GATEWAY 1: Why do different places experience different weather and climate?

What is the difference between weather and climate?

Weather	Climate
● The specific conditions of the atmosphere of a particular place and time ● Shows the short term conditions of the atmosphere. ● Varies from time to time and place to place ○ For example, Singapore on 1st May 2016 at 10 am, hot and sunny but at 4pm raining heavily.	● The average weather conditions of the atmosphere over a long period of time, at least 30 years. ● Climate is what people expect to experience year after year. ○ Places with high temperatures and high rainfall experiences hot wet climate. ○ A place with high temperature in summer and low temperature in winter experiences temperate climate.

Elements of weather

- **Temperature** which is measured with a thermometer.
- **Relative humidity** which is measured using a sling psychrometer and a relative humidity table.
- **Clouds** which are measured with your eyes, obviously.
- **Rainfall** which is measured using a rain gauge.
- **Air pressure** which is measured using a barometer.
- **Wind** which is measured using an anemometer.

Temperature

- **Temperature** is the degree of heat or coldness of a place.
- It is measured in **Celsius or Fahrenheit** scale.
- It is measured using an **analogue or digital thermometer,** although a **maximum and minimum thermometer** can be used too.

Temperature calculation

- **Mean daily temperature** is the sum of hourly temperatures divided by 24 hours.
- **Diurnal temperature range** is the difference between maximum and minimum temperatures recorded in a day.
    - Maximum daily temperature - Minimum daily temperature
- **Mean monthly temperature** is the average of the daily temperatures in a month
- **Mean annual temperature** is the average of the monthly temperatures recorded in a year
- **Annual temperature range** is the difference between maximum and minimum mean monthly temperatures recorded in a year.

Factors affecting temperature

- **Latitude (Angle of Incidence)**
    - Latitude is the distance of any point on the earth measured north or south of the equator.
    - Nearer to the equator, the angle of incidence is higher/vertical and the sun rays are more vertical.
    - This causes solar energy to be concentrated into a smaller area and thus, the temperature will be higher.
    - The opposite is true for areas further away from the equator, causing those areas to have a lower temperature.
- **Latitude (Curvature of the Earth)**
    - At lower latitudes because of the curved shape of the earth's surface, the sun rays travel through a shorter distance in the atmosphere.
    - There is less solar radiation lost by reflection, scattering and absorption.
    - Thus places near equator will have higher temperatures as less energy is lost to these processes.
- **Altitude (Distance from the surface)**
    - The sun emits short wave radiation which is absorbed by the earth's various surfaces and then re-emitted as longwave radiation.
    - The higher up in the atmosphere you go, the further you are from the majority of the surface of the earth which is being heated by the sun.
    - Therefore, temperature decreases with increasing altitude.
- **Altitude (Amount of Particles)**
    - The sun emits short wave radiation which is absorbed by the earth and then re-emitted as longwave radiation.
    - With increasing altitude or elevation, air becomes less dense and hence contains less dust and water vapour.
    - Heat from the earth's surface thus escapes more rapidly, thereby lowering the air temperature.
    - In general, air temperature decreases with increasing altitude at a rate of about 0.6°C to 0.65°C per 100 metres (or 6°C to 6.5°C per 1000 m) in a free atmosphere.
    - This change of temperature gradient is called the normal lapse rate (or vertical lapse rate).
    - Examples would be Kota Kinabalu vs. Mt. Kinabalu.
        - Kota Kinabalu is only 200m above sea-level and its temperature ranges from 24 degrees in the night to 33 degrees in the day.
        - Mt. Kinabalu which is 3300m above sea-level and its temperature drops below freezing sometimes.

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        - However, these two areas are of similar latitudes so it shows how altitudes cause temperature differences.
- **Distance from the Sea**
    - **Coastal location (Maritime effect)**
        - Maritime effect is the effect that large ocean bodies have on the climate of coastal areas.
        - During summer, as the sea heats up slower than the land, the air over the sea is cooler than the air over the land, causing winds from the sea to have the added effect of cooling down coastal areas.
        - Likewise, during winter as the sea loses heat slower than the land, the air over the sea is warmer than the air over the land, causing winds from the sea to have the effect of warming up coastal areas.
        - This causes a smaller annual temperature range, characterised by milder seasons.
    - **Inland location (Continental effect)**
        - Inland regions situated at a great distance from the sea have hotter summers and colder winters than coastal regions.
        - The annual range of temperature in inland regions is greater, and the climate is thus more extreme than that of coastal areas
        - This is because the temperatures of these areas are not influenced by the sea.

- **Cloud Cover**
    - **Presence of clouds**
        - During the day, clouds help increase the albedo of the area, increasing amount of solar energy reflected back into space.
        - This keeps the earth's surface cool as it reduces the amount of solar energy the ground receives, thereby reducing temperatures during the day.
        - During the night, clouds help absorb longwave radiation emitted from the earth's surface, preventing it from escaping into space.
        - This keeps the earth's surface warm at night as not as much thermal energy is lost into space, increasing temperatures during the day.
        - This results in a lower daily temperature range.
    - **Absence of clouds**
        - During the day, there are no clouds to help reflect solar radiation back into space, thus the earth's surface receives the full amount of solar energy.
        - This increases the amount of insolation the earth's surface receives relative to when there were clouds present, causing the temperatures to be relatively higher during the day.
        - During the night, there are no clouds to absorb the longwave radiation emitted from the earth's surface, causing more energy to be lost into space.
        - This causes the earth's surface to lose heat more rapidly, causing temperatures during the night to be relatively lower.
        - This results in a higher daily temperature range.

Relative humidity

- **Humidity** is the amount of water vapour present in the air.
- **Relative humidity** is the proportion of water vapour present in the air in relation to the maximum amount that air can hold at a particular temperature.
- **Saturation** occurs when relative humidity is at 100 per cent, causing **condensation.**
- **Dew point** is the temperature at which saturation is reached.

Factors affecting relative humidity

- **Temperature**
    - The air parcel gets warmer and expands.
    - This means that it can hold more water.
    - It continues to expand and hold more moisture until it reaches saturation, where the air cannot absorb any more water vapour.
- **Moisture available**
    - The amount moisture available in an area affects the amount of water that can evaporate into the air.
- **Onshore winds**
    - Winds coming from the sea carry lots of moisture due to having travelled across an open body of water.

Clouds

- A **cloud** is a visible mass of water droplets or ice crystals that are suspended in the atmosphere.

Rainfall

- **Precipitation** refers to water in any form that falls from the atmosphere to the surface of the Earth.

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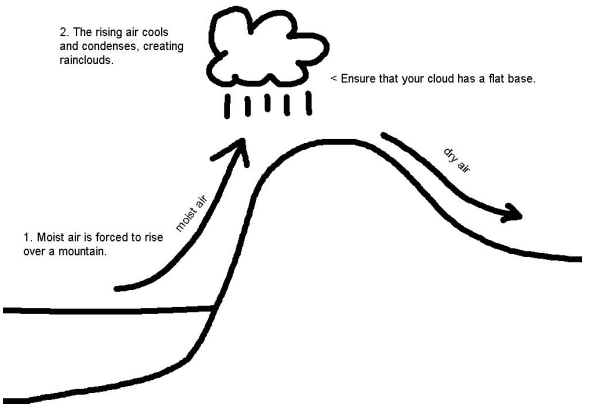
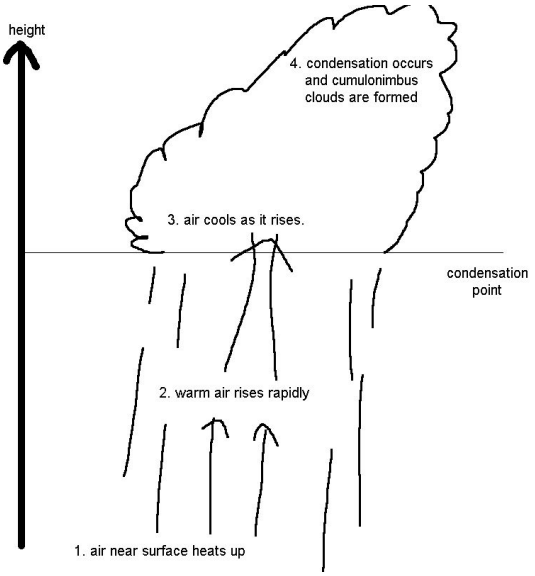
Types of Rainfall

- **Relief Rain**
    - Relief rain or orographic rain is rain that occurs when warm, moist air is forced to rise over landforms such as a mountain.
    - Winds from the sea blow inland and when winds come into contact with the highland, it is forced to rise.
    - As air rises up, it cools down to the dew point temperature and condensation takes place, causing rain to fall on the windward side.
    - By the time the air moves over the highland, it has lost its moisture.
    - The other side of the mountain, called the leeward side, experiences a rain-shadow as a result of this.



- **Convectional Rain**
    - The sun radiates energy which is absorbed by the surface of the earth, heating it up.
    - Air near the surface is heated up and this causes it to expand and rise.
    - The rising air eventually cools to the dew point temperature and this results in the condensation of large amounts of water vapour.
    - Cumulonimbus clouds, with a flat base near the condensation level, are formed.
    - This results in heavy convectional rain, which may be accompanied by thunder and lightning.
    - This type of rain typically only occurs in tropical climates.



Air Pressure

- **Air pressure** is the force exerted on a unit area of the earth's surface by the weight of the air column above it.
- Areas of similar pressure are usually grouped together and demarcated by isobars.
- Air pressure at sea level is 1013 millibars.
    - If it's higher than this, it is considered high air pressure.
    - If it's lower than this, it is considered low air pressure.

Factors affecting Air Pressure

- **Temperature**
    - An increase in temperature causes the air to expand, leading to lower density and lower pressure and vice versa.
- **Altitude**
    - Altitude also affects air pressure due to its density and amount of air above the particular area.
    - Areas closer to sea level have a higher column of air above them, causing them to be more compressed than areas further away from the sea.

Winds

- **Wind** is the movement of air from high pressure areas to low pressure areas
- **Winds** that blow most frequently from a specific direction are called prevailing winds.

Different types of wind systems

- **Small-scale wind systems**
    - These are localised systems that usually only affect coastal areas.
    - They are caused by the differential heating and cooling of the land and sea
    - **Sea breeze**
        - During the day, land heats up faster than the sea.
        - The land is warmer so the air there is warmer and less dense thus there is a lower air pressure.
        - The sea is cooler so the air there is colder and more dense. Hence, there is higher air pressure.
        - As winds blow from high pressure areas to low pressure areas to equalise the pressure, the wind blows from the sea to the land, creating sea breeze.
    - **Land breeze**
        - During the night, land cools down faster than the sea.
        - The land is colder so the air there is colder and denser thus there is a higher air pressure.

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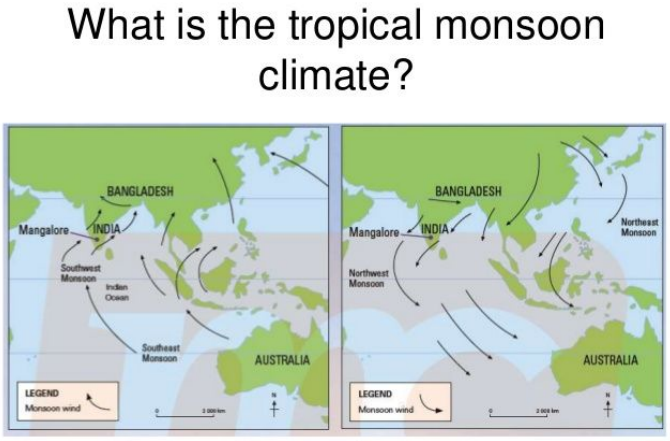
        - The sea is warmer so the air there is warmer and less dense. Hence, there is lower air pressure.
        - As winds blow from high pressure areas to low pressure areas to equalise the pressure, the wind blows from the land to the sea, creating land breeze.
- **Large-scale wind systems**
    - **Monsoons**
        - **Monsoons** are regional winds which reverse direction seasonally.
        - They are caused by the large-scale changes in pressure during the changing seasons between summer and winter.
        - They are affected by the **coriolis effect** which is a force produced by earth's rotation, causing the deflection of winds.
    - **Southwest monsoon (June to September)**
        - It is summer in the northern hemisphere so the air over central Asia heats up, expands and rises, forming an area of low pressure.
        - It is also winter in the southern hemisphere so the air over Australia cools down, contracts and sinks, forming an area of high pressure.
        - As air flows from a region of high pressure to a region of low pressure, the difference in pressure causes air to flow from Australia to central Asia, creating the southeast monsoon.
        - However, due to the coriolis effect, the winds are deflected to the right once they cross the equator, causing them to become the southwest monsoon.
        - The winds also warm up and begin to pick up moisture from the Indian ocean, bringing heavy rain to the indian sub-continent.



    - **Northeast monsoon (October to February)**
        - It is winter in the northern hemisphere so the air over central Asia cools down, contracts and sinks, forming an area of high pressure.
        - It is also summer in the southern hemisphere so the air over Australia heats up, expands and rises, forming an area of low pressure.
        - As air flows from a region of high pressure to a region of low pressure, the difference in pressure causes air to flow from central Asia to Australia, forming the northeast monsoon.
        - However, due to the coriolis effect, the winds are deflected to the left once they cross the equator, causing them to become the northwest monsoon.
        - The winds also warm up and begin to pick up moisture from the Indian ocean, bringing heavy rain to the Australian region.

What are the different climatic types and their defining characteristics?

Describing climate characteristics

- **Temperature**

Temperature	Descriptor
>30	Very hot
20 - 30	Hot
10 - 20	Warm
0 - 10	Cool
-10 - 0	Cold

- **Temperature range**

Temperature range	Descriptor
<5	Small
5 - 15	Moderate
15 - 30	Large
>30	Very large

- **Annual Rainfall**

Annual rainfall	Descriptor
>1500mm	Very high

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1000mm - 1500mm	High
500mm - 1000mm	Moderate
250mm - 500mm	Low
<250mm	Very low

Equatorial climate

- Equatorial climates are characterised by a few traits.
    - **High mean annual temperatures** caused by the high solar angle.
    - **Small annual temperature ranges** caused by the lack of seasons.
    - **Very high total annual rainfall** caused by the high temperatures and hence prevalence of convectional rain.
    - **A lack of distinct dry and wet seasons** due to a lack of monsoons.
- Places that experience this climate are typically located 10 degrees north or south of the equator such as Johor, Malaysia.

Monsoon climate

- Monsoon climates are characterised by a few traits.
    - **High mean annual temperatures** that are comparatively lower than equatorial climates caused by the high solar angle.
    - **Small annual temperature ranges of about 3-4 degrees** also caused by the lack of seasons.
    - **High total annual rainfall** caused by the increase in rainfall brought by monsoons.
    - **Distinct dry and wet seasons** caused by the presence of monsoons.
- Places that experience this climate are typically located between 5 degrees to 25 degrees north or south of the equator such as Chittagong in Bangladesh.

Cool temperate climate (Marine west coast climate)

- Cool temperate climates are characterised by a few traits.
    - **Cool mean annual temperatures** caused by the low solar angle.
    - **Large annual temperature range of** 21 degrees caused by the presence of seasons.
    - **Moderate total annual rainfall** caused by the lack of convectional rainfall.
    - **Lack of distinct dry and wet seasons** caused by a lack of monsoons.

GATEWAY 2: What is happening to the earth's climate?

How has the global climate changed?

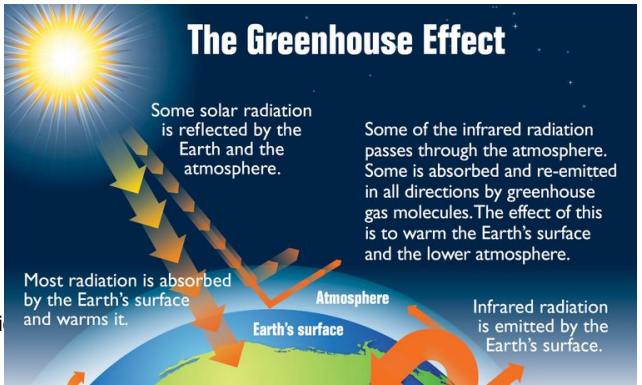
- **Global climate change** refers to the variation in the global climate or climatic patterns in the long term.
- Since the 1800s, the earth has experienced a significant but irregular upward trend in temperatures. This process is known as **global warming,** which is the increase in global temperatures over a long period of time.

What are some of the natural causes of recent climate change?

- **Variations in solar output**
    - The magnetic activity of the sun has a cycle that lasts about 11 years.
    - This affects the number of sunspots present on the sun which is linked to the amount of solar radiation emitted as areas around the sunspots radiate more energy to make up for the cooler sunspot areas.
    - With higher solar radiation, global temperatures will rise, causing a change in annual temperatures.
- **Volcanic eruptions**
    - **Global dimming** is the gradual reduction in the amount of sunlight reaching the earth's surface.
    - This cools down the earth for months or years as the amount of solar energy the earth receives is directly lessened.
    - When a volcano erupts, large amounts of carbon dioxide, water vapour, sulfur dioxide, dust and ash are released into the atmosphere.
    - The sulfur dioxide reacts with water in the atmosphere to further form sulfur-based particles.
    - All of these particles may reflect solar energy back into space, resulting in a cooling influence on regional and global temperatures.
    - Dust particles may also form condensation nuclei, creating greater cloud cover which also has the same effect.
    - Mount Pinatubo eruption lowered temperatures by as much as 0.6 degrees for two years.

What is the greenhouse effect and how does it work?

- **Greenhouse effect** is the process in which the gases in the Earth's atmosphere trap longwave radiation emitted from the Earth's surface, warming the atmosphere.
- **Greenhouse gases** are the gases which absorb longwave radiation well and as such are the main contributors to this effect.
    - Examples of these gases are chlorofluorocarbons, methane and carbon dioxide.
- Incoming shortwave radiation passes through the atmosphere.



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- Some shortwave radiation is reflected by the earth and the atmosphere.
- Most shortwave radiation is absorbed by the earth's surface which then heats up as a result.
- The warmed surface of the earth emits longwave radiation to the atmosphere.
- Greenhouse gases absorb longwave radiation, warming the atmosphere.

What is the enhanced greenhouse effect?

- The **enhanced greenhouse effect** refers to an increase in concentration of greenhouse gases in the atmosphere, leading to a rise in global temperatures.
- It is generally caused by human activities which release an increased amount of greenhouse gases, most notably carbon dioxide.

How do human activities lead to the enhanced greenhouse effect?

- **Deforestation and associated increase in atmospheric carbon dioxide**
    - **Deforestation** is the loss of forests due to the removal or clearance of trees in forested areas.
    - Trees are chopped down either to make wood-based products or to clear the area for further human development.
    - As forests absorb billions of tonnes of carbon dioxide every year via photosynthesis, the reduction in area of forests thus results in a decreased absorption of carbon dioxide, leading to an increase of carbon dioxide levels in the atmosphere.
    - **Soil** is also one of the largest sources of carbon in the world.
    - Deforestation exposes soil to sunlight which increases soil temperature and rate of carbon oxidation in the soil.
    - This thus results in an enhanced greenhouse effect.
- **Changing land use and associated increase in greenhouse gases**
    - **Agriculture** is the practice of cultivating land, producing crops and raising livestock.
        - The operation of machinery such as tractors or combine harvesters requires the burning of fossil fuels.
        - The use of inorganic fertilisers increases the amount of nitrous oxide in the soil which is released when soil is ploughed or when rain flows through it.
        - Organic matter such as decaying leaves releases methane, a strong greenhouse gas.
    - **Industries** refer to the production of goods and services within a country.
        - Secondary industries and heavy industries involve the burning of fossil fuels which results in the release of greenhouse gases, usually as a byproduct.
    - **Urbanisation** is the process by which an increasing number of people live in urban areas such as cities or towns.
        - Large amounts of fossil fuels are burnt to provide energy for household activities in urban areas.
        - The high concentration of cars, buses and other forms of transportation also contribute to an increased amount of greenhouse gases emitted from these areas.
        - Constructing infrastructure also releases greenhouse gases.

Impacts of climate change

- **Sea level rise** is the increase in the mean height of the sea's surface between high tide and low tide relative to the land.
    - Higher temperatures cause the **melting of glaciers** in Antarctica and Greenland. The resultant meltwater causes a rise in sea level.
    - Higher temperatures cause **water in seas and oceans to expand**, increasing the sea level.
    - **Vanuatu** in the Pacific Ocean is an example of a place where sea level rise has directly affected the livelihoods of the population. Many areas have been flooded as a result of the rise in sea level.
- **More frequent extreme weather events**
    - Extreme weather events are believed to be increasing due to higher land and sea temperatures which result in greater amounts of latent heat in a warmer atmosphere.
    - Such an atmosphere serves as a driving force for extreme weather events like hurricanes such as **Hurricane Irma**, one of the strongest hurricanes ever recorded in the Atlantic ocean.
    - Higher temperatures could also lead to wildfires, which is another example of an extreme weather event.
- **Spread of some infectious insect-borne diseases**
    - Heavy rainfall may allow mosquitoes to grow in numbers in aquatic habitats, resulting in the spread of malaria and dengue fever.
    - As climate change alters local weather patterns and climates globally, the distribution of the occurrence of infectious insect-borne diseases is bound to grow larger as conditions become more favourable for insects to proliferate and spread.
    - This can be seen in how Nepal and Bhutan, which previously had no known cases of dengue fever due to the climate being unfavourable for Aedes moquitoes to grow, had their first case of dengue fever in 2004.
- **Lengthening of growing season in certain regions**
    - Higher temperatures may result in longer growing seasons in some regions.
    - This is because higher temperatures in certain cold areas means plants can afford to grow for a longer period of time as they can spend more time above the minimum temperature which they can grow in.
    - This results in the lengthening of growing seasons in some areas, particularly Siberia in Russia.
    - This also results in the ability for regions to grow certain types of new fruit like blackberries in the United Kingdom.
    - However, this results in the loss of average yield in certain regions as well like in Yunnan, China where the production of apples has been reduced because they require cool weather conditions.

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Responses to Climate Change

- **International Agreements**
  - International agreements are contracts signed by two or more countries.
  - In this case, an international agreement is one that combats climate change be it by reducing emissions or otherwise.

Agreement	Explanation	Successes	Limitations
Kyoto Protocol	• The Kyoto Protocol is an agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC), an international convention set up with the goal of reducing the levels of greenhouse gases in the atmosphere. • Under the protocol, various targets to reduce greenhouse gas emissions were set for participating countries.	• Many countries have met or exceeded the targets set by the Kyoto Protocol. • Finland, Greece and Ireland have met their emission reduction targets. • It was also successful in encouraging sustainable development because developed countries were incentivised to carry out emission-reduction projects in less developed countries like installing energy-efficient infrastructure.	• Despite most countries being able to reach its targets, countries such as Denmark and Austria did not meet their assigned targets. • Furthermore, some of the largest contributors to greenhouse gas emissions such as China and India did not sign the agreement.

- **National responses**
  - National responses are strategies which tackle reducing greenhouse gas emissions locally.
  - They are necessary because there are measures that are specific to certain countries.

Agreement	Explanation	Successes	Limitations
Singapore Green Plan 2012	• Launched by the ministry of the Environment in 2002 and aimed to generate 60 percent of Singapore's energy needs through natural gas by 2012.	• Natural gas is a cleaner form of energy because it does not produce smoke. • As early as 2010, about 79% of Singapore's electricity was being generated from natural gas, exceeding the Ministry's target. • This reduces the amount of pollution created by energy generation.	• However, this usage of natural gas results in a requirement for complex treatment plants to process and pipelines to transport. • The pipelines have high maintenance costs because they have to be laid underground and have to be checked regularly for leakage.
Green Mark Scheme: Constructing 'green' buildings	• Launched by the BCA in 2005, the scheme allows buildings to be evaluated and certified according to how energy-efficient and environmentally friendly they are. • The scheme aims to encourage more 'green' buildings.	• Existing 'green' buildings like the Plaza by the Park, Standard Chartered @ Changi and the National Library Building have reported 15 percent to 35 percent in energy savings compared to conventional buildings. • This decreases greenhouse gas emissions by reducing the amount of fossil fuels required to power the building.	• 'Green' buildings may cost more to build because 'green' materials may be more expensive and the implementation of certain 'green' technologies like solar panels may require more money to be spent in construction.
Plant-A-Tree Programme: Planting more trees and plants	• The Plant-A-Tree Programme by the Garden City Fund and Singapore Environment Council encourages residents to donate money to buy a tree or to take part in tree planting events.	• The programme has contributed to an estimated 60,000 trees planted yearly throughout Singapore. • Trees help remove carbon dioxide from the atmosphere, reducing the amount of greenhouse gases present.	• Trees take very long to mature so positive benefits will take time to materialise. • Even relatively fast-growing trees like angsanas took 25 years to reach their full height.

GATEWAY 3: Is the weather becoming more extreme?

What are the characteristics of tropical cyclones?

- **Tropical cyclones** are weather systems that develop over the warm oceans in the tropics.
- **Diameters** ranging from 150km to 1500km.
- **Strong winds** of over 119km/h.

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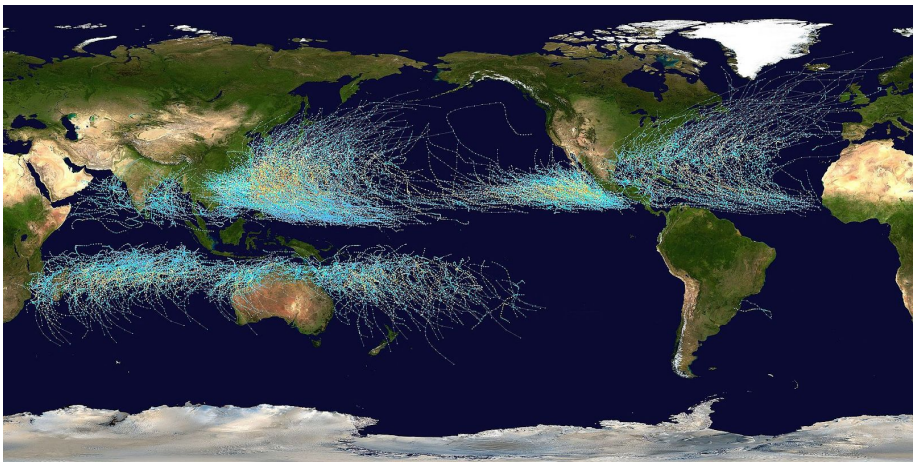
- **Low central pressure**
    - Moist air over the warm oceans expands and rises.
    - As the warm air rises, condensation occurs and releases latent heat.
    - The continuous large-scale release of latent heat warms the air, causing it to expand and become more buoyant.
    - This process continually reduces the air pressure near the ocean surface, sustaining a region of low pressure in the centre of the cyclone.
    - As the air rises, it then cools and sinks creating a descending column of dry air.
    - This causes an area of calmness and an absence of clouds known as the **eye**.

Where are tropical cyclones found?

- They are found between the latitudes of 8 to 15 degrees north and south of the Equator.
    - They are not found near the equator as a tropical cyclone requires the presence of a strong coriolis force to form.
- They are found in areas with high ocean surface temperatures of above 26.5C because the heat and moisture from the ocean waters are required for their formation.
- In real life, they are typically found in various tropical cyclone basins like those of the Caribbean and the Bay of Bengal.



What are the hazards associated with tropical cyclones?

- **Storm surges** which are a sudden rise of the sea level beyond normal conditions at high tide.
    - They are caused by a combination of low pressure and strong winds.
    - The intense low pressure in the eye of a cyclone causes sea levels to rise.
    - Strong winds push the water towards the coast and create huge waves, creating a storm surge.
    - The greatest amount damage to coastal areas is caused by storm surges as they cause massive flooding.
- **Strong winds**
    - The strong winds that accompany cyclones can damage infrastructure and injure people.
    - The wind picks up loose debris which flies and hits people and buildings.
    - Strong winds affect more areas than storm surges as they can affect inland areas too.
    - For example, many areas in inland Florida were damaged by strong winds during Hurricane Irma in 2017 despite not being close to the coast.
- **Torrential rain**
    - Tropical cyclones produce lots of rainfall which can result in inland flooding.
    - The increased precipitation adds to the flow of water in rivers and streams and causes them to overflow their banks.
    - The flooded rivers can flow across low-lying land, causing those areas to suffer from flooding related damage.
        - Hurricane Irma in 2017 flooded rivers in Florida, causing widespread flooding.
    - Heavy rainfall can also destabilise slopes when there is too much water in the soil, causing landslides.
    - These landslides can then destroy entire buildings.

What are the impacts of tropical cyclones? (PES)

Type of Impact	Impacts	Explanation of Impact	Example
Physical	Destruction of infrastructure	• Cyclones destroy roads, bridges and homes. • This makes it difficult to transport food, clean water and medicine to these areas.	• For example, during Cyclone Nargis in Myanmar, it was very difficult for officials to coordinate a response as much of the infrastructure in cities like Yangon like roads were destroyed.
Economic	Costs of repair	• Cyclones can destroy homes and buildings. These buildings then need to be repaired, incurring costs for rebuilding.	• Hurricane Katrina, which struck the east coast of the United States in 2005, cost an estimated US$81 billion dollars.
	Damaged crops	• Cyclones can destroy crops or damage them, preventing them from being sold as produce.	• For instance, Cyclone Yasi which struck Australia in 2011 damaged about 75% of the total banana crop, leading to financial losses of more than 250 million USD.

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Social	**Disruption to water supply, sanitation and hygiene facilities**	• Physical damage to infrastructure caused by tropical cyclones could cause water pipes or pumps to be damaged, preventing people from getting fresh water.	• For instance, when Cyclone Nargis struck Myanmar, many water pipes were destroyed or damaged and many wells were also contaminated with saltwater, preventing people from getting safe drinking water.
	Spreading of diseases	• Flooding caused by tropical cyclones may also cause sewage pipes to burst, contaminating water supplies. • The consumption of contaminated water leads to the spreading of diseases like typhoid fever.	• When Cyclone Aila hit West Bengal in India, contaminated drinking water caused a large cholera outbreak.
	Displacement of people	• Hurricanes may destroy homes and hence displace people from communities as they have nowhere to return to.	• Hurricane Katrina destroyed the homes of more than one hundred thousand people, forcing them to live in temporary shelters.

How do people respond to tropical cyclones?

Emergency action

- Emergency action involves taking immediate action in response to any situation that poses risk to people's health and lives.

Emergency action	Description	Successes	Limitations
Community cyclone shelters	• Governments can evacuate people to cyclone proof places such as a community cyclone shelter before one occurs. • Shelters are built with strong concrete to withstand the strong winds and are elevated to ensure that they are not flooded by storm surges.	• Community cyclone shelters can significantly reduce casualties in a cyclone because people have a safe place to evacuate to. • In Bangladesh, the presence of cyclone shelters helped reduce the casualty rates of cyclones like Cyclone Sidr.	• The effectiveness of community cyclone shelters is dependent on whether members of a community can get to it in time. • If a cyclone shelter is too far away, members of a community may not want to evacuate to it and may face greater danger as a result. • This is particularly a problem in some rural communities in Bangladesh where the nearest community cyclone shelter can be in the next town away.

Mitigation measures

- Mitigation measures are strategies taken to reduce or avoid the impact of a hazard.

Mitigation measures	Description	Successes	Limitations
Prediction and warning	• By analysing long-term climate records, we can establish the pattern of occurrences and the severity of damage caused by past cyclones. • We can also use sensors, satellites, computer simulations as well as meteorological analysis to determine if an area is at risk of being hit by a cyclone, thereby allowing for early cyclone warnings.	• In Japan and the United States, this system is especially well developed, allowing people to have ample time to evacuate, reducing overall casualty rates. • Residents of Florida were warned of Hurricane Irma 5 days before it made landfall in Florida, this allowed hundreds of thousands of people to evacuate and as a result saved many lives.	• However, hurricane predictions may not always be accurate as it is not possible to simulate events perfectly. • Thus, computer modelling may not be entirely reliable in predicting the path of a hurricane and if the hurricane takes an unexpected path, may lead to greater destruction than normal.
Land use control	• Land use control regulates the use of the land by placing restrictions on how land can be used. • It can take the form of floodplain or coastal plain management.	• By having a masterplan that maps the land use of an area and implements evacuation routes based on it and measures to prevent floods, cities can reduce the potential of flood damage. • For instance, by ensuring that new developments on floodplains are not prone to floods, this reduces the chance	• However, land use control is only successful when authorities are able to enforce them. • Effective implementation of land use controls requires much time and power. • Areas may have already been developed prior to the implementation of

		of potential damage caused. ● Cairns, Australia has a floodplain management plan that includes evacuation routes.	land use control and hence the implementation of it may be trickier and more challenging.
Reducing vulnerability of infrastructure	● Infrastructure, if built to withstand tropical cyclones, should be resistant to wind and water damage. ● There should also be regular inspection of river embankments and coastal dikes for breaches due to erosion. ● Utilities should be moved underground to reduce chance of damage by cyclones.	● Buildings that are designed to be resistant to cyclones are less vulnerable to being damaged, directly leading to reduced rebuilding costs. ● Galvanised steel hurricane ties can be used to reinforce roofs and prevent them from being blown off. ● In Jensen Beach, Florida, due to homeowners having cyclone resistant roofs, Hurricane Wilma only caused minor damage to roofs in the area when it struck in 2005.	● The implementation of such measures can be costly. ● Protective barriers need to be regularly checked and repaired, resulting in high maintenance costs. ● The relocation of utility lines underground may be costly as excavation is required to do so.

Notes by some weirdo called Conrad Soon. I don't guarantee the full accuracy of the information here.
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