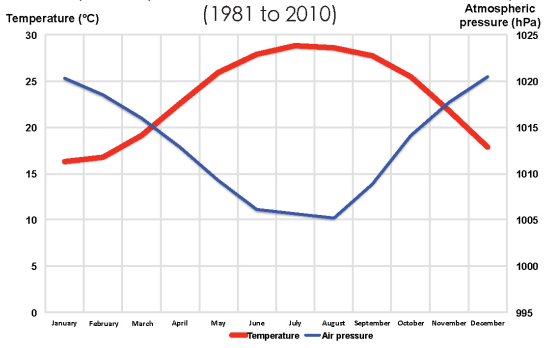


Fig 1.1d Monthly mean temperature and monthly mean atmospheric pressure of Hong Kong

Data source: HKO

Monthly mean of rainfall in Hong Kong (1981 to 2010)

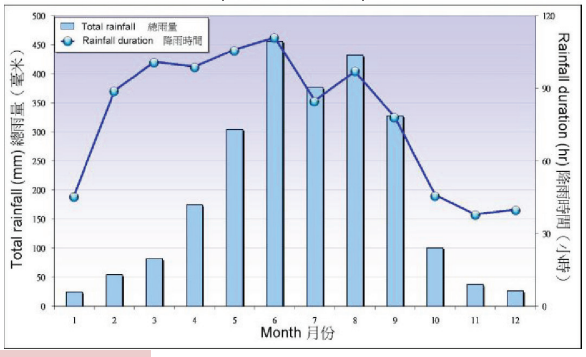
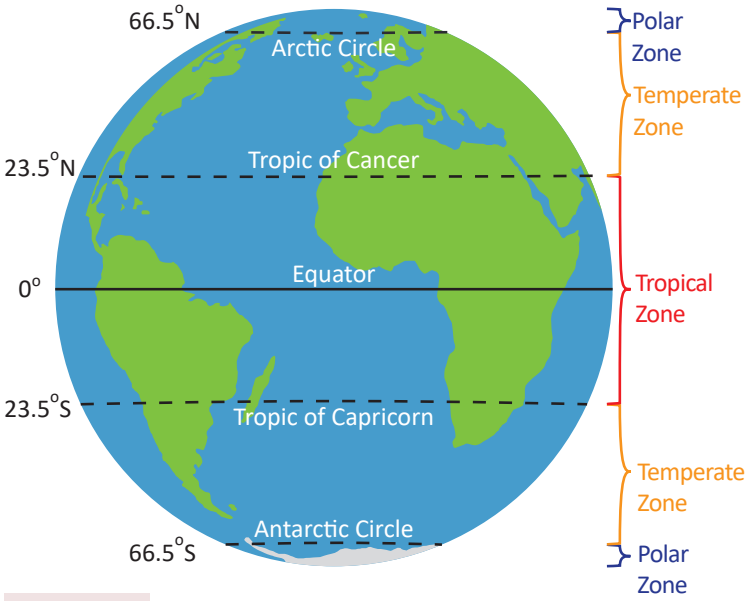


Fig 1.1e Monthly mean of rainfall in Hong Kong

Source: HKO

7.1.2 How is the global climate?

One of the most important factors affecting regional climate is the solar radiation, known as insolation, received. A simple climate classification divides the Earth into climatic zones by the Arctic Circle, the Tropic of Cancer, the Tropic of Capricorn and the Antarctic Circle. **Tropical zone** refers to the region between the Tropic of Cancer and the Tropic of Capricorn; **temperate zone** refers to the region between the Arctic Circle (the Antarctic Circle) and the Tropic of Cancer (the Tropic of Capricorn); **polar zone** fills the areas within the Arctic and Antarctic Circles. Among the three climatic zones, tropical zone receives the greatest amount of insolation, and polar zones receive the least.



Climatic zones (Köppen climatic classification)

More information

Fig 1.2 **Climatic zones classified by the Tropic of Capricorn, the Tropic of Cancer, the Antarctic Circle and the Arctic Circle**

Other climate classifications may take into account parameters such as temperature, precipitation, duration of precipitation and types of vegetation. Regions with similar parameters will be grouped into a climatic zone. For example, Köppen's climatic classification divides the world into 6 major climatic zones based on 3 factors: growth of vegetation, temperature and precipitation.

In addition to latitude, there are other factors such as geographical location, altitude, distance from the sea, ocean currents and prevailing wind, which affect the regional climate.

7.1.3 How are the climates in China and Hong Kong?

Climate in China

Located in the southeast of the Eurasian continent, China is vast in size with complex terrain. It has the Pacific Ocean in the east and Qing Zang Gaoyuan in the west. The interactions among the ocean, continent and terrain give rise to typical monsoon climates. Fig 1.3 shows the major climatic features in China.

What is monsoon?

Monsoon refers to the seasonal reversal of wind direction.

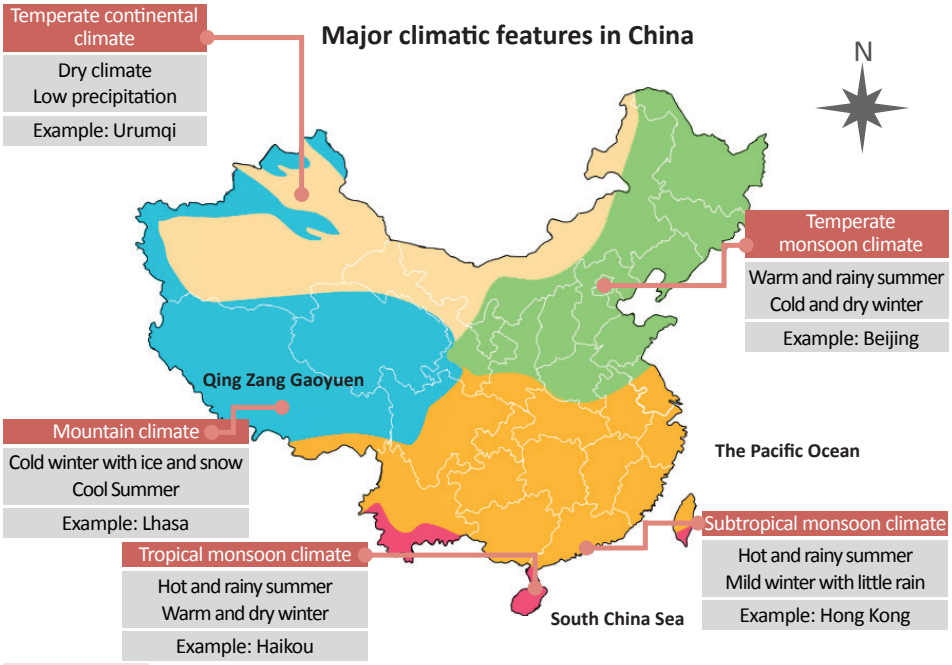


Fig 1.3 **Major climatic features in China**

Source: China Meteorological Administration

In winter, China is affected by the Asian high pressure system, with cold and dry prevailing northerly offshore winds. In summer, China is affected by the subtropical ridge of high pressure over the western North Pacific. The prevailing southerly airstreams generally bring warm, humid and rainy weather.

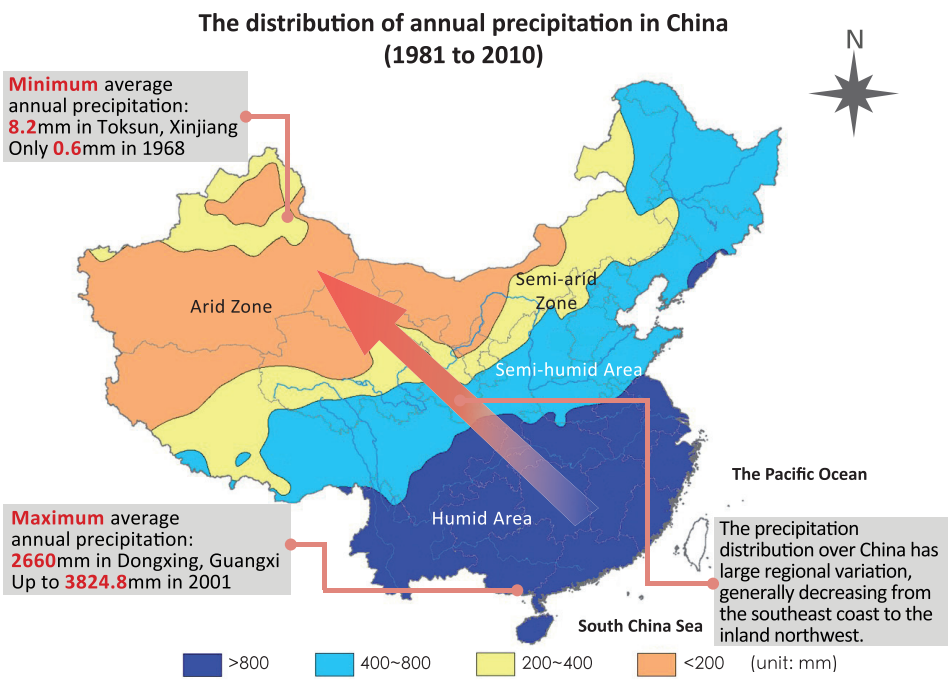


Fig 1.4 **The distribution of annual precipitation in China**

Source: China Meteorological Administration

What are the major climatic features in China?

More information

Climate in Hong Kong

Hong Kong's climate is sub-tropical, tending towards temperate for nearly half the year. During November and December there are pleasant breezes, plenty of sunshine and comfortable temperatures. Many people regard these as the best months of the year. January and February are cloudier, with occasional cold fronts followed by dry northerly winds. It is not uncommon for temperatures to drop below 10°C in urban areas. March and April are milder although there are occasional spells of high humidity, with fog and drizzle bringing about low visibilities. May to August are hot and humid with occasional showers and thunderstorms, particularly common during the mornings. There is usually a fine dry spell in July which may possibly last for one to two weeks, or even longer in some years. July and September are the months during which Hong Kong is most likely to be affected by tropical cyclones, although tropical cyclones are not unusual at any time between May and November.

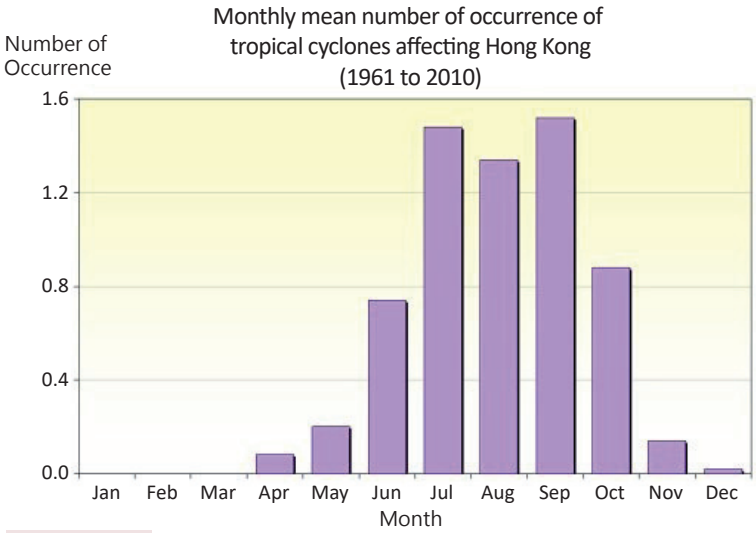


Fig 1.5 **Monthly mean number of occurrence of tropical cyclones affecting Hong Kong**

Source: HKO

The mean annual rainfall ranges from about 1,400mm at Ping Chau to more than 3,000mm in the vicinity of Tai Mo Shan. About 80% of the rain falls between May and September.

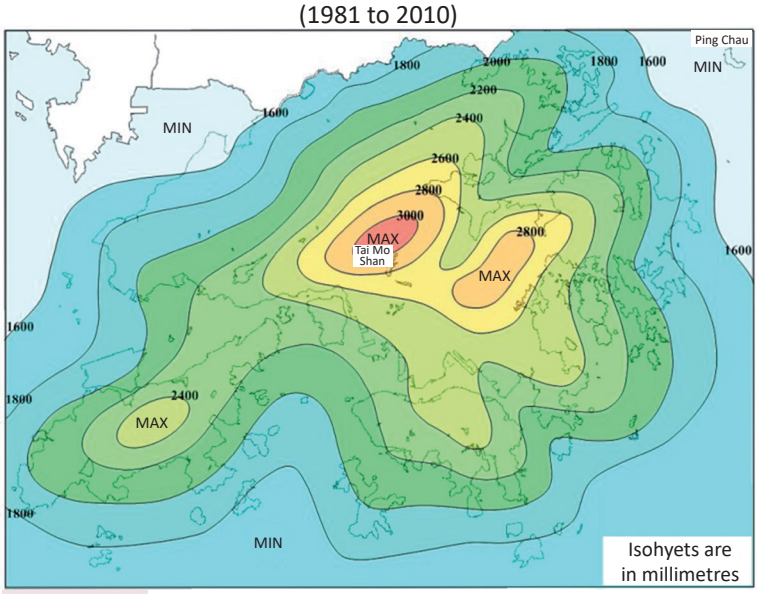


Fig 1.6 **Distribution of mean annual rainfall in Hong Kong**

Source: HKO

Climate in Hong Kong

More information

Monthly Weather Summary

More information

Climate Statistics

More information

7.1.4 The scientific evidence of climate change

A large number of studies have shown that the scientific evidence of climate change is overwhelming, and there is a clear scientific consensus among climate scientists. The scientific evidence of climate change is set out in the following.

(a) Increasing global surface temperature

The analyses of global temperature data from various meteorological institutions and research centres have reached the same conclusion that the average global temperature has been increasing significantly over the past hundred years. According to the WMO Statement on the State of the Global Climate in 2017[i], global mean temperature in 2017 was about 1.1°C above pre-industrial levels (Fig 1.7). Fig 1.8 shows almost every corner of the globe has experienced a warming trend over the past hundred years.

The latest global temperature trend

More information

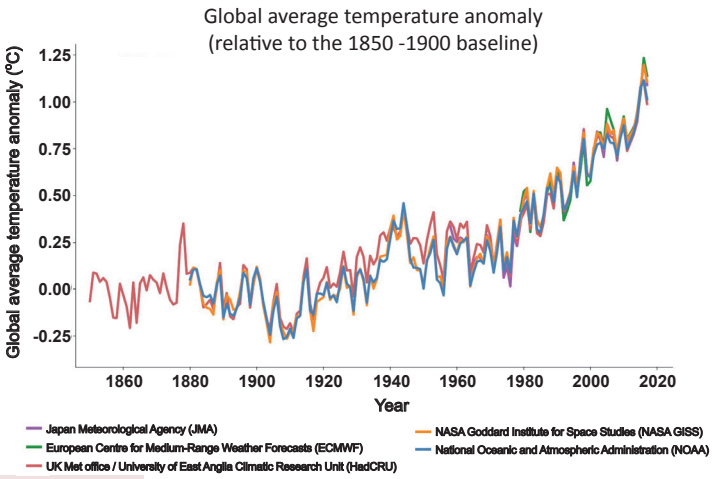


Fig 1.7 Global average temperature anomaly

Source:The WMO Statement on the State of the Global Climate in 2017

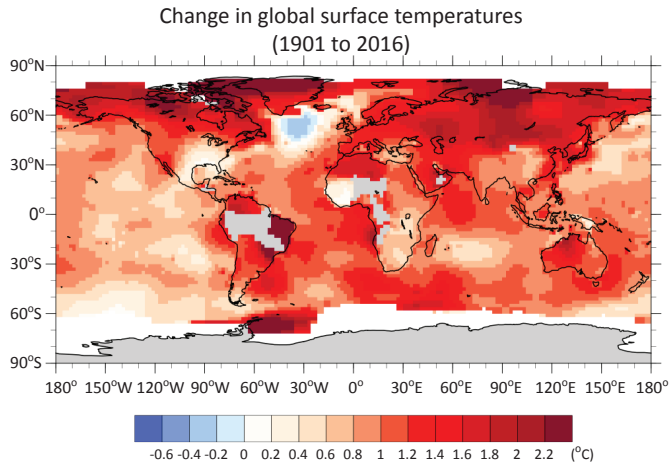


Fig 1.8 Change in global surface temperatures

Data source: NASA

How long has the global surface temperature been persistently higher than the 20th century average?

The reality of the inconvenient truth

More information

Why snowstorms and extremely cold weather still occur in some regions under global warming?

Cold events in a certain place at a certain time are just weather, and say nothing about climate. Against the backdrop of natural climate variability, global warming refers to the increase in global average temperature since the 20th century as a result of human activities. Snowstorms and extremely cold weather are parts of the natural climate variability and are not precluded by global warming. However, global warming has reduced the frequency of extremely cold events over the last few decades. The frequency of extremely cold events is expected to decrease further if global temperature keeps rising in the future.

Is global warming really at work?

More information

(b) Increase in sea surface temperature and ocean heat content

The ocean covers more than 70% of the Earth's surface. The heat capacity of ocean is much higher than that of land. Fig 1.9a and Fig 1.9b clearly show the long-term increasing trend of sea surface temperature and ocean heat content.

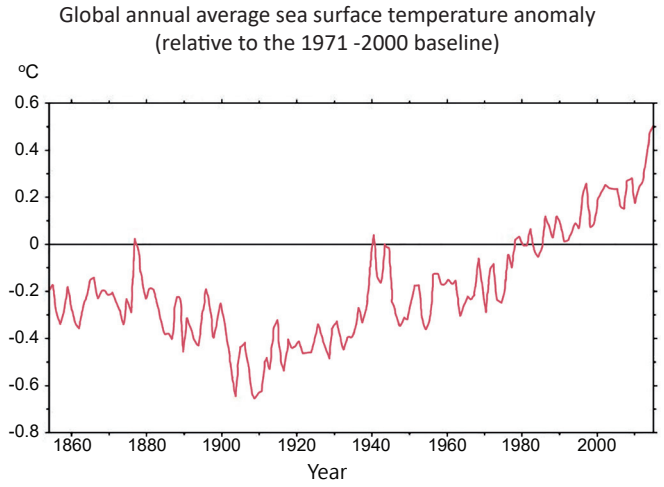


Fig 1.9a **Global annual average sea surface temperature anomaly[ii]**

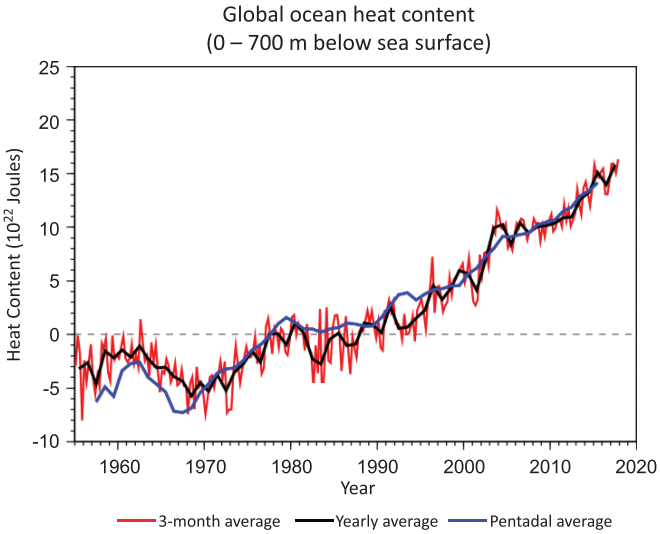


Fig 1.9b **Global ocean heat content[iii] (0 - 700m below sea surface)**

Source: US National Oceanic and Atmospheric Administration (NOAA)

Climate change: Ocean heat content

The ocean absorbs and stores energy from the Sun. If the ocean absorbs more heat than it releases, the heat content increases.

The latest ocean heat content

More information

Ocean heat as 'fuel' for tropical cyclones

More information

(c) Shrinking sea ice

Arctic sea ice is decreasing in all seasons. The decrease is particularly more prominent in summer. Studies have shown that the loss of Arctic summer sea ice over the past 30 years was unprecedented in the last 1,450 years.

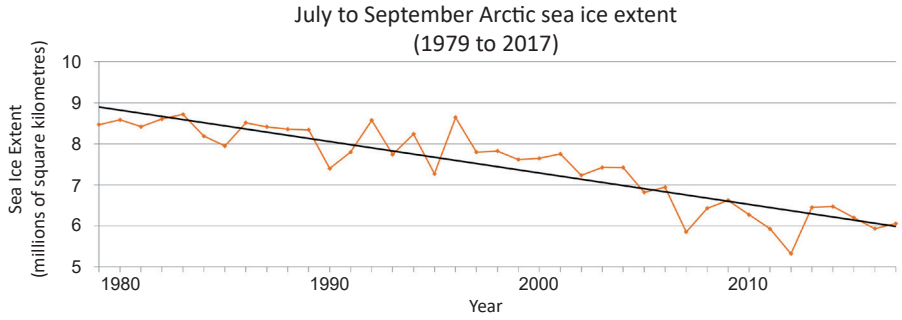


Fig 1.10 **July to September Arctic sea ice extent**

Data source: US National Snow and Ice Data Center (NSIDC)

The latest Arctic sea ice extent

More information

Although Antarctic sea ice extent has increased slightly over the past few decades, the overall global sea ice extent is on the decline. Antarctic sea ice extent exhibits large fluctuations in recent years and hit its lowest value ever recorded by satellites in early 2017.

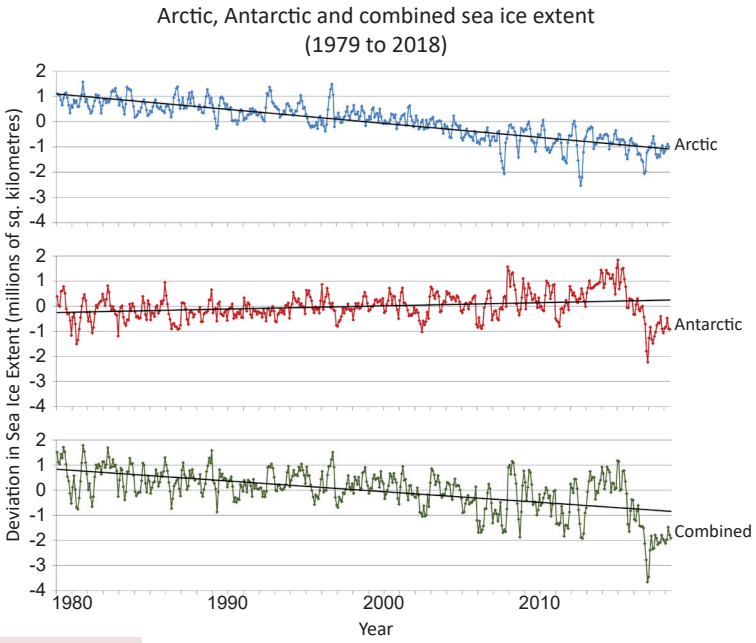


Fig 1.11 **Arctic, Antarctic and combined sea ice extent**

Data source: NSIDC

Disappearing Ice

More information

Changes of Antarctic sea ice extent from 31 August 2016 to 3 March 2017

More information

Fig 1.12 **Antarctic sea ice (2007)**

Source: Acaro[iv]

(d) Decrease in the Northern Hemisphere snow cover extent

Snow cover extent has decreased in the Northern Hemisphere, especially in spring.

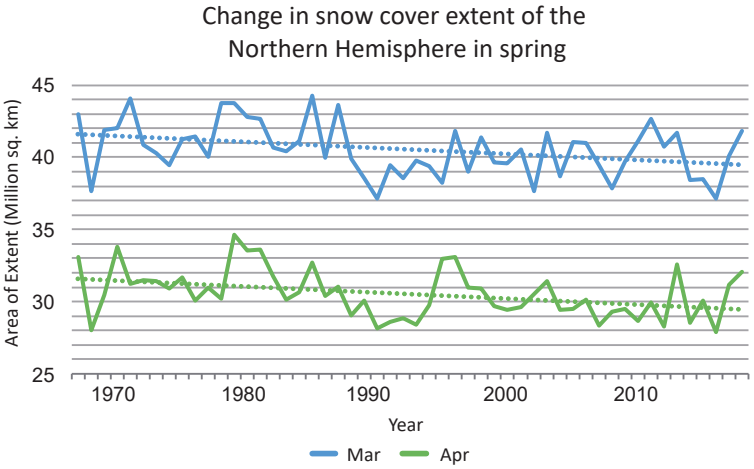


Fig 1.13 **Change in snow cover extent of the Northern Hemisphere in spring[v]**

Data source: Rutgers University

(e) Mass loss of ice sheets

The Greenland and Antarctic ice sheets are the two largest ice sheets on Earth. In recent years, scientists measure the ice mass variation of Antarctica and Greenland by tracking gravity changes on Earth with satellites. Mass loss of the Greenland ice sheet has accelerated since 1992. The average rate of ice loss has increased from 34 billion tonnes per year over the period of 1992 - 2001 to 215 billion tonnes per year over the period of 2002 - 2011.

The average rate of ice loss from the Antarctic ice sheet has increased from 30 billion tonnes per year over the period of 1992 - 2001 to 147 billion tonnes per year over the period of 2002 - 2011. The losses are mainly from the northern Antarctic Peninsula and the Amundsen Sea sector of West Antarctica.

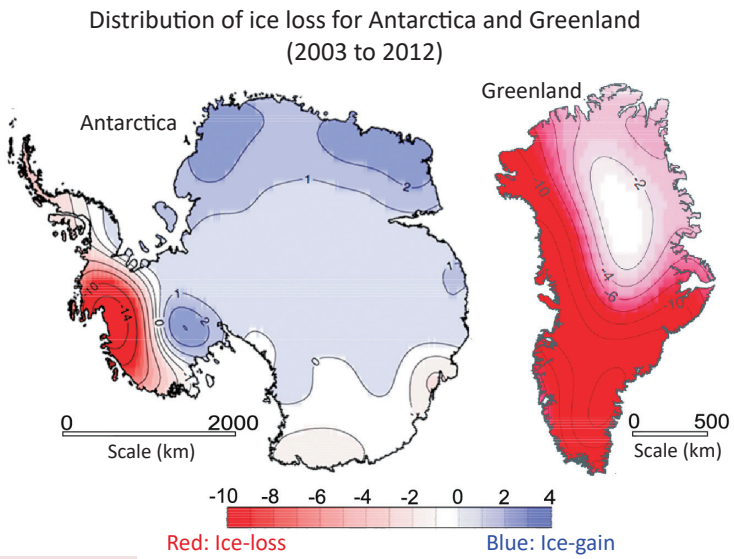


Fig 1.14 **Distribution of ice loss for Antarctica and Greenland**

Source: The Fifth Assessment Report of IPCC

The latest mass variation of Antarctic and Greenland ice sheets

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Ice losses from Antarctica have tripled since 2012, accelerating global sea level rise

More information

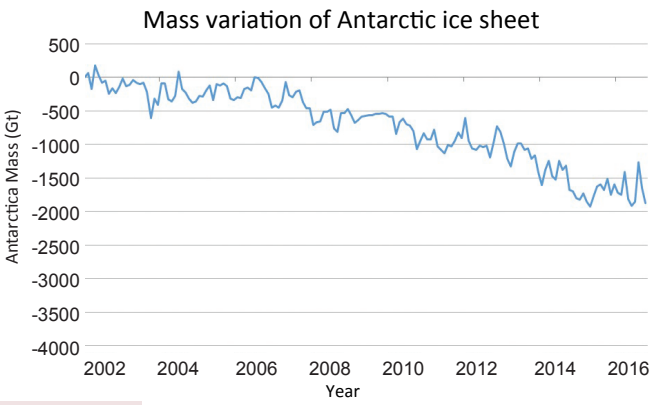


Fig 1.15a **Mass variation of Antarctic ice sheet**

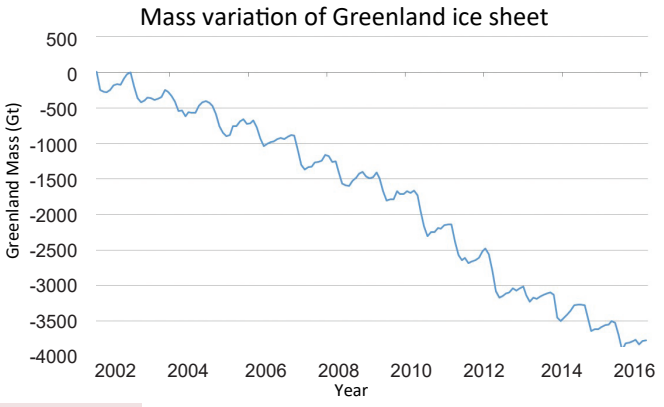


Fig 1.15b **Mass variation of Greenland ice sheet**

Data source: NASA

(f) Retreating glaciers

Report of World Glacier Monitoring Service (WGMS) indicates that the overall mass balance of glaciers in the world has continued to shrink for about 40 years. The mean annual mass balance of global glaciers has been persistently negative since 1980[vi].

Latest glacier mass balance

More information

The film "Chasing Ice" captured the largest glacier calving event in Greenland

More information

Fig 1.16 **Columbia Glacier, Alaska (upper photo: 2009, lower photo: 2015)**

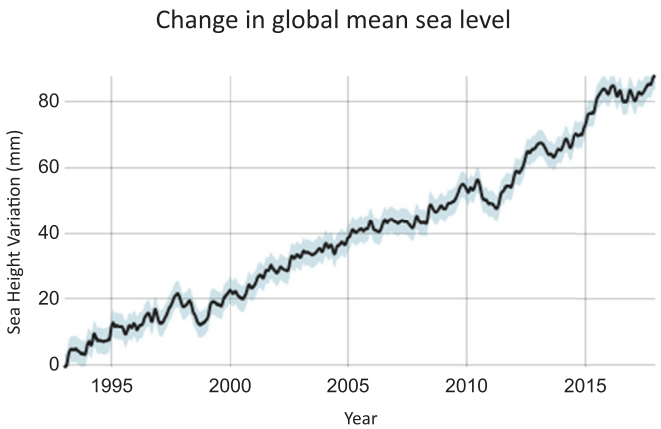
Source: James Balog and the Extreme Ice Survey

(g) Sea level rise

Seawater expands when it warms and melting land-based ice and snow adds water to the oceans, resulting in global sea level rise. As shown in Fig 1.17a, satellite data clearly shows the rise of global sea level over the past 20 years. Fig 1.17b, extracted from the Fifth Assessment Report of IPCC, shows that the rate of global sea level rise during the satellite altimetry era is nearly twice the average rate over the 20th century, which, in turn, is much higher than the average rate over the last two millennia.

Latest sea level

More information



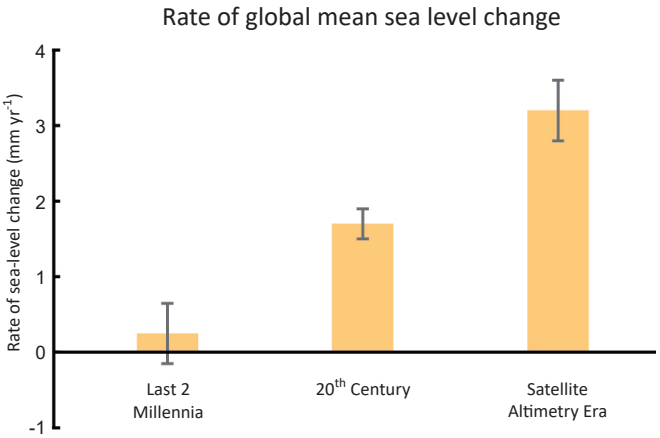


Fig 1.17a **Change in global mean sea level**[vii]

Source: NASA

Fig 1.17b **Rate of global mean sea level change**[viii]

Source: The Fifth Assessment Report of IPCC

(h) More frequent extreme weather events

Climate change leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather events. According to the Fifth Assessment Report of IPCC, the numbers of warm days and nights have increased globally since 1950 while the numbers of cold days and nights have decreased. Most land areas have experienced more heat waves since the middle of the 20th century. More land regions experience increase in heavy precipitation events.

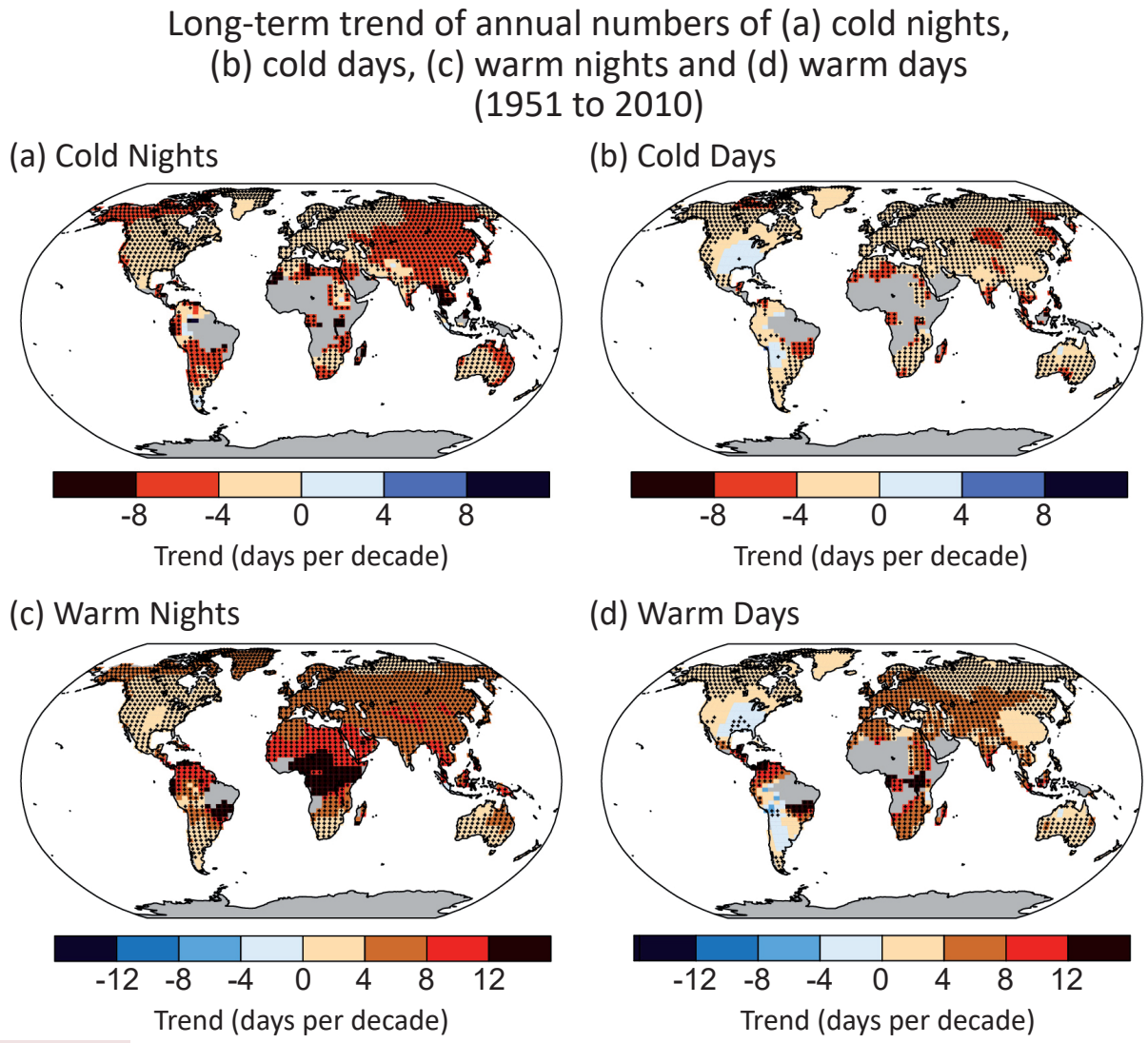


Fig 1.18 **Long-term trend of annual numbers of (a) cold nights, (b) cold days, (c) warm nights and (d) warm days**[ix]

Source: The Fifth Assessment Report of IPCC

Both the Fourth and Fifth Assessment Reports of IPCC confirmed that warming of the climate system was unequivocal.

What is IPCC?

The Intergovernmental Panel on Climate Change (IPCC), established under the auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), is a scientific body tasked to evaluate the risk of climate change caused by human activities.

Climate change is a very complex issue. Policymakers need an objective source of information about the causes of climate change, its potential environmental and socio-economic consequences, and the adaptation and mitigation options to respond to its impacts. This is the key motivation behind the establishment of IPCC in 1988 as the authority on climate change.

The main activity of IPCC is the compilation of assessment reports on a regular basis. The First Assessment Report in 1990 played a decisive role in the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The Second Assessment Report in 1995 provided key input to the negotiations of the Kyoto Protocol. The Third Assessment Report in 2001 and a number of special reports provided relevant information for the development of the UNFCCC and the Kyoto Protocol. The Fourth Assessment Report in 2007 confirmed that warming of the climate system was unequivocal. The Fifth Assessment Report in 2013 reaffirmed this finding and concluded that it was extremely likely that human influence had been the dominant cause behind the observed warming since the mid-20th century.

7.2 What are the causes of global warming?

7.2 Causes – What are the causes of global warming?

Summary

To understand the causes of climate change, we have to first understand the factors affecting the Earth's temperature, then identify whether they are natural or human-caused.

There are three factors affecting the Earth's temperature, namely, the solar radiation reaching the Earth, Earth's albedo and atmospheric concentration of greenhouse gases. This section explains the working principles of these factors and how scientists draw the conclusion of man-made climate change.

What is global warming? What is climate change?

"Global warming" and "climate change" are closely related, but the latter has a broader meaning than the former.

"Global warming" refers to the temperature increase of the entire Earth since the early 20th century due to burning fossil fuels since the Industrial Revolution. According to the World Meteorological Organization (WMO) Statement on the State of the Global Climate in 2017, the global mean temperature in 2017 was about 1.1 °C above pre-industrial levels.

"Climate change" refers to a broad range of global phenomena created by burning fossil fuels which increases atmospheric concentration of greenhouse gases. These phenomena include "global warming", sea level rise, mass loss of the Greenland and Antarctic ice sheets, diminishing Arctic sea ice, glaciers retreat, more frequent extreme weather events as well as changes in phenology.

7.2.1 Factors affecting the Earth's temperature

The Sun is the Earth's primary source of energy.

As shown in Fig 2.1, solar radiation reaches the Earth in the form of **shortwave radiation**. After going through a number of physical processes including reflection, absorption, evaporation, conduction, convection and radiation, some of the energy is directly reflected back to space, some is distributed to different Earth systems, e.g. atmosphere, ocean, land and ice sheet, and some is radiated back to space in the form of **longwave radiation**.

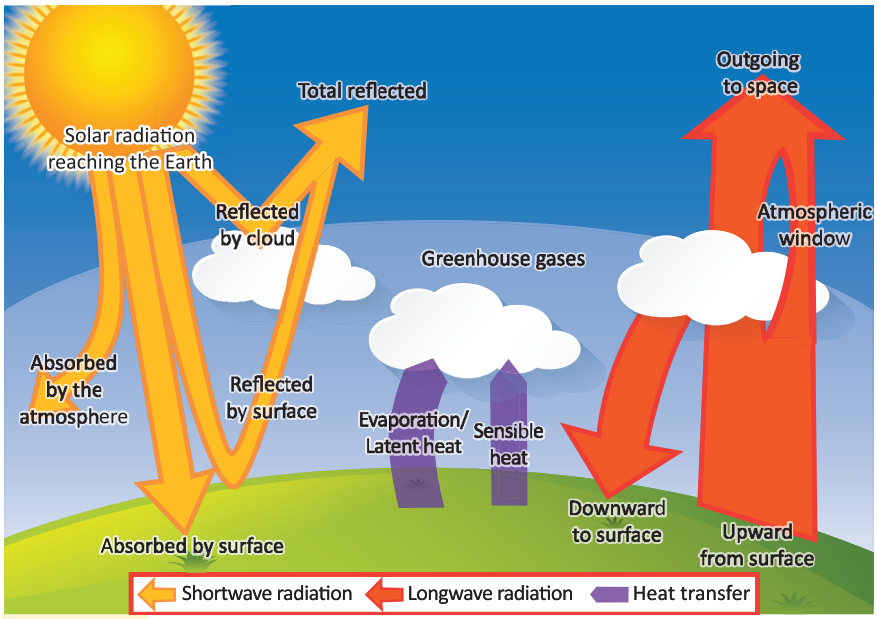


Fig 2.1 **Earth's energy budget**[i]

If the energy reaching the Earth is more than the energy leaving the Earth, positive energy imbalance will result and the Earth will warm.

If the energy reaching the Earth is less than the energy leaving the Earth, negative energy imbalance will result and the Earth will cool.

There are three factors affecting the Earth's temperature, namely, the solar radiation reaching the Earth, Earth's albedo and atmospheric concentration of greenhouse gases.

		? Find from the content	
Solar radiation reaching the Earth	Solar activity	Has solar activity increased or decreased in recent years?	The strength of solar activity affects the output of solar energy.
	Earth's orbit	How does it relate to the solar radiation reaching the Earth?	The Earth's orbit around the Sun changes throughout the time. Orbital changes affect the distance between the Earth and the Sun, altering the amount of solar radiation reaching the Earth.
Albedo	Surface	Among ocean, sea ice, snow, which surface reflects the most solar radiation?	Sea ice and snow are highly reflective. Hence the change in ice and snow cover plays an important role in affecting the Earth's climate.
	Suspended particulates in atmosphere	Do volcanic eruptions increase albedo?	Increase in cloud amount or suspended particulates in the atmosphere will reflect more solar radiation back to space, reducing the amount of heat absorbed by the Earth.
Atmospheric concentration of greenhouse gases	Natural carbon cycle	In an unperturbed natural carbon cycle, what is the atmospheric concentration of carbon dioxide?	Many greenhouse gases occur naturally in the atmosphere. Greenhouse effect keeps the Earth warm, enabling many species to flourish.
	Human activities	What human activities increase atmospheric concentration of greenhouse gases?	If the Earth had no atmosphere, laws of physics suggest that the average surface temperature of the Earth would be around -18°C. However, increases in the atmospheric concentration of greenhouse gases will intensify the greenhouse effect, resulting in global warming.

Fig 2.2 **Factors affecting the Earth's temperature**

7.2.2 Solar radiation

Is solar activity responsible for global warming?

Fluctuations in solar activity are natural. Satellite-based instruments have been measuring the amount of solar energy reaching the top of the atmosphere (also known as total solar irradiance, or TSI in short) since the late 1970s. The average value of TSI is found to be about 1,361 W/m^2.

While solar activity follows a cycle of roughly 11 years, the average fluctuation of TSI over the past several solar cycles is only about 0.1%. For pre-satellite times, TSI variations had to be estimated from sunspot numbers or radioisotope analysis of polar ice and tree rings.

As shown in Fig 2.3, both **total solar radiation** and **global mean temperature** showed upward trends in the early 20th century. However, **total solar radiation** showed a downward trend since the 1960's while **global mean temperature** continued to rise.

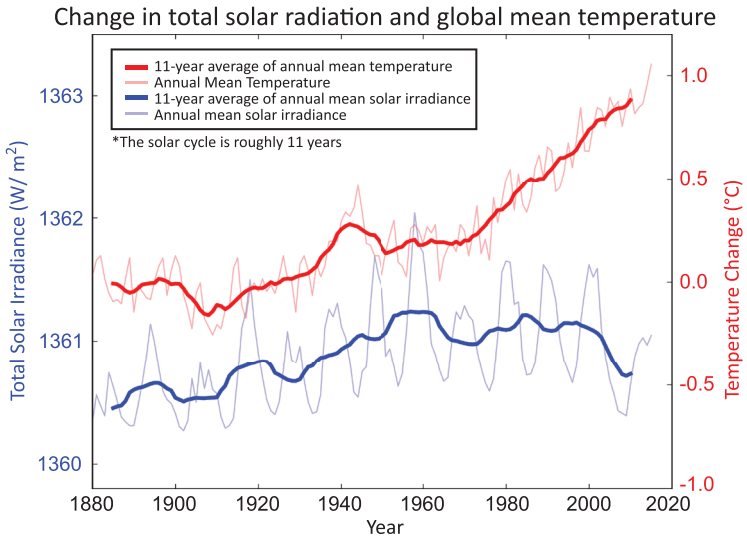


Fig 2.3 **Change in total solar radiation and global mean temperature**[ii]

Source: Skeptical Science

Teachers reference - Temperature variations in troposphere and stratosphere

If solar activity is the main cause of global warming, the temperature of the whole atmosphere will be affected. If global warming is mainly caused by greenhouse gases, the increase in greenhouse gases will raise the temperature in the lower troposphere but the lower stratosphere will cool. This is a distinctive characteristic of an intensifying greenhouse effect. Observations show that there is a long-term warming trend in the lower troposphere but a long-term cooling trend in the lower stratosphere.

IPCC WGI AR5, Chapter 2, Figure 2.24

Why the Sun is not responsible for recent climate change

7.2.3 Albedo

Light-coloured surfaces have higher albedo than dark-coloured ones. As shown in Fig 2.4, sea ice has a higher albedo than ocean. Snow has an even higher albedo than sea ice, reflecting around 90% of the incoming solar radiation. In cities, road surfaces with asphalt have low albedo and absorb more solar radiation.

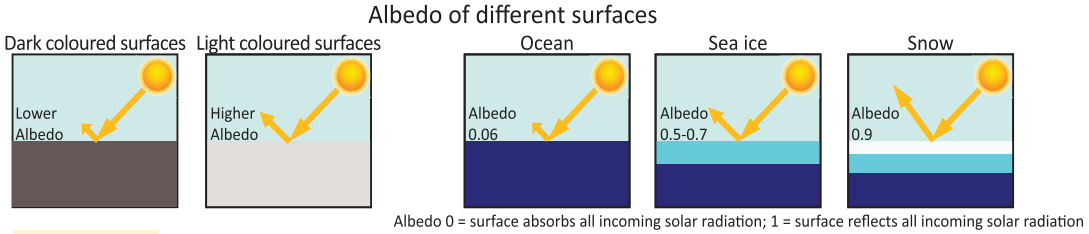


Fig 2.4 **Albedo of different surfaces**[iii]

Data source: National Snow and Ice Data Center (NSIDC)

Volcanic eruption

Volcanic eruption is a natural phenomenon which releases large amounts of gases, volcanic ash and aerosols to the atmosphere.

In small scale eruptions, the gases and aerosols are usually well contained in the troposphere, and will likely be washed out by rain within a couple of weeks. Powerful eruptions are capable of blasting gases and aerosols into the stratosphere. The aerosols will remain in the stable stratosphere for a couple of years. These additional aerosols increase Earth's albedo and cause a short-term cooling effect.

Volcanoes, weather and climate

More information

The eruption of Mount Pinatubo in the Philippines in 1991 is one of the examples of major volcanic eruptions leading to a decline in global average temperature. The eruption lowered the global average temperature by about 0.5°C in the following 18 months. However, the temperature returned to the pre-eruption level a few years later.

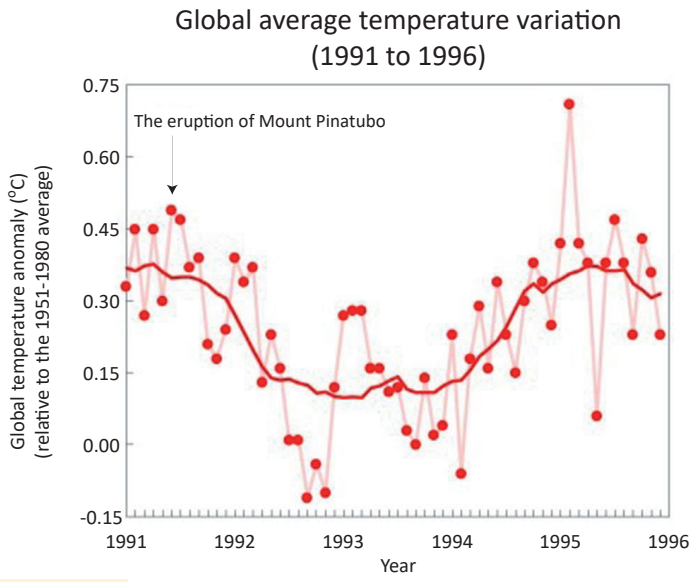


Fig 2.5a **Global average temperature variation[iv]**

Source: Hong Kong Observatory (HKO)

Fig 2.5b **The eruption of Mount Pinatubo in the Philippines**

Source: U. S. Geological Survey Photograph taken by Richard P. Hoblitt.

Earth's orbit (Milankovitch Cycles)

The Earth's orbit around the Sun changes throughout the time. There are also natural variations in the parameters of the Earth's rotation. In the early 20th century, Milutin Milankovitch, a Serbian astronomer, proposed that the coming and going of ice ages on Earth were closely related to three orbital geometric parameters of Earth's revolution around the Sun. The variations of these three parameters are referred as Milankovitch Cycles[v]. See Fig 2.6 for further details.

"Cool Met Stuff": Milankovitch Cycles

More information

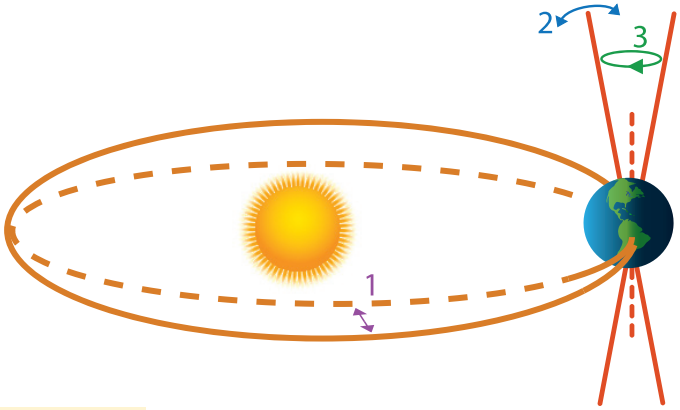


Fig 2.6 **Milankovitch Cycles**[vi]

1. Shape of Earth's orbit around the Sun	2. Earth's axial tilt	3. Precession of Earth's rotational axis
The first parameter is the shape of Earth's orbit around the Sun. The orbit changes from nearly circular to elliptical in a periodical manner. The whole cycle takes about 100,000 years. The orbital changes will affect the amount of solar energy reaching the Earth in different seasons.	The second parameter is the tilt of Earth's rotational axis. The axial tilt varies between 22.1° and 24.5° in a cycle of around 40,000 years. Changes in this parameter will not alter the total amount of solar energy reaching the Earth but will affect the latitudinal distribution of insolation.	The third parameter is the precession of Earth's rotational axis, i.e. the wobbling of Earth's axis. A full cycle of the wobbling takes about 26,000 years. Changes in this parameter will also affect the latitudinal distribution of insolation.

"Climate – Albedo" feedback

"Climate – Albedo" feedback means that the change in the Earth's albedo caused by climate change will further promote climate change, forming a vicious cycle.

The impact of the three parameters of Milankovitch Cycles on the amount of insolation reaching the high latitudes in the Northern Hemisphere, where most of the ice and snow on Earth are found, is particularly important. Variation in ice and snow cover can lead to a positive feedback.

For example, when the amount of insolation reaching the northern high latitudes decreases, summer heat is not sufficient to melt all the ice and snow precipitated in the preceding winter, leading to an overall increase of ice and snow in the course of the year. The increased ice and snow will reflect more sunlight back into space, thereby reducing the amount of heat absorbed by the Earth. This will set up a vicious cycle that supports the further growth of ice and snow.

The warming rate of the Arctic is twice the global average. Positive "climate – albedo" feedback is a major cause of this phenomenon.

Global warming has led to melting of ice and snow in the Arctic, exposing the darker and less reflective surfaces of ocean and land. The Arctic thus absorbs more solar energy, enhancing warming and promoting further melting of ice and snow in a vicious cycle.

Are Milankovitch Cycles responsible for recent climate change?

Milankovitch Cycles are natural variations with time scales of tens of thousands of years. It is difficult to explain the Earth's abrupt warming in the past hundred years by Milankovitch Cycles.

According to the Milankovitch Cycles, the Earth should be on a cooling trend in the present day. This prediction is consistent with the results of paleoclimate studies which revealed that the Earth was cooling slowly for five thousand years before the Industrial Revolution. However, this slow cooling trend spanning the past five thousand years was completely reversed by the abrupt warming in the recent century.

An ever-extending hockey stick

More information

7.2.4 Greenhouse gases

Greenhouse effect

Greenhouse gases such as carbon dioxide, methane, nitrous oxide occur naturally in the atmosphere. Greenhouse gases absorb part of the infrared radiation emitted from the Earth and then re-radiate the energy in all directions, also in the form of infrared radiation. Part of the infrared radiation goes back to the Earth, heating up the surface. This is known as the greenhouse effect.

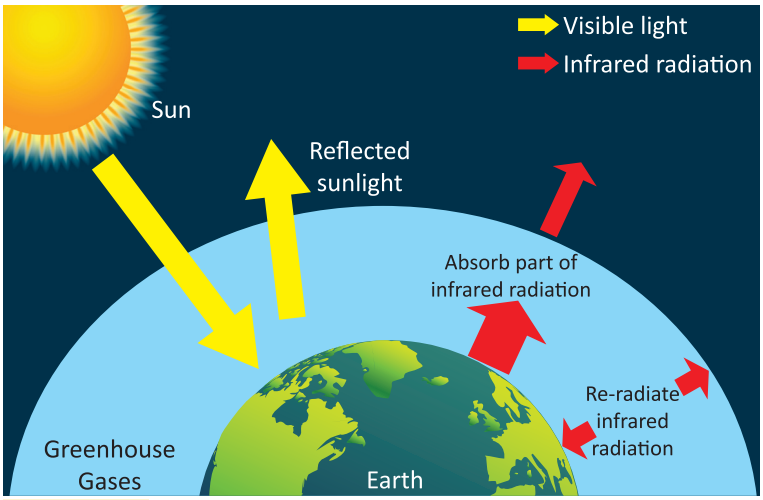


Fig 2.7 Greenhouse effect

Carbon cycle

Carbon cycle is a biogeochemical cycle in which carbon is continuously exchanged and recycled among several natural reservoirs, including atmosphere, ocean, biosphere, rocks and fossil fuels, where carbon is stored.

In an unperturbed natural carbon cycle, these exchanges between reservoirs are approximately balanced.

Carbon cycle

More information

? In the last 800,000 years before the Industrial Revolution, the atmospheric concentration of carbon dioxide fluctuated roughly between 180 and 280 ppm[1]. However, human activities have disturbed the global carbon cycle. The present-day atmospheric concentration of carbon dioxide has exceeded 400 ppm, unprecedented in the past 800,000 years. And the concentration keeps on rising.

1 ppm stands for "parts per million"

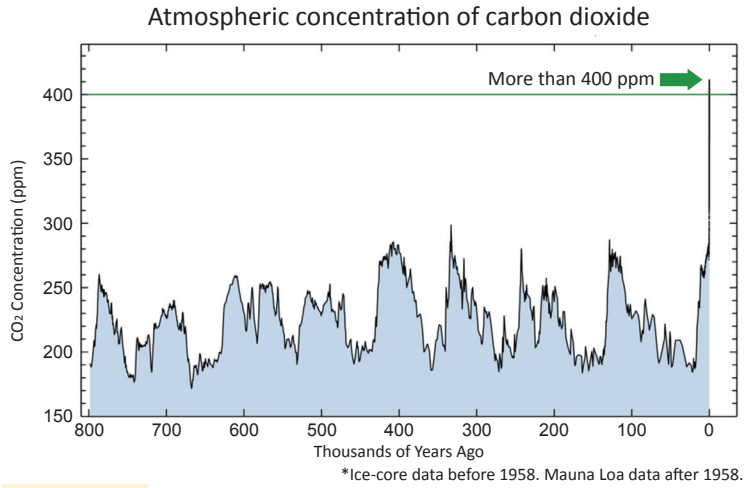


Fig 2.8 **Atmospheric concentration of carbon dioxide**[vii]

Source: Scripps Institution of Oceanography

Global carbon dioxide concentration

More information

History of atmospheric concentration of carbon dioxide

More information

Animation of atmospheric carbon dioxide

More information

What human activities increase greenhouse gases

Human activites emit huge amount of greenhouse gases to the atmosphere, enhancing the greenhouse effect to trap more energy on Earth and leading to global warming.

Major greenhouse gases emitted by human activities

Greenhouse Gases	Human Activities
Carbon Dioxide (CO_2)	- Burning fossil fuels - Deforestation - Use of machineries - Cement production - Waste incineration
Methane (CH_4)	- Burning fossil fuels - Pastoral farming - Rice farming - Waste incineration - Waste decomposition
Nitrous Oxide (N_2O)	- Burning fossil fuels - Using nitrogen fertilizers - Nylon production - Waste incineration

Table 2.1 **Major greenhouse gases emitted by human activities**

(a) Burning fossil fuels

Fossil fuels include coal, oil and natural gas. Humans have been burning massive amount of fossil fuels for many purposes since the Industrial Revolution, such as power generation, heating and powering machines and vehicles. Large amounts of carbon dioxide, methane and nitrous oxide are emitted to the atmosphere.

(b) Deforestation

To acquire land for agricultural and urban development, forests are cut down or burned on a massive scale. Carbon dioxide is released from the burning process. Moreover, plants capable of absorbing and storing carbon dioxide decrease, resulting in increasing atmospheric concentration of carbon dioxide. Data[viii] show that around 140 million hectares of forest are lost globally for 1990-2015.

(c) Agricultural activities

Pastoral farming emits a lot of methane, e.g. cows ruminating, and so does rice farming. The use of large amounts of nitrogen fertilizers releases nitrous oxide. Moreover, agricultural machineries are mostly powered by fossil fuels and therefore contribute to carbon dioxide emission.

(d) Industrial activities

Industrial activities emit large amount of greenhouse gases. For example, the production of nylon releases nitrous oxide and the production of cement releases carbon dioxide. Chlorofluorocarbons (CFCs), which were developed and used as refrigerants and aerosol propellants in the past century, are also greenhouse gases.

Chlorofluorocarbons (CFCs)

More information

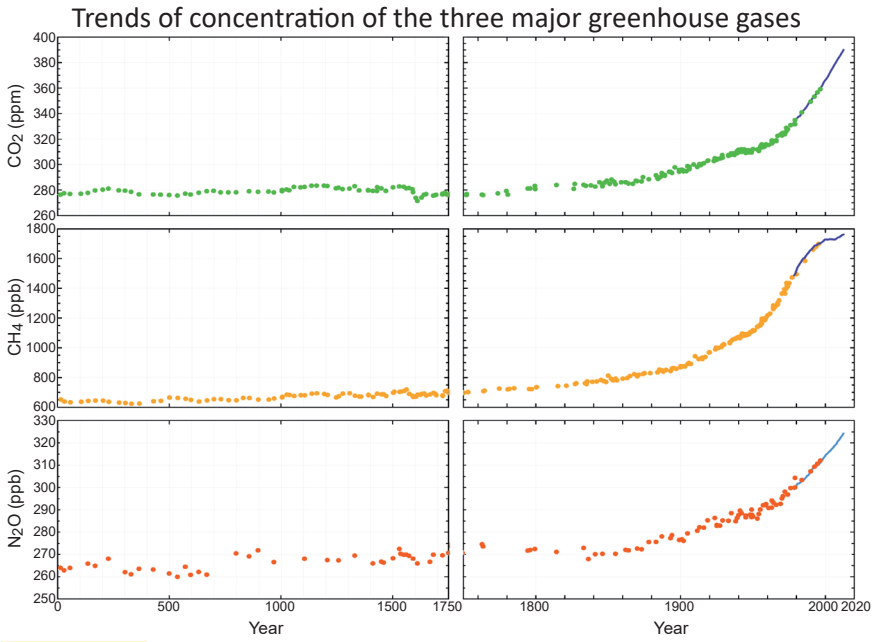
(e) Waste treatment

With improving living standard and the rise of consumerism, humans consume resources and produce large amounts of waste as well. Wastes are treated by either incineration or landfilling. The incineration process produces carbon dioxide, methane and nitrous oxide while waste decomposition in landfills produces methane.

Since 1750, the atmospheric concentration of carbon dioxide has increased by more than 40%. Methane and nitrous oxide have increased by about 160% and 20% respectively.

Do volcanoes emit more carbon dioxide than human activities?

One of the natural factors affecting the climate is volcanic eruptions as large amount of gases and particles can be released to the atmosphere. However, various studies have shown that, in the last century, the annual amount of carbon dioxide released by human activities far exceeded that released by terrestrial and submarine volcanoes. Latest data shows human activities emit 60 times or more the amount of carbon dioxide released by volcanoes each year.



The latest global CO_2 concentration

More information

WMO Greenhouse Gas Bulletin

More information

Fig 2.9 Trends of concentration of the three major greenhouse gases[ix]

Note: ppm and ppb stand for "parts per million" and "parts per billion" respectively

Source: The Fifth Assessment Report of IPCC

7.2.5 Is global warming natural or human-caused?

After synthesizing the results of numerous studies and related data, Fig 2.10 shows the Earth's energy budget under present-day conditions. The **positive imbalance in the Earth's energy budget is around 0.6 W/m²**, which leads to global warming.

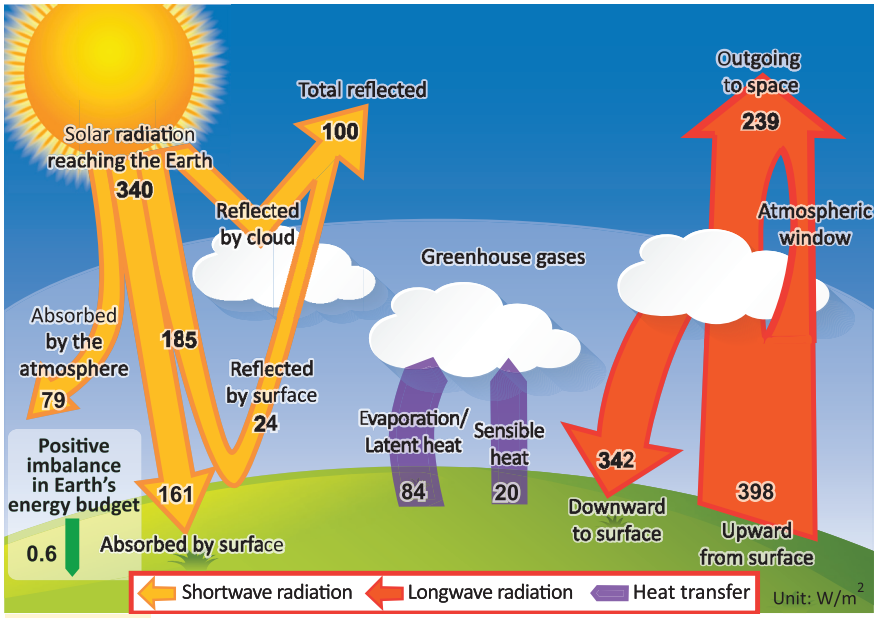


Fig 2.10 **Earth's energy budget under present-day conditions**[x]

Data source: The Fifth Assessment Report of IPCC

What's really warming the world?

More information

Why is there an imbalance in the Earth's energy budget? Scientists use computer climate models to simulate the change in global surface temperature in the past hundred years. Fig 2.11 shows the simulation results of temperature anomaly (relative to the average of 1880-1919) under different situations.

There are significant differences between model simulations and actual observations and climate models would not be able to reproduce the observed warming if **only natural factors** such as the changes in the Earth's orbit, solar activity and volcanic activity are considered. However, model simulations match with actual observations when **both human and natural factors** are considered, including the changes in greenhouse gas concentration, land use and man-made pollution.

The Fifth Assessment Report of IPCC clearly points out that it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.

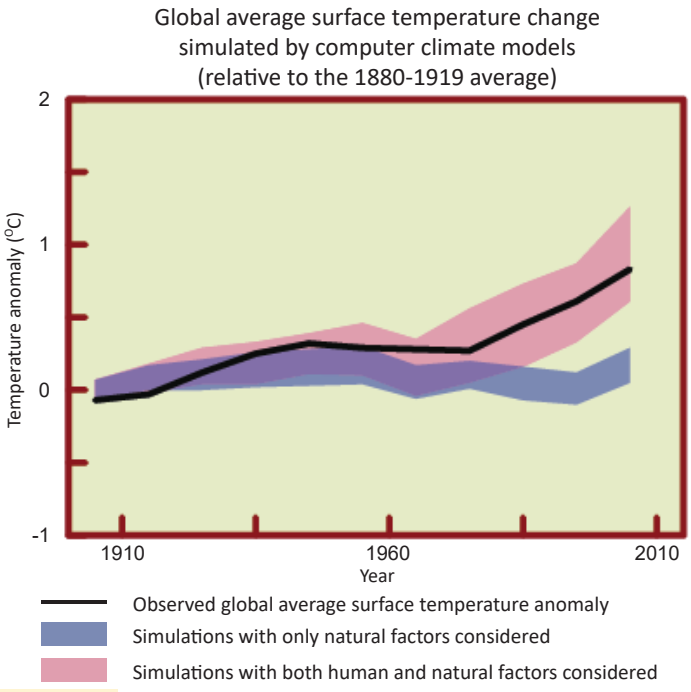


Fig 2.11 **Global average surface temperature change simulated by computer climate models**[xi]

Source: The Fifth Assessment Report of IPCC

Radiative forcing

Scientists use the parameter "radiative forcing" to quantify the contribution of factors affecting global temperature. **Positive radiative forcing** indicates that the factor causes a positive imbalance in the Earth's energy budget and hence warming of the Earth. **Negative radiative forcing** indicates that the factor causes a negative imbalance in the Earth's energy budget and hence cooling of the Earth.

As shown in Fig 2.12, carbon dioxide has the highest **positive radiative forcing**, followed by methane. Human activities such as changing land uses and releasing aerosols to the atmosphere will cause an increase in albedo, leading to negative radiative forcing. The net human-caused radiative forcing is positive, far greater than the contribution of solar activities.

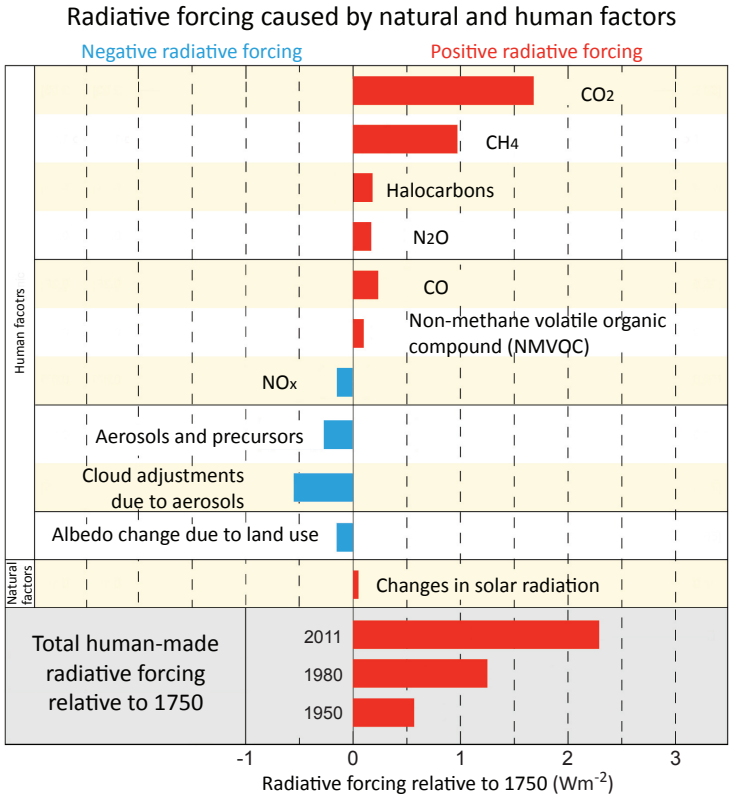
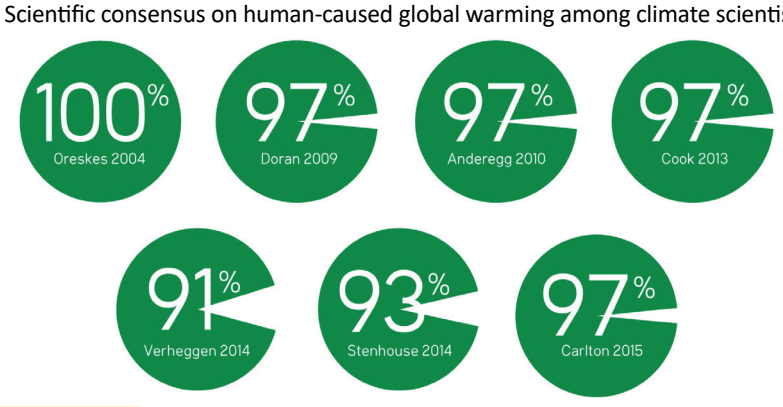


Fig 2.12 **Radiative forcing caused by natural and human factors**[xii]

Source: The Fifth Assessment Report of IPCC

The 97% scientific consensus

Over the past 20 years, many studies examined the consensus on human-caused global warming among climate scientists. The scientific consensus was found to be between 90% and 100%.



Are you aware of the scientific consensus on global warming?

More information

Fig 2.13 **Scientific consensus on human-caused global warming among climate scientists**[xiii]

Source: Skeptical Science

In The Consensus Project[xiv] released in 2013, researchers examined the abstracts of more than 10,000 peer-reviewed scientific papers in the past 20 years and found 97% of the papers expressing a position endorsing the human-caused global warming assessment.

Assessment Reports of Intergovernmental Panel on Climate Change (IPCC)

IPCC publishes assessment reports every several years, summarizing the results of scientific researches worldwide. The assessment reports represent the scientific consensus on climate change. IPCC has published five assessment reports since 1990. The main conclusions are as follows. (See teaching kit 7.1 "Scientific evidence of climate change" for more information about IPCC)

1990

The First Assessment Report

- Global mean surface temperature has increased by 0.3°C to 0.6°C over the last 100 years
- The size of this warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural climate variability

1995

The Second Assessment Report

- The balance of evidence suggests that there is a discernible human influence on global climate

2001

The Third Assessment Report

- The warming over the past 100 years is very unlikely (1-10% chance) to be due to internal variability alone
- Most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations

2007

The Fourth Assessment Report

- Warming of the climate system is unequivocal
- Most of the observed increase in global average temperature since the mid-20th century is very likely (>90% chance) due to the observed increase in human-caused greenhouse gas concentrations

2013

The Fifth Assessment Report

- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia
- It is extremely likely (95-100% chance) that human influence has been the dominant cause of the observed warming since the mid-20th century

Global warming: Clear and Present Danger (1)

More information

7.3 Climate change in Hong Kong?

7.3 Hong Kong is no exception - Climate change in Hong Kong?

Summary

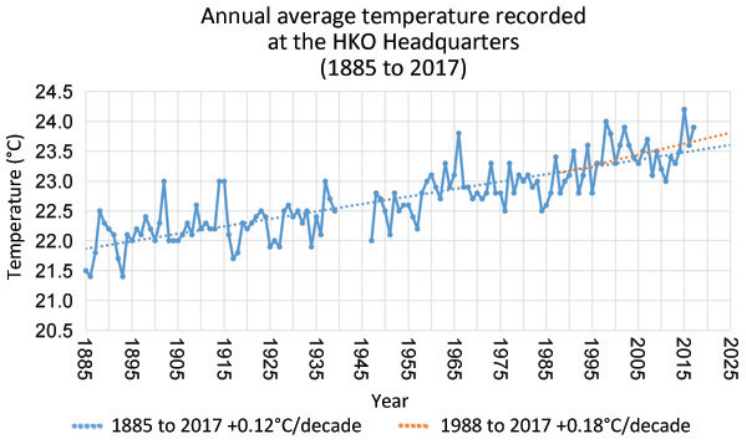
Hong Kong is not exempted from the impacts of climate change. In line with the global trends, Hong Kong records more hot weather, more extreme rainfall and sea level continues to rise. With Hong Kong gradually developing into a densely populated city, urban development also plays a role in affecting the climate of Hong Kong.

7.3.1 Climate change in Hong Kong

The Hong Kong Observatory (HKO) has been conducting meteorological observations since 1884 except for the Second World War during 1940-1946. The HKO possesses more than 130 years of meteorological observation records which are important references for climate change researches in Hong Kong.

(a) Temperature rise

Fig 3.1 shows a long-term ascending trend of the annual average temperature in Hong Kong. For the past hundred years, the annual average temperature increased at a rate of about 0.12°C per decade. The increase has become more significant in the later half of the 20th century.



Latest temperature trend

More information

Fig 3.1 **Annual average temperature recorded at the HKO Headquarters**[i]

Data source: HKO

(b) More very hot days but fewer cold days

The number of hot nights (with a daily minimum temperature of 28°C or above) and very hot days (with a daily maximum temperature of 33°C or above) have increased by about 35 times and 6 times respectively over the last hundred years or so. On the contrary, the number of cold days (with a daily minimum temperature of 12°C or below) has decreased.

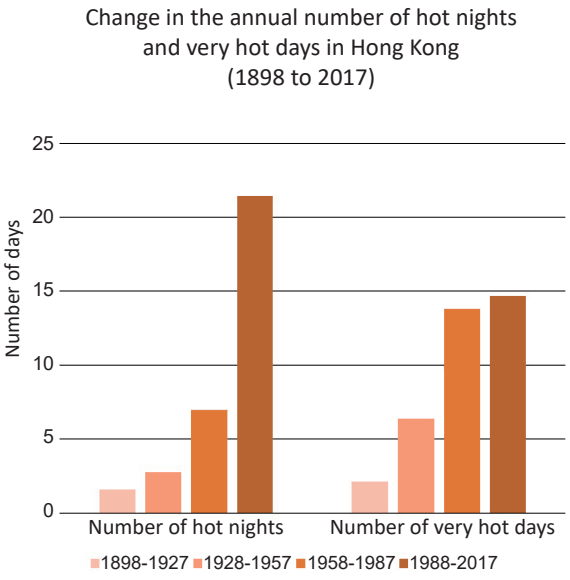


Fig 3.2a **Change in the annual number of hot nights and very hot days in Hong Kong[ii]**

Data source: HKO

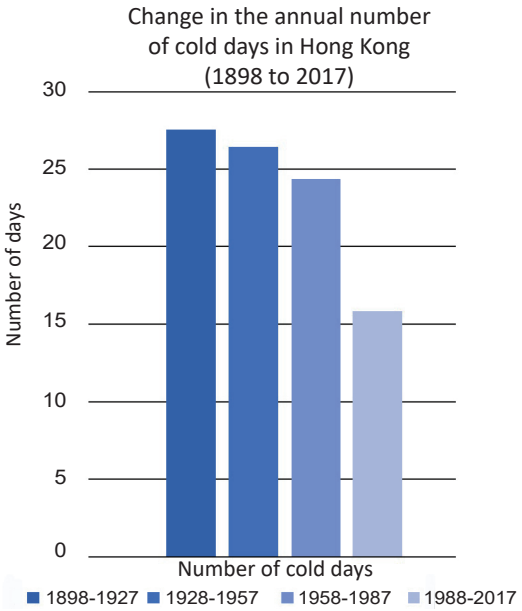


Fig 3.2b **Change in the annual number of cold days in Hong Kong**

Data source: HKO

(c) More frequent extreme rainfall

Extreme rainfall events have become more frequent. The hourly rainfall record at the HKO Headquarters was usually broken once per decade in the past, but it was repeatedly broken in recent decades. The latest record of the highest hourly rainfall at the HKO Headquarters was 145.5mm in 2008. A more sophisticated analysis shows that the chance of an extreme rainfall event with hourly rainfall of 100 mm or more has doubled over the last century.

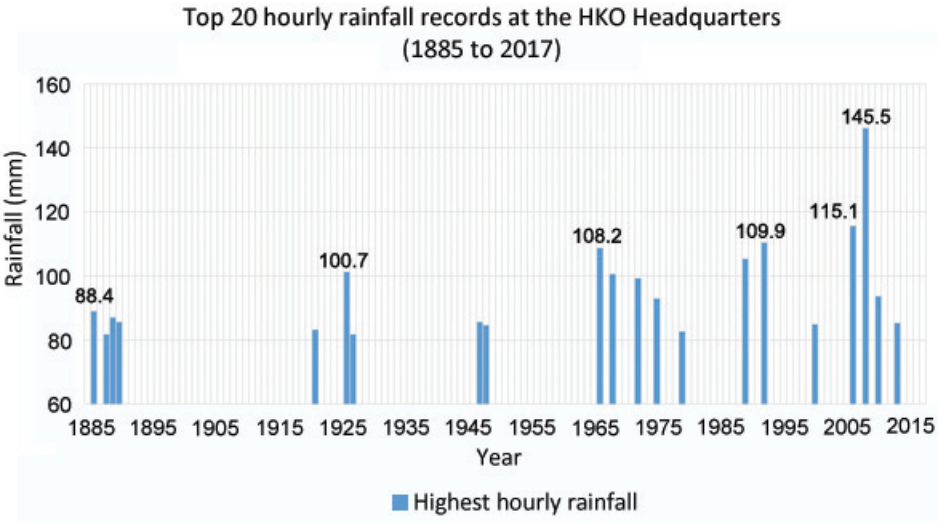


Fig 3.3 **Top 20 hourly rainfall records at the HKO Headquarters[iii]**

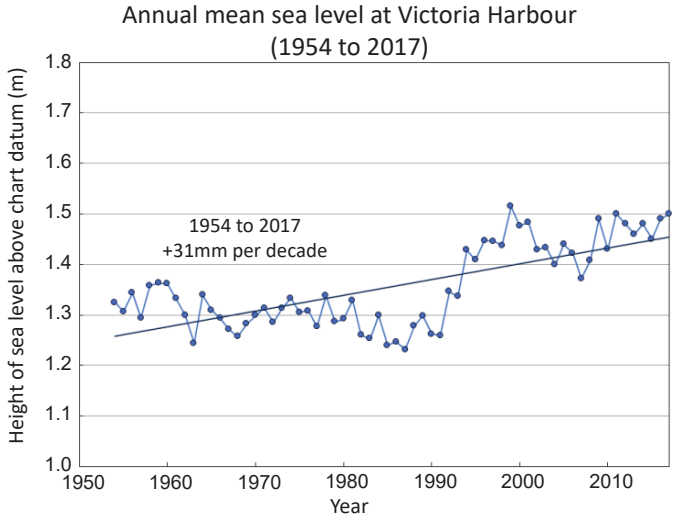
Data source: HKO

Extreme weather events

More information

(d) Sea level rise

Tide gauge records in Victoria Harbour since 1954 indicated an obvious rise of the mean sea level. On average, the mean sea level in Victoria Harbour rose at a rate of about 31 mm per decade in the past 60 years or so.



Latest mean sea level trend

More information

Fig 3.4 **Annual mean sea level at Victoria Harbour[iv]**

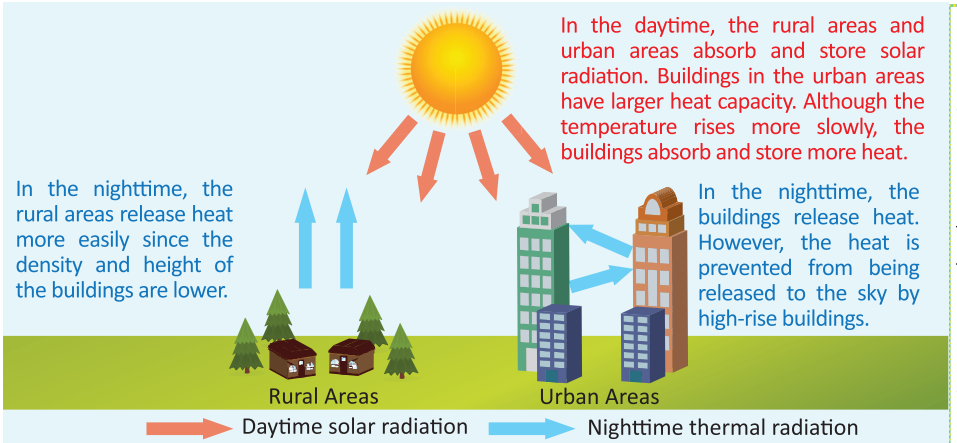
Source: HKO

7.3.2 How does urban development affect the climate of Hong Kong?

Both global warming and local urban development affect the climate of Hong Kong. According to researches from the HKO, urban development is one of the factors causing Hong Kong's warming trend and the contribution could be up to 50%.

Urban heat island effect

Owing to urban development, the cooling rate of the urban areas has gradually become lower than that of the rural areas, causing the average temperature in the urban areas to be generally higher than that in the rural areas. This phenomenon is called the urban heat island effect. Urban development includes land use changes, dense building development, heat emissions and human activities. Fig 3.5 shows the causes of the urban heat island effect.



- Buildings in the urban areas have higher heat capacity, absorbing and storing more solar radiation.
- High-density and tall buildings block the view of the sky, reducing the amount of heat released to the sky.
- A lot of heat is emitted from buildings, air conditioners, vehicles and industrial activities in the urban areas.
- High-density buildings reduce wind speed and cooling rate.

Fig 3.5 **Impact of urban development on the heat balance in the urban areas[v]**

In Hong Kong, the urban heat island effect is primarily a nighttime phenomenon, which is more significant in winter, especially with a stable atmosphere, light breezes and clear skies. Fig 3.6 shows an example in 2010. Under the influence of a continental airstream over southern China, the weather in Hong Kong was mainly fine on 17 December 2010. Light winds at night enhanced radiation cooling, bringing the temperature at Ta Kwu Ling down to a minimum of 0.2°C in the early morning on 18 December. Affected by urban development, the nocturnal cooling in the urban areas was much slower than that in the rural areas and the minimum temperature at the HKO Headquarters in Tsim Sha Tsui was 10.7°C, more than 10°C higher than that at Ta Kwu Ling.

The daily minimum temperatures from urban to rural areas on 18 December 2010

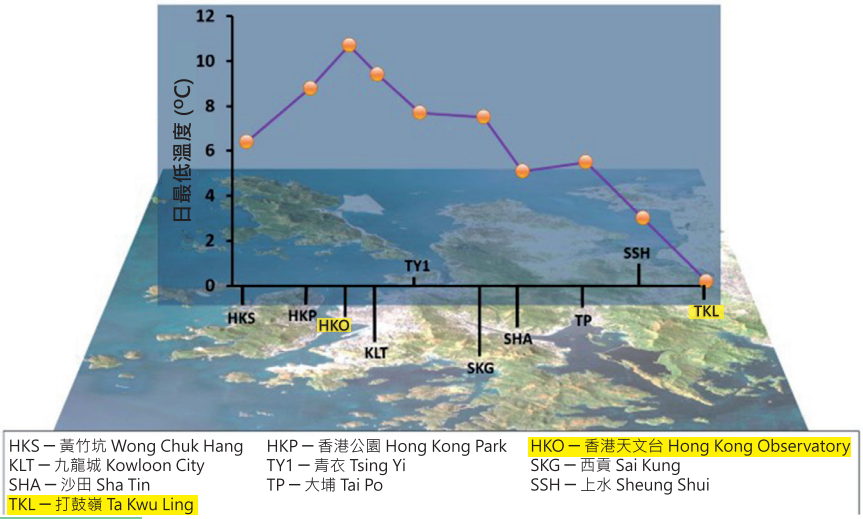


Fig 3.6 The daily minimum temperatures from urban to rural areas on 18 December 2010[vi]

Source: HKO

Impact of urban development on the surface wind speed

The high-rise buildings and dense urban development in Hong Kong have increased land surface friction, obstructing air flow and reducing wind speed in the urban areas. Fig 3.7 shows that there is no obvious trend of the annual average wind speed at Waglan Island for 1968-2015, while the wind speed at King's Park in the urban areas exhibits a significant downward trend.

The annual average wind speed at King's Park and Waglan Island (1968 to 2015)

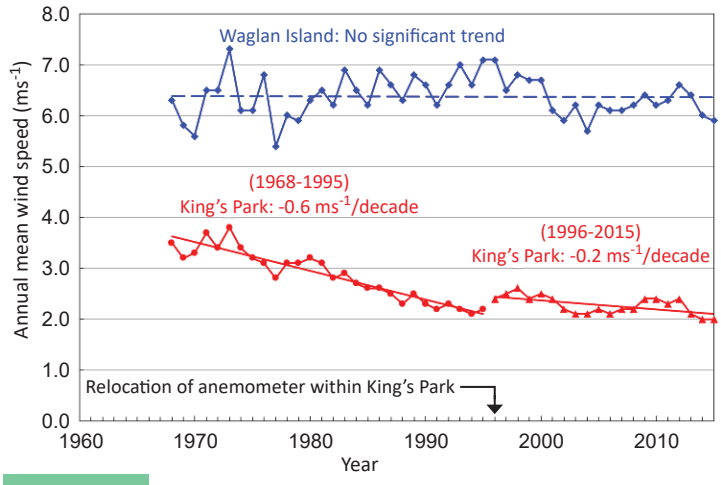


Fig 3.7 The annual average wind speed at King's Park and Waglan Island[vii]

Source: HKO

Buildings creating wall effect

More information

Other possible impacts of urban development

Over the past 50 years or so, the annual mean cloud cover in Hong Kong has increased by about 1.1%[viii] per decade. One of the possible reasons is that human activities release suspended particulates into the atmosphere, increasing the concentration of condensation nuclei and favouring cloud formation. In addition to the increased condensation nuclei in the atmosphere, the urban heat may enhance convection. Both factors favour precipitation. Research from the Hong Kong Observatory points out that the increasing trend of rainfall in the urban areas was higher than that in the New Territories and offshore areas for 1956-2005.

The increase in suspended particulates and cloud cover reduces the amount of solar radiation reaching the ground. Since the 1970s, the amount of solar radiation observed in Hong Kong shows an overall decreasing trend.

Relative humidity is affected by air temperature and the amount of water vapour in the air. In general, relative humidity decreases with increasing temperature. During the day, the temperature rise in the rural areas is significantly higher than that in the urban areas and hence the relative humidity is lower in the rural areas. In the evening, the rural areas cool faster than the urban areas and hence the relative humidity is higher in the rural areas.

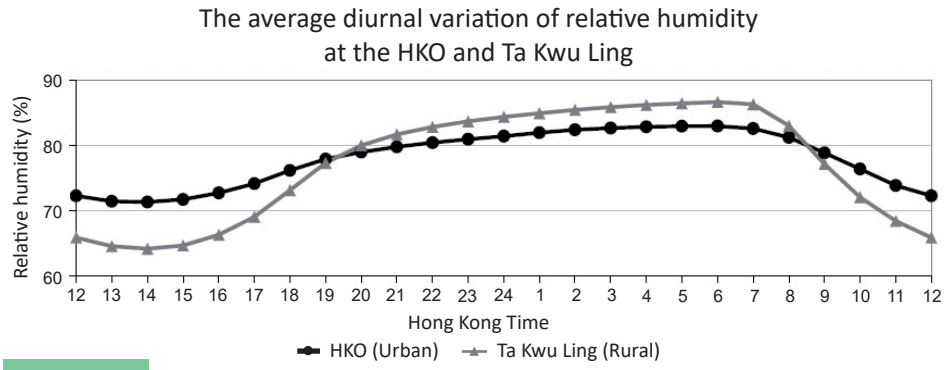


Fig 3.8 **The average diurnal variation of relative humidity at the HKO and Ta Kwu Ling[ix]**

Source: HKO

Urban heat island effect and global warming

Urban development causes the urban heat island effect, which then makes the city warmer. However, the impact of the urban heat island effect is confined to cities and has limited contribution to global warming. The Fifth Assessment Report of IPCC points out that the urban heat island effect has contributed no more than 10% to the warming of global land surface over the past hundred years.

Measures to mitigate urban heat island effect

Enhance urban greening: Trees help to provide cooling. The temperature in tree shades is much lower than the temperature of concrete or asphalt exposed to sunlight. Increase in the urban greening ratio can provide more tree shades and create a cooler environment for pedestrians.

The yellow and orange areas in the thermal image at Fig 3.9a show that road surface and buildings exposed to direct sunlight have relatively higher temperature. The blue and dark blue areas show that the temperature is relatively lower in areas under tree shades. The temperature difference can be 10°C or higher.

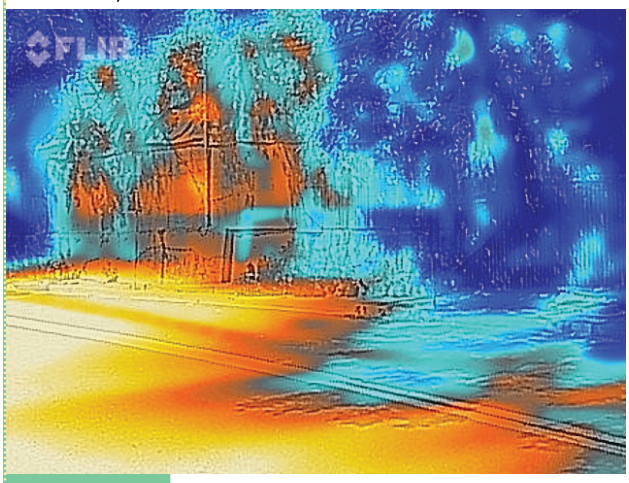


Fig 3.9a **Thermal image**

Fig 3.9b **Photo**

Improve building materials: Use heat-proof building materials and enhance reflectivity of buildings.

Improve urban planning: Urban planning and design are very important. Building bulk, building height, city permeability and green coverage should all be considered in the planning stage. For example, widening the distance between buildings can reduce the "wall effect", enhancing natural ventilation and mitigating the urban heat island effect.

7.3.3 Microclimate

Although Hong Kong is a small place, the variation in geographical location and site environment results in significant differences in temperatures as shown in Fig 3.10a and Fig 3.10b. Even in the same district, the temperature and humidity at different locations can be different. This is referred as microclimate.

Microclimate is a special climatic situation within a small range, mainly affected by factors such as topography, wind direction, building orientation and density.

Smart weather: Microclimate

More information

Spatial variation of the average maximum temperature at different stations in summer (2010 to 2015)

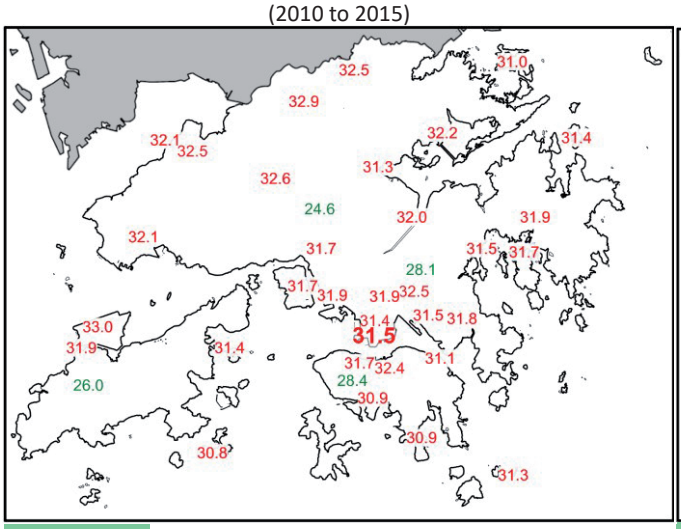


Fig 3.10a **Spatial variation of the average maximum temperature at different stations in summer. Stations on high ground shown in green[x]**

Source: HKO

Spatial variation of the average minimum temperature at different stations in winter (2010 to 2015)

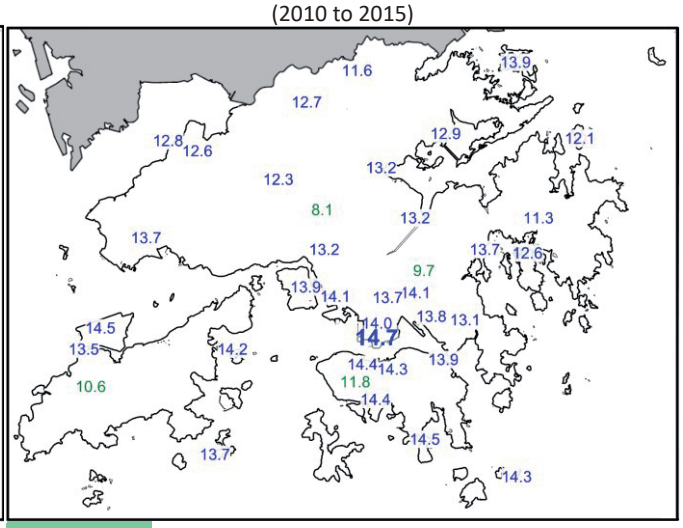
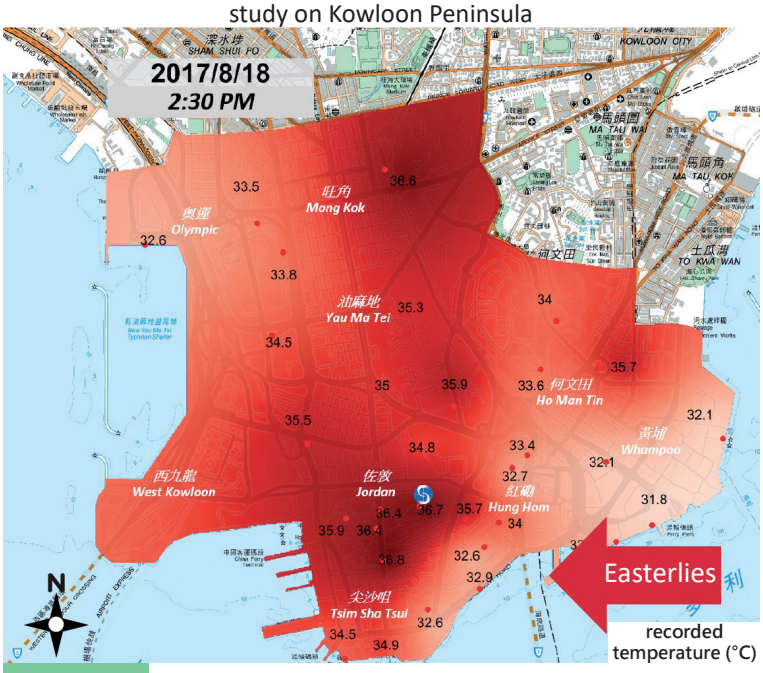


Fig 3.10b **Spatial variation of the average minimum temperature at different stations in winter. Stations on high ground shown in green**

Source: HKO

In 2017, the HKO installed more than 30 temperature micro-stations on Kowloon Peninsula to study microclimate in the urban areas. Preliminary findings of the study show that the temperature distribution of Kowloon Peninsula is affected by wind direction. Fig 3.11 shows that in the case of easterly winds, the temperature on the east side of Kowloon Peninsula is relatively lower compared to the urban centre and the west side of the Peninsula and the temperature difference can be up to about 4°C.

Preliminary results of the microclimate study on Kowloon Peninsula



recorded temperature (°C)

Fig 3.11 **Preliminary results of the microclimate study on Kowloon Peninsula**

Source: HKO

There are temperature differences between different parts of Nathan Road in Tsim Sha Tsui. Fig 3.12 shows that the temperature station at the **junction of Nathan Road and Haiphong Road** generally recorded higher temperatures, followed by the temperature station near **Park Lane Shopper's Boulevard**. The temperature station near the **ChungKing Mansions** generally recorded lower temperatures. The higher temperatures at the junction of Nathan Road and Haiphong Road could be due to the heavy traffic on-site while the lower temperatures near ChungKing Mansions could be attributed to the blocking of sunlight by the buildings around.

Urban microclimate studies can provide basic urban climate information to support improvement of town planning.

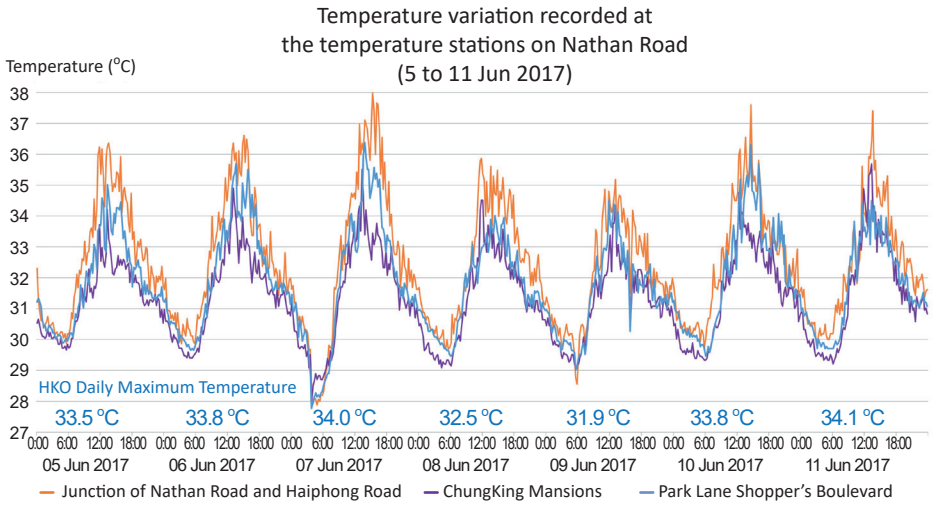


Fig 3.12 **Temperature variation recorded at the temperature stations on Nathan Road**

Source: HKO

Fig 3.13 **Urban microclimate stations**

Source: HKO

7.4 What are the impacts of climate change?

7.4 Effects – What are the impacts of climate change?

Summary

This section introduces the impacts of climate change on the natural environment and humans. It also covers the impacts on biodiversity, public health and economy of Hong Kong.

Trends of climate change

What are the impacts of climate change on the natural environment and humans?

7.4.1 The impacts of climate change on the natural environment

Climate change affects the delicate balance of ecosystems. In response to the changing climate, some terrestrial, freshwater and marine species change their geographical distributions, seasonal activities, migration patterns, abundance and interactions with other species. Those species that cannot adapt sufficiently fast to the changing climate will decrease in abundance or even go extinct.

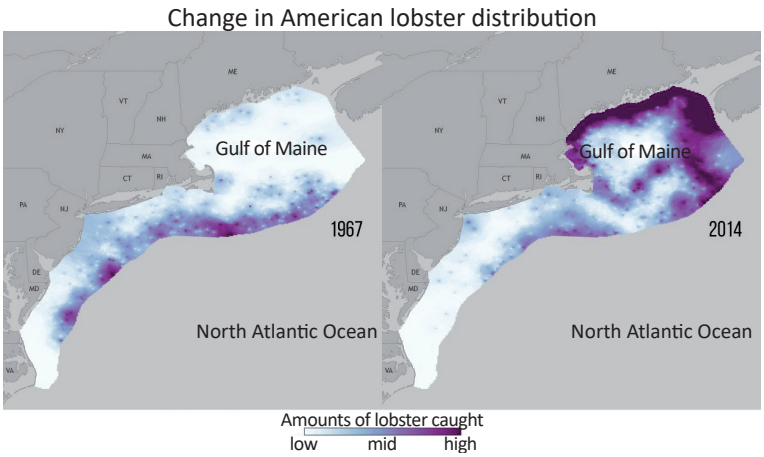
Geographical distribution of species

For those species unable to adapt to a warmer environment, they must migrate to cooler areas. While terrestrial species migrate to higher latitudes or higher ground, marine species migrate to higher latitudes or deeper oceans.

Examples:

(a) American lobsters shifting to higher latitudes

Sea Temperature



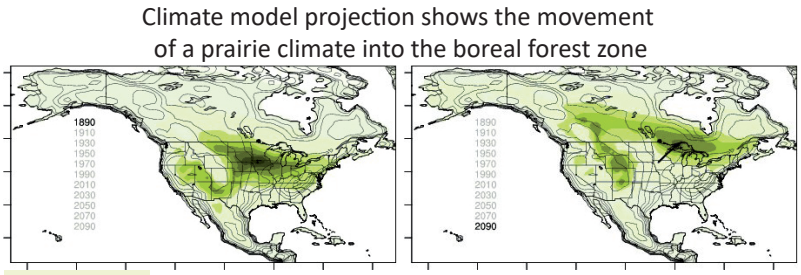
More information

Fig 4.1 **Change in American lobster distribution**

Source: US National Oceanic and Atmospheric Administration (NOAA)

(b) Northern forests shifting northwards

Temperature



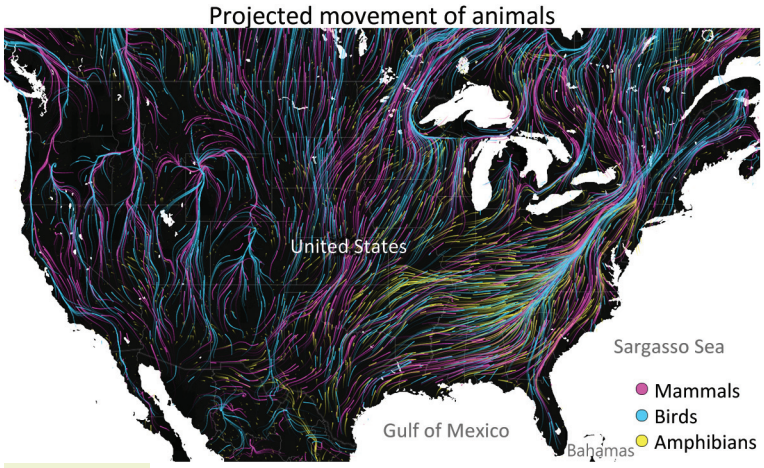
More information

Fig 4.2 **Climate model projection shows the movement of a prairie climate into the boreal forest zone**[i]

Source: Charles Koven, Lawrence Berkeley National Lab

(c) Animals shifting northwards

Temperature



More information

Fig 4.3 **Projected movement of animals**[ii]

Source: The University of Washington

Migration may not be a feasible option for those species limited by certain living conditions. For example, Giant Spiny Frogs (Quasipaa spinosa) in Hong Kong inhabit in high-altitude streams on Tai Mo Shan. They may have nowhere to go as the climate warms.

Temperature

More information

Fig 4.4 **Giant Spiny Frogs in Hong Kong may have nowhere to go as the climate warms**

Source: Gary Chan

Phenology

Climate warming with increased precipitation may extend the length of growing season for plants in some areas. Changes in the timing of seasons disrupt the migration routes and cycles of migratory birds. The early arrival of spring may cause trees and flowers to bloom earlier and shorten the length of hibernation of animals.

Examples:

(a) The mismatch between bloom and pollinator arrival affects plant reproduction and food availability for the pollinators, leading to profound consequences.

Temperature

More information

Fig 4.5 **Mismatch between bloom and pollinator arrival**

Source: Dickson Wong

(b) The mismatch between timing of migration and breeding of migratory birds and emergence of prey significantly reduces the reproduction rate of migratory birds, causing long-term impacts on the abundance and structure of the species.

Temperature

More information

Fig 4.6 **Climate change affects migration, breeding and foraging of migratory birds**

Source: Gary Chan

Habitats

Climate change causes direct or indirect damages to terrestrial and marine habitats.

Examples:

(a) Loss of Arctic sea ice reduces polar bears' living and hunting areas, directly threatening their survival. The International Union for Conservation of Nature projects that the population of polar bears will decline by more than 30% in the next 40 years[iii].

Sea Ice

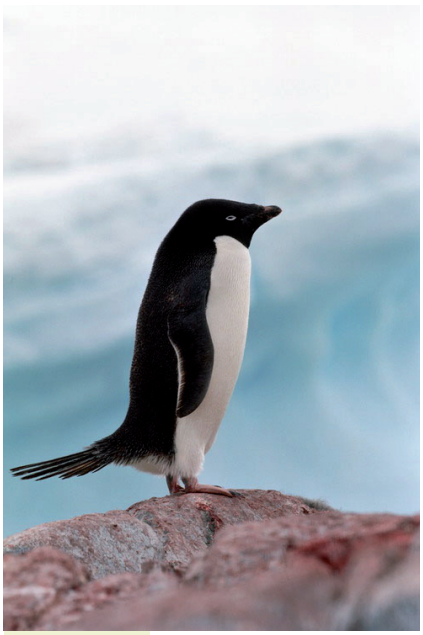
More information

Fig 4.7 **Loss of sea ice threatens polar bears' survival**

Source: Pixabay

(b) The increasing sea surface temperature of Antarctic coastal regions may be disadvantageous to the rearing of Adelie penguins. The population of Adelie penguins in Antarctica is projected to decline by about 60% by the end of this century[iv].

Sea Temperature



More information

Fig 4.8 **The population of Adelie penguins in Antarctica is projected to decline significantly by the end of the century**

Source: Jerzy Strzelecki[iv]

(c) Rising seas inundated the habitats of the Bramble Cay melomys, the first mammal which became extinct in the Great Barrier Reef due to climate change.

Sea Level

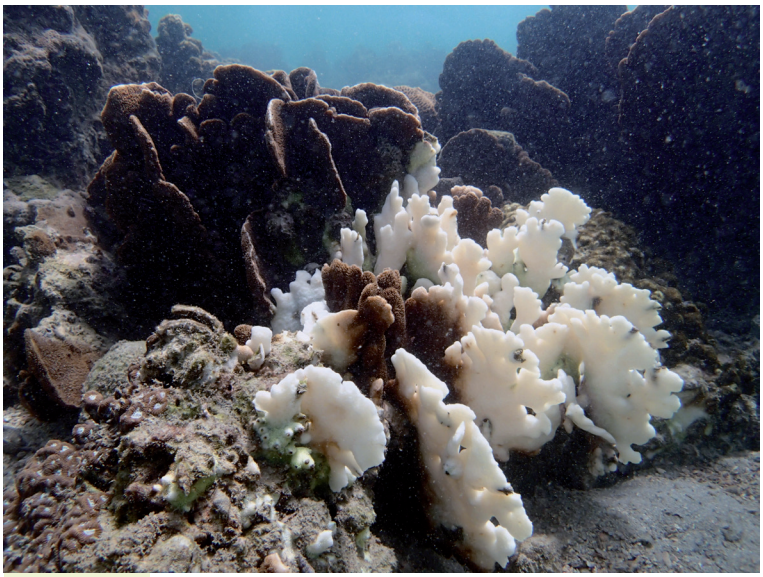
More information

Fig 4.9 **The Bramble Cay melomys became extinct in the Great Barrier Reef due to climate change**

Source: Ian Bell, © Queensland Government[vi]

(d) As sea water gets warmer, corals tend to expel the symbiotic algae living in their tissues and turn white. Bleaching corals will become fragile and weak, and may even die. About 30% of the carbon dioxide emitted by human activities is absorbed by the ocean, leading to ocean acidification and affecting the growth of corals. The death of coral reefs will lead to loss of habitat or food for many marine creatures, disrupting the food chain and threatening the ecosystem. As assessed by the United Nations Educational, Scientific and Cultural Organization, all coral reefs on the World Heritage List are likely to disappear by 2100 unless there is a drastic reduction in carbon dioxide emission.

Sea Temperature



More information

Ocean acidification weakens coral skeletons

More information

Fig 4.10 **Coral bleaching affects marine food chain and ecosystem**

Source: Dickson Wong

(e) Wetlands, where a wide variety of species inhabit, will be inundated by rising seas, leading to habitat loss.

Sea Level

More information

Fig 4.11 **Loss of habitat by drowning wetlands**

Source: Kwok Chi Tai

(f) High temperature and drought increase the risk of wildfires. Research reveals that fire seasons across the globe are getting longer. Habitats for many species will be lost when forests are burned down. Besides, forests face a higher risk of pests and diseases.

Temperature

More information

Fig 4.12 **In a wildfire at Fort McMurray, Alberta, Canada in 2016, many animals were killed or injured when fleeing the scene. A lot of trees and plants were burned down**

Source: Chris Schwarz[vii]

7.4.2 The impacts of climate change on humans

Health

High temperatures become more frequent due to global warming, with heat waves becoming more frequent and intense with longer duration. High temperatures can induce health problems such as heat stroke or heat exhaustion, increasing the morbidity rate of respiratory diseases and heart cerebrovascular diseases.

(a) The 2003 European heat wave	- In 2003, the summer temperature of Europe was much higher than the long-term mean. Research reveals that human influence has more than doubled the chance of the heat wave. - The heat wave led to drought and wildfires with many major rivers (e.g. Rhine, Danube) falling to record low levels. The death toll of the heat wave exceeded 70,000.	More Information
(b) The 2010 Russian heat wave	- In July 2010, Russia recorded its hottest July since 1880. Research shows that human influence has increased the chance of the heat wave by three times. - This heat wave led to a severe drought with around 9 million hectares of crop perished. Also, there was extreme air pollution caused by wildfires. - The Russian heat wave caused a death toll of around 55,000.	More Information
(c) The 2015 India-Pakistan heat wave	- In late May 2015, temperatures exceeding 45°C persisted for days in many places in India. In late June, Pakistan also suffered from similar high temperatures. The heat stress during the two episodes was significantly higher than the long-term average. Research shows that human influence has increased the chance of the heat wave by more than eight times. - The combination of high temperature and high humidity led to high heat stress which was seriously detrimental to human health. The numbers of deaths in India and Pakistan were more than 2,500 and 700, respectively.	More Information

Table 4.1 Significant heat waves in recent years

Medical alert! Climate change is harming our health	Climate change already damaging health of millions globally	Deadly heatwaves could affect more than 70 percent of the world's population	Deadly heat stress could threaten hundreds of millions even if climate targets reached

More Information

Climate warming creates favourable environment for some disease vectors (e.g. mosquitoes) to expand their ranges. Some studies point out that the distribution of mosquitoes will spread to higher latitudes (e.g. the United States, Europe) and higher altitudes, increasing the risk of tropical disease transmission. In addition, bacteria will become more active, threatening human health.

Temperature

More information

More information

Fig 4.13 **Climate warming helps to expand the ranges of mosquitoes**

Source: Dickson Wong

Global warming may have positive impacts in certain cold regions as there would be fewer cold related diseases with winters generally becoming warmer. However, research shows that under the business-as-usual scenario of carbon emissions, the negative health impacts of climate change will disproportionately affect warmer and poorer regions.

More information

Warm Arctic, Cold Continents

This topic has been hotly debated among scientists in recent years. The rate of warming in the Arctic is twice as fast as the global average. The rapid Arctic warming affects the westerly jet stream aloft in the Northern Hemisphere and makes it more susceptible to wavy meanders, allowing easier outbreaks of frigid Arctic air to the south. A recent study shows that the warming Arctic has caused colder and snowier winters in the Northeastern U.S. Climate change has made climate forecasting more difficult.

Agricultural production

The Fifth Assessment Report[viii] of Intergovernmental Panel on Climate Change (IPCC) points out that the overall impact of climate change on agriculture is negative while a few studies show that positive impacts are mainly confined in high-latitude regions.

More information

Climate change has more significant negative impacts on the production of wheat and maize while the effect on the yield of soybean and rice is smaller.

For major crops (e.g. wheat, rice, and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production if local temperature increases by 2°C above the late-20th-century levels, although individual regions may benefit.

The cost of feeding a warming world

More information

Risk of coastal inundation by sea water

Many densely populated cities around the world are situated in coastal areas. Rising sea level not only increases the risk of inundation by sea water, but also heightens the threat of storm surges. In addition, some island nations like the Maldives in the Indian Ocean, Tuvalu and Kiribati in the Pacific Ocean are facing the threat of drowning.

Example:

In 2012, Hurricane Sandy hit the east coast of the United States on high tide. The storm surge brought about by Sandy caused extensive damages. In New Jersey, around 350,000 homes were damaged or destroyed, and more than two million people were left with no power supply. The cost of Hurricane Sandy was about 70 billion US dollars.

Sea Level

More information

Fig 4.14 **Storm surge caused by Hurricane Sandy along the east coast of the United States in 2012**[ix]

Source: Mark C. Olsen, US Air Force

What is storm surge?

Storm surge is a rise of sea level due to the combined effects of low air pressure and high winds associated with tropical cyclones.

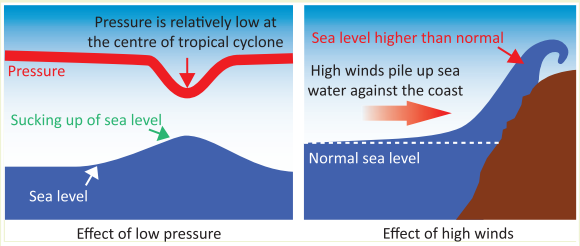


Fig 4.15 **Formation of storm surge**

Water resources

In some areas, decrease of precipitation and increase of evaporation may cause lakes to shrink and river discharge to reduce and hence freshwater resources to decrease. The warming climate accelerates melting of glaciers and ice caps, which may increase freshwater supplies in short term. However, the problem of water shortage will emerge immediately if the glaciers and ice caps melt away completely without replenishment.

As sea level rises, seawater intrusion into rivers and groundwater will increase the salinity of fresh water, making the water not suitable for drinking and irrigation.

Fig 4.16 **Melting glaciers in Arctic Svalbard region (2015)**

Source: Andreas Weith[x]

More information

Infrastructure and transportation

Extreme weather may damage urban infrastructure such as buildings, transport networks, power supply and communication facilities, disrupting normal functions of cities and even causing economic losses. Buildings and infrastructure built on permafrost may be damaged due to the thawing of permafrost[xi].

Loss of Arctic sea ice may open up more convenient shipping routes. But, at the same time, it may also lead to more human activities and extraction of resources, in particular fossil fuels, resulting in more pollution and greenhouse gas emissions.

Energy supply

Both hydroelectric and thermoelectric power generation (e.g. fossil-fuelled, nuclear) rely on adequate water resources (e.g. rivers). In other words, energy production can be affected by climate change. In addition, thermoelectric power generation facilities need water for cooling. Therefore, the temperature of water will also affect energy production.

It is estimated that more than 60% of power plants worldwide would have production capacity reduced by mid-century due to climate change[xii].

As the climate warms, the demand for energy for cooling will increase, making power outages or overloads more likely.

More information

Tourism

A number of tourist attractions are disappearing or being damaged as a result of climate change, for example, coral bleaching and death in Australia's Great Barrier Reef. Sea level rise would also destroy tourist facilities in some island countries.

More information

National security

The report of US Department of Defense indicates that climate change will aggravate problems such as poverty, social tensions, environmental degradation, ineffectual leadership, weak political institutions and eventually threaten the stability in a number of countries. The report regards climate change as a security risk because it degrades living conditions, human security and the ability of governments to meet the basic needs of their populations. Countries that are fragile and have limited resources are far less likely to respond effectively to challenges[xiii].

The government of Sweden sees climate change as a national security issue. In 2018, they distributed a brochure to remind Swedish citizens to be prepared for the crises caused by war and climate change.

More information

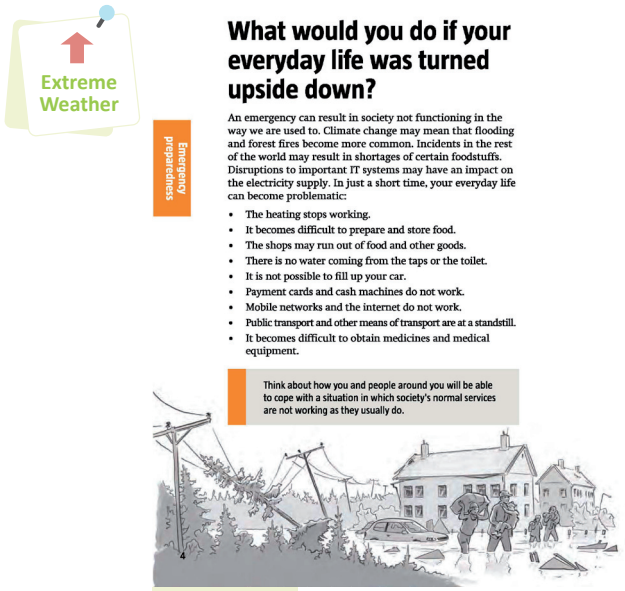


Fig 4.17 **The government of Sweden reminded Swedish citizens to be prepared for the crises caused by climate change**

Source: Sweden national security brochure[xiv]

The Fifth Assessment Report of IPCC indicates that the frequency and intensity of drought in the Mediterranean[xv] may have increased. Since the winter of 2006/07, Syria has experienced a severe drought[xvi] which led to high food prices. A large number of farmers moved to the peripheries of urban centres where a lot of refugees reside, adding instability to the situation.

Climate migrants

A World Bank report indicates that hundreds of millions of people will move within their countries due to climate change. People of the three densely populated regions: Sub-Saharan Africa, South Asia, and Latin America will be forced to migrate to other places in their countries to build new lives due to impacts of climate change, such as decrease in agricultural productivity, water shortage and sea level rise.

7.4.3 The impacts of climate change in Hong Kong

The climatic trends observed in Hong Kong are basically consistent with the global trends. As for the future climate in Hong Kong, the Hong Kong Observatory utilized computer climate model data from the Fifth Assessement Report of IPCC to conduct the projection under different greenhouse gas concentration scenarios. The scenarios considered include low concentration, medium-low concentration, medium-high concentration and high concentration.

Even under the medium-low concentration scenario, the annual number of hot nights and very hot days in Hong Kong will increase significantly. Under the high concentration scenario, the annual number of very hot days at the end of the century will exceed one hundred. For the rest of the century, the number of extremely dry years will be more or less the same as the historical observation. However, the number of extremely wet years will significantly increase. Regardless of the greenhouse gas concentration scenario, sea level in Hong Kong will continue to rise.

	Temperature	Precipitation			Mean sea level
	Annual number of very hot days	Annual Maximum 3-day rainfall (mm)	Extremely wet Years	Extremely dry Years	Hong Kong and its adjacent waters (m)
Actual Observations (1986-2005)	9	367	3 (1885-2005)	2	1.4
Projection for high greehouse gas concentration scenario (2091-2100)	112 ↑	523 ↑	12# ↑	2#	2.3 ↑
Projection for medium-low greehouse gas concentration scenario (2091-2100)	45 ↑	454 ↑	9# ↑	2#	2.1 ↑

Projection for 2006-2100

Fig 4.18 **Future Climate of Hong Kong**

Source: HKO

Fig 4.19 **As extreme rainfall increases, the risks of flooding and landslides will increase correspondingly.**

Climate Projections for Hong Kong

More information

As the climate warms, the average intensity of tropical cyclones and the associated rainfall will increase. More intense tropical cyclones will be more damaging. Exacerbated by sea level rise, the threat of storm surge will heighten.

Fig 4.20 **Over 60,000 reports of fallen trees due to Super Typhoon Mangkhut in 2018**

Special Series for Hato - Storm Surge blamed for all the calamity

More information

Record breaking Mangkhut

More information

Fig 4.21 **Super Typhoon Hato hit the Pearl River estuary in 2017. The storm surge brought about by Hato raised water level in Hong Kong generally by about one to two metres. Coinciding with the high water of the astronomical tide, the aggregated effect caused inundation of many low-lying areas in Hong Kong by sea water. Super Typhoon Mangkhut came in 2018 with record breaking storm surges. The maxium sea level recorded at Quarry Bay was even higher than that recorded during the passage of Hato, causing serious flooding in many coastal and low-lying areas in Hong Kong.**

A Wake up Call from Mangkhut

More information

Global warming: Clear and Present Danger (2)

More information

Climate change also affects biodiversity, public health, energy supply and infrastructure in Hong Kong.

Impacts on the natural environment

Biodiversity

More pressure on montane and freshwater ecosystems due to increasing temperature and more frequent extreme weather events; loss of inter-tidal habitats such as coral reefs and mangroves because of sea level rise; change in species distribution and migration patterns as a result of climate change.

Fig 4.22 Increase in temperature affects the breeding of Paramesotriton hongkongensis

Source: Ho Koon Nature Education cum Astronomical Centre

Impacts on the public

Human health

Chronic illness issues aggravated; risk of heat exhaustion, heat stroke and asthma exacerbated; more accidents and emergency situations; changes in transmission patterns of infectious diseases.

Food and water resources

Reduction in local food production due to more frequent extreme weather events; higher water demand because of rising temperature. If food production elsewhere in the world is affected by extreme weather or drought, there will be less food supply and price hikes may be triggered.

Energy supply

Climate warming increases the energy demand for cooling and the pressure on the power supply system, resulting in overloads and power outages. More frequent extreme weather will increase damage risk of power lines and other power supply facilities.

Economy

Higher maintenance and insurance costs will be induced by damages caused by extreme weather. The insurance sector will bear higher risks associated with extreme weather.

Infrastructure

More frequent extreme rainfall will increase the risks of floods and landslides which can damage building foundations, utility cables and roads, etc. Rising sea level accentuates the risk of storm surge inundation to coastal facilities, especially underground facilities.

7.5 How can we respond to the impacts of climate change?

7.5 Our responses – How can we respond to the impacts of climate change?

Summary

This section first introduces the international cooperation in tackling climate change, including two international agreements, the Kyoto Protocol and the Paris Agreement. It will then discuss actions in respect of mitigation, adaptation and resilience, as well as individual actions to combat climate change.

7.5.1 International cooperation

The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) in 1988. On a regular basis, IPCC reviews most up-to-update scientific literature on climate change and prepare assessment reports, providing clear scientific perspectives and objective information to the world, including the scientific bases and causes of climate change, its potential environmental and socio-economic consequences, and the adaptation and mitigation options to respond to the impacts.

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted during the Rio de Janeiro Earth Summit in 1992. It is an international environmental agreement which aims at stablising the level of atmospheric greenhouse gases in order to prevent dangerous interference to the climate system due to human activities. To achieve this goal, two important international agreements were adopted by the United Nations, namely, the Kyoto Protocol in 1997 and the Paris Agreement in 2015.

The Kyoto Protocol

In 1997, the 3rd session of the Conference of the Parties (COP 3) of UNFCCC took place in Kyoto, Japan and adopted the Kyoto Protocol. But the Protocol did not enter into force until 2005.

The Kyoto Protocol recognizes the principle of "common but differentiated responsibilities", meaning that combating climate change is a responsibility commonly shared by all nations. However, since more developed countries[1] are principally responsible for the current high levels of atmospheric greenhouse gases as a result of more than a hundred years of industrial activity, the Protocol places a heavier burden on more developed countries than less developed countries[2] in emission reduction.

A top-down approach was adopted in negotiating the emission reduction targets among the more developed countries. It is difficult to implement the agreement because each country has to consider its own circumstances and economic interests.

The emission reduction commitment period of the Kyoto Protocol was 2008 - 2012. The European Union and 37 more developed countries[3] pledged to reduce at least 5% greenhouse gas emissions against 1990 levels.

In 2012, the Doha Amendment to Kyoto Protocol was adopted at the 18th session of the Conference of the Parties (COP 18) of UNFCCC. The 2nd commitment period of 2013 - 2020 was adopted. Relevant Parties pledged to reduce their greenhouse gas emissions by at least 18% against 1990 levels.

Effectiveness of the Kyoto Protocol

There are criticisms of the effectiveness of the Kyoto Protocol, citing the lack of participation of some more developed countries. For example, the United States in 2001 declared that it had no intention of implementing the Kyoto Protocol, and Canada formally withdrew in 2012.

During the 1st commitment period from 2008 to 2012, some more developed countries achieved the emission reduction targets while some did not.

Party	Committed emission reduction[i] (relative to 1990 levels)	Actual emissions[ii] (average value from 2008 to 2012)	Target achieved
European Union (15 countries)	-8%	-18%	√
Japan	-6%	4%	X
Canada	-6%	24%	X
Croatia	-5%	-15%	√
New Zealand	0%	38%	X
Russia	0%	-50%	√

Table 5.1 Emission reduction pledges for the 1st commitment period and actual emissions of some countries

Other criticisms are directed towards the principle of "common but differentiated responsibilities". Under this principle, less developed countries are not required to share the responsibility of emission reduction. However, increased emissions from less developed countries have offset the reductions made by more developed countries.

1 Teachers reference: Referred as Developed Countries by UNFCCC
2 Teachers reference: Referred as Developing Countries by UNFCCC
3 Teachers reference: Referred as Industrialized Countries by UNFCCC

The Paris Agreement[iii]

In 2015, the 21st session of the Conference of the Parties (COP21) of UNFCCC took place in Paris, France and adopted the Paris Agreement.

The main goal of the Paris Agreement is to contain global average temperature rise by the end of this century well below 2°C relative to pre-industrial levels and to pursue efforts to limit the temperature rise to 1.5°C in order to avoid the dangerous impacts of climate change. The Paris Agreement entered into force in November 2016 and was later ratified by 181[iv] Parties as of September 2018.

Unlike the Kyoto Protocol, the negotiation in the Paris Agreement was based on a bottom-up approach. Each country compiles its own "nationally determined contribution" with greenhouse gas emission reduction target and schedule according to its national circumstances. Each country will conduct review every 5 years and provide update of "nationally determined contribution" with a more aggressive emission reduction target. Since the countries determine their own emission reduction targets, it is easier to implement the agreement.

Party	Emission reduction target
China	Peak of carbon dioxide emissions at around 2030. Pursue to advance the peak. Carbon intensity in 2030 lower than the 2005 level by 60-65%.
Japan	Carbon emissions in 2030 lower than the 2013 level by 26%.
European Union	Carbon emissions in 2030 lower than the 1990 level by at least 40%.
India	Carbon intensity in 2030 lower than the 2005 level by 33-35%.

Table 5.2 Emission reduction targets of some Parties[v]

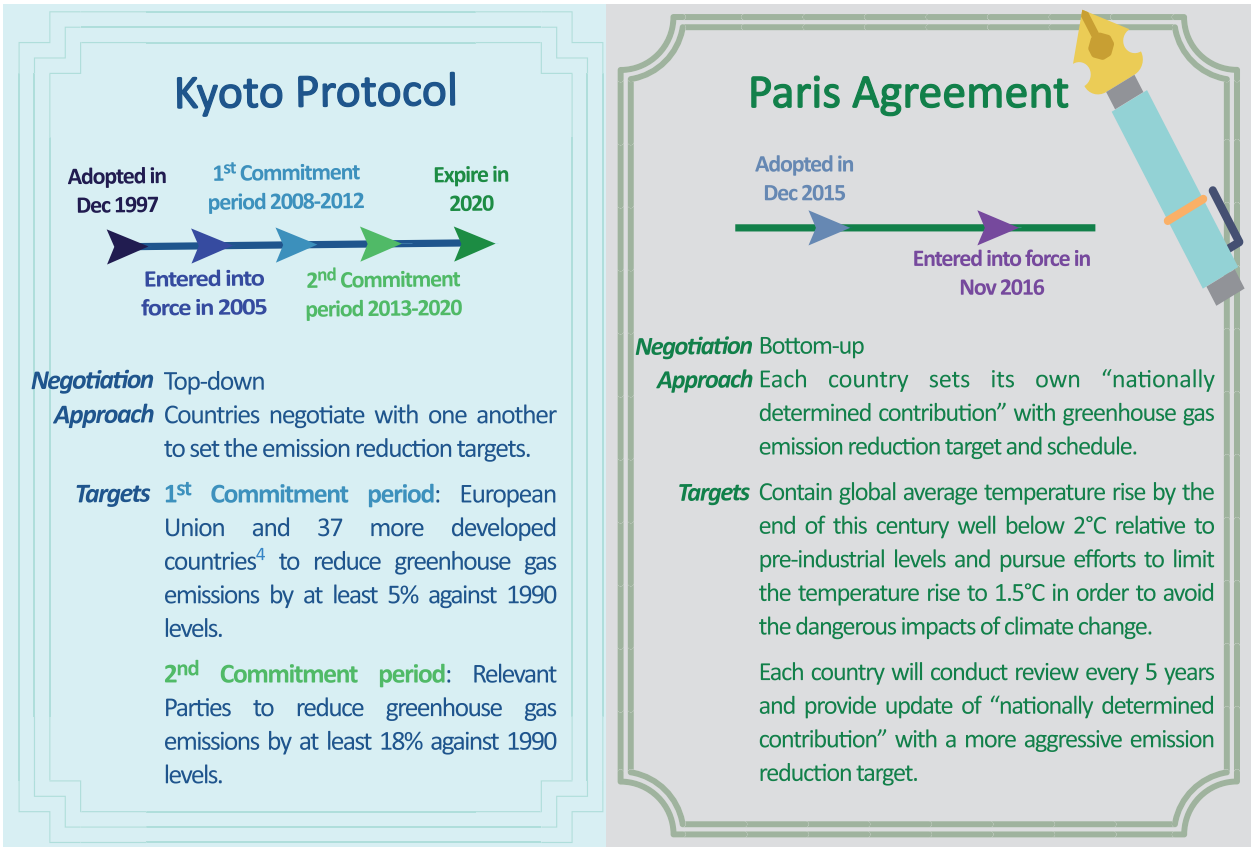


Fig 5.1 Comparison of the Kyoto Protocol and the Paris Agreement

4 Teachers reference: Referred as Industrialized Countries by UNFCCC

Special Report on Global Warming of 1.5°C

In response to one of the decisions made at COP21, the IPCC published the Special Report on Global Warming of 1.5°C in October 2018. The Special Report makes an urgent call for policymakers that limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society. The Special Report clearly presents the multiple benefits of limiting global warming to 1.5°C compared to 2°C, for example,

1. a slower rate of sea level rise which enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas;
2. lower impact on terrestrial, freshwater and coastal ecosystems which helps retain more of their services to human;
3. lower ocean warming and acidification and hence lower risks to marine biodiversity and ecosystems;
4. lower climate-related risks to health, food security, water supply, human security and economic growth; and
5. lower adaptation needs.

Human activities have already caused approximately 1°C of global warming above pre-industrial levels and we are already seeing the consequences of global warming through more extreme weather, rising sea levels and diminishing Arctic sea ice. To contain global warming to 1.5°C, human-caused carbon emissions have to decline by about 40% from 2010 levels by 2030, reaching net zero around 2050. Current national pledges of emission reductions under the Paris Agreement would not suffice to achieve the goal. The goal can only be achieved if global carbon emissions start to decline well before 2030. Based on the "nationally determined contributions" for reductions in greenhouse gas emissions made by the countries at the Paris Agreement, a global warming of around 3°C would be more likely by the end of this century.

7.5.2 Government actions

Each country has to implement emission reduction measures according to its "nationally determined contribution" in order to **mitigate** climate change. At the same time, the country also has to be prepared to **adapt** to impacts of climate change and to strengthen **resilience**.

Mitigation	Adaptation	Resilience
Reduce greenhouse gas emissions or remove greenhouse gases from the atmosphere.	Reduce the impacts of climate change.	Cope with and absorb climate change related stresses. Maintain public services and socio-economic functions.

Fig 5.2 **Three key aspects in responses to climate change**

Mitigation

(a) Replace fossil fuels with renewable energy

- Reduce the use of fossil fuels. Increase the share of solar power, wind power and hydro-electric power in the energy mix.

Fig 5.3a Solar panels

Source: American Public Power Association[vi]

Fig 5.3b Hydroelectric dams

Source: American Public Power Association[vii]

(b) Improve energy efficiency

- Improve energy efficiency. For example, use energy efficient electrical appliances and fuel-efficient vehicles, install intelligent energy saving systems in buildings.

(c) Improve transportation systems

- Encourage the public to use public transportation, cycle or walk. Promote the use of electric or hybrid vehicles.

(d) Improve waste management

- Develop waste-to-energy technologies, which can manage urban waste efficiently and reduce reliance on fossil fuels.

(e) Afforestation and urban greening

- Afforestation increases carbon sinks[5]. Roof greening or vertical greening on buildings have cooling effects and therefore can reduce energy consumption of air conditioners. They can also alleviate the urban heat island effect by reducing heat absorbed by building surfaces.

Fig 5.4 Building with vertical greening[viii]

(f) Carbon capture and storage

- Scientists have been developing technology to capture atmospheric carbon dioxide and store it underground or in deep ocean for long term, or store it in biomass. Most of the technologies are still at their infancy and not ready for large-scale deployment.

5 Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere

Adaptation

Sluice in Holland: Maeslant Barrier

More information

Video of Maeslant Barrier

More information

(a) Coastal and drainage projects

- Coastal protection structures: Raise the height of seawalls or build sluices (flood gates) to guard against extreme water level caused by storms.
- River channel improvement: Enhance the drainage capacity of channels.
- Drainage system planning: Design new drainage systems according to flood prevention strategies and improve existing systems; keep the drainage systems in good shape and perform preventative maintenance.

Fig 5.5 Coastal protections in Japan

Source: Pekachu[ix]

Fig 5.6a Thames Barrier, sluice in River Thames, England

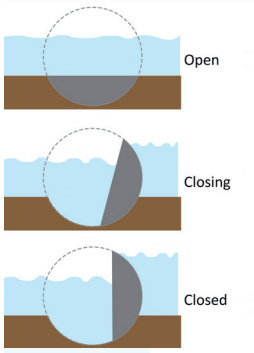


Fig 5.6b Operation of Thames Barrier[x]

Source: Kleon3[xi]

(b) Building design

- Highly reflective materials can reflect more sunlight, reducing the energy absorbed by buildings. Flood resilient houses or floating houses can reduce the losses of life and property.

Fig 5.7 Flood resilient house

Source: Infrogmation[xii]

An architectural firm in Holland designed floating facilities such as floating house, restaurant, hotel and golf course to adapt to climate change

(c) Land use planning

- A better land use planning can avoid building important infrastructure like hospitals in high-risk areas such as coastal areas and slopes.
- Buffer zones like parks, waterfront promenade should be constructed in high-risk areas to replace high-density development. River revitalization and roof greening can alleviate the urban heat island effect effectively.

(d) Food supplies

- Breeding new crops which are more resistant to high temperature and drought.

Resilience

By strengthening climate resilience, we can cope with the stress brought by climate change. Table 5.3 shows the steps of strengthening climate resilience suggested by the US National Oceanic and Atmospheric Administration.

	Explore hazards	Assess vulnerability and risks	Investigate options	Prioritize and plan	Take action
Steps[xiii]	- Establish a team - Examine past and future extreme weather for the region - List the "assets" that could be affected, including people, resources, ecosystems, infrastructures	- Determine which assets are exposed to impacts of extreme weather - Assess each asset's vulnerability - Estimate the risk to each asset	- Consider all possible solutions - Study other cases - Determine the feasible solutions	- Evaluate costs and benefits of each solution and resilience of all departments - Pick the best solution	- Take action - Gain public support - Monitor the effectiveness, and revise the resilience plan when necessary
Example[xiv]	- Houston of the United States faces extreme rainfall and storm surge inundation - More frequent extreme rainfall and higher threat of storm surge are projected	- The team paid special attention to Houston's petrochemical industry and Johnson Space Center	- The team cooperated with various government departments to compile climate data and conducted research using a handful of resilience enhancement tools	- Based on the research results, they built a climate change website www.adapt2climate.org,and compiled nine guidelines	- Provide relevant information to the public - Continue to enrich the website

Table 5.3 Five steps and an example of resilience enhancement

Fig 5.8 Houston, U.S. faces extreme rainfall and storm surge inundation

Source: Michael Slaten[xv]

Case study: Hong Kong (City level)

As Fig 5.9 shows, Hong Kong's total greenhouse gas emissions in 2014 amounted to about 45,000 kilotonnes[xvi] of carbon dioxide equivalent (CO_2-e) [6], accounting for less than one thousandth of global emissions. However, per capita greenhouse gas emissions in Hong Kong were about 6.2 tonnes[xvii] CO_2-e, close to the global per capita emissions of 7.3 tonnes[xviii,xix] CO_2-e.

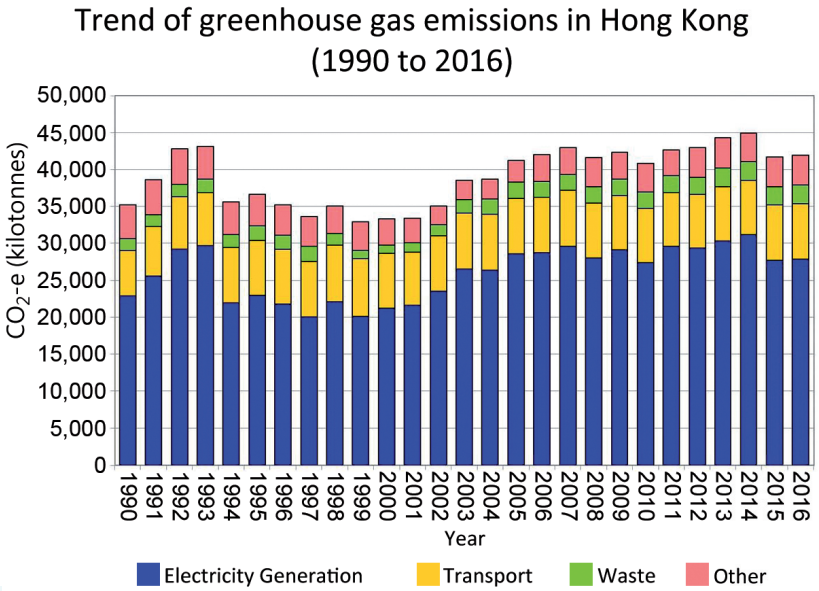


Fig 5.9 **Trend of greenhouse gas emissions in Hong Kong**[xx]

Source: Hong Kong Environmental Protection Department [xx]

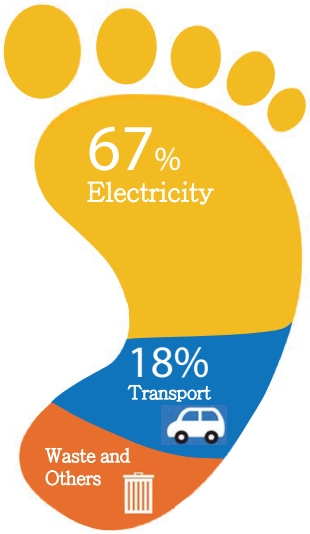


Fig 5.10 **Greenhouse gas emissions in Hong Kong**

Source: Environmental Bureau

Hong Kong government released "Hong Kong's Climate Action Plan 2030+"[xxi] in 2017. It sets a target to reduce carbon intensity by 65 - 70% by 2030 against the 2005 level. To achieve this goal and combat climate change, Hong Kong also takes actions in the three aspects: **mitigation**, **adaptation** and **resilience**.

Greenhouse Gas Emissions and Carbon Intensity in Hong Kong

More information

Emissions Gap Report 2015

More information

Concise Report on the World Population in 2014

More information

Mitigation

(a) Manage energy demand

- Reduce energy intensity[7] by 40% by 2025 using 2005 as the base.

(b) Adopt renewable energy

- Use more renewable energy. It is estimated that between now and 2030, about 3 - 4% of energy required by Hong Kong can be generated from wind, solar and waste-to-energy technologies.

(c) Improve transport system

- Railway serving as the backbone of low-carbon public transport.
- Control the growth of private cars.
- Promote walking and cycling to reduce carbon emissions from road transport.

6 Carbon dioxide equivalent: Commonly adopted in carbon audits to evaluate the warming effect of various greenhouse gases with reference to carbon dioxide

7 Energy demand per unit of economic output

Adaptation

Hong Kong West Drainage Tunnel

More information

(a) Improve infrastructure

- Strengthen slope safety.
- Integrate drainage and flood management plans. Intercept, store and discharge stormwater more efficiently.
- Carry out coastal protection works to reduce the impacts of sea level rise.

(b) Improve town planning

- Improve urban thermal comfort and ventilation.
- Strengthen urban fabric and develop smart city to better prepare for climate change.

(c) Increase water resources

- Conduct study on increasing water resources, including desalinated water, reclaimed water, recycled grey water and harvested rainwater.

(d) Protect ecosystems

- Promote sustainable agriculture and fisheries.
- Enhance country parks.
- Enhance biodiversity in urban environment.

What is reclaimed water?

Reclaimed water is highly treated wastewater.

What is grey water?

Water collected from baths, showers, wash basins, kitchen sinks and laundry machines etc. is known as grey water. Along with harvested rainwater, the grey water can be treated and reused for non-potable purposes such as toilet flushing.

Resilience

(a) Be prepared for emergencies

- Enhance emergency information sharing and support mechanism for dealing with hazards.
- Improve mechanisms of decision-making and coordination in emergency response.

(b) Raise community awareness of climate change

- The government collaborates with commercial, professional, academic and community bodies to organise workshops and activities pertaining to climate change.
- The Hong Kong Observatory (HKO) studies and makes long-term projections about climate change impacts in Hong Kong, and provides such information through its website. HKO also organises regular school and public talks, as well as other public education activities to promote the understanding of climate change.

7.5.3 Individual actions

Hong Kong's recyclable materials

More information

Just as mankind has played an undeniable role in bringing about climate change, every one of us has an inescapable responsibility in mitigating the impact so caused. Whatever the governments of this world pledged in the Paris Agreement, ultimately it is down to us as citizens of the planet to achieve the targets set through a change in mindset, lifestyle and consumption behaviour.

To achieve the low-carbon target, we can start from daily life and develop habits to reduce carbon emissions.

Clothing

- Choose energy efficient washing machine.
- Run washing machines or dishwashers with a full load.
- Choose a washing machine that meets your household's needs.
- Hang-dry washed clothes in an outdoor area, whenever possible.
- Line dry clothes, dry with cold air, or remove clothes promptly from the dryer to keep wrinkles to a minimum.
- Wash clothes in cold water.

Food

- Prepare a shopping list before buying so as to avoid purchasing more than needed.
- Buy family-sized product with less packaging if possible.
- Allow hot/ warm food to cool down to room temperature before putting it in the refrigerator.
- Avoid setting the refrigerator temperature unnecessarily low.
- Leave enough space between refrigerators and the walls or cabinets so air can circulate around the condenser coils. Trapped heat increases energy consumption.
- Bring your own container for drinks and food.
- Cut down on take-away food which usually uses non-recyclable materials.
- Use durable tableware instead of disposable ones such as foam container, plastic cutlery, paper cup and wooden chopsticks.
- Buy drinks contained in plastic or glass bottles which can be recycled.
- Avoid buying tetra pack drinks which do not have recyclable outlets locally cannot be recycled.
- Buy fresh local food which consumes less energy and hence less pollution.
- Bring the items purchased earlier to the front (first-in-first-out system).
- Consume food close to expiry date first.
- Store food in accordance with the instructions on the packaging.
- Reuse food trimmings/ surplus portions for second dish recipe.
- Separate food waste to facilitate recycling.
- Eat what you can consume comfortably by ordering the right portion and number of dishes.
- Donate surplus festive food or gift packs to the needy.

Living

- Purchase energy-efficient electrical appliances (with energy labels).
- Use energy efficient light bulbs (such as compact fluorescent lamps (CFLs)).
- Set your air-conditioners at 24-26°C.
- Turn off electrical appliances when they are not in use.
- Avoid leaving electrical appliances on standby mode.
- Install a low-flow shower-head and take a quick shower.
- Turn off the lights in any room which are not using.
- Use fans instead of room coolers as far as possible.
- Clean the filters of room coolers regularly.
- Keep the windows and doors closed when the room cooler is turned on and use curtains or blinds to shade against sunlight.
- Avoid putting the refrigerator near a heat source - an oven, the dishwasher or direct sunlight from a window.
- Bring your own bags to reduce consumption of plastic shopping bags.
- Adopt simple packaging and minimise gift wrapping to avoid wastage of resources.
- Choose more durable products. Think twice before shopping to avoid purchasing unnecessary items and cause wastage.
- Donate unwanted gifts to the needy through charitable organisations.
- Separate all recyclable materials, such as metals, plastics, waste paper and other recyclables from waste stream and put them in recycling bins to facilitate recycling.

Travelling

- Use public transportation.
- Drive less.
- Plan and schedule the route wisely.
- Switch off idling engines.
- Drive at proper speed.
- Keep your vehicle well maintained.
- Maintain proper tire pressure.
- Buy fuel-efficient vehicle (such as electric or hybrids vehicles).
- Share your car with others.
- Use stairways instead of lift.

Fig 5.11 **Ways to reduce carbon emssions[xxii]**