

# DP IB Geography: SL



Your notes

## Consequences of Global Climate Change

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## Effects on the Hydrosphere & Atmosphere

### Water Stores

- The increase in mean global temperature has wide-ranging effects, including melting ice caps and glaciers, shifts in precipitation patterns, and changes in ecosystem dynamics
- The higher concentration of greenhouse gases are contributing to the intensification of extreme weather events such as hurricanes, droughts, heatwaves, and heavy rainfall
- Long-term changes in climate and weather patterns occur as a result of the altered energy balance in the Earth's atmosphere and oceans
- Rising greenhouse gas levels also contribute to the thermal expansion of seawater and the melting of land-based ice, resulting in sea level rise

### Effects on water stores

- The hydrological cycle involves the exchange of energy, which leads to temperature changes
  - As water evaporates, energy is taken from its surroundings which cools the environment
  - When it condenses, it releases energy and warms the environment, this exchange of energy influences the local climate
- **Changes in temperatures** have **reduced polar ice** and the **albedo effect**
  - Ice melt in the polar region releases fresh water into the oceans and this changes the **thermohaline** pattern
  - This circulation pattern relies on heavy salt water to transport water, carbon and heat around the globe
  - Large deposits of freshwater into the oceans will disturb the **ocean conveyor belt**
  - This has the potential of stalling or reversing the ocean circulation pattern
- **Dark oceans absorb more heat**, which increases evaporation into the atmosphere - a **positive feedback loop**
  - However, **increased evaporation** also **increases cloud formation**, which **radiates insolation back** out of the atmosphere which creates a **cooling effect - negative feedback**
  - The higher the temperature, the higher the volume of water in the atmosphere, which leads to more precipitation
  - This is because the atmosphere can retain more moisture with higher temperatures



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## Changes in water availability

- Global warming can lead to alterations in precipitation patterns, resulting in changes in water availability
- Some regions may experience increased rainfall and flooding, while others may face more frequent and severe droughts, impacting water resources for agriculture, drinking water, and ecosystems

## Sea-level change

- Changes in the amount of sea ice, lead to a greater volume of water in the **ocean basins**, as a result of **thermal expansion**
- Thermal expansion occurs as water warms, and the warmer fluids expand to take up a greater volume
- During the last Ice Age, **sea levels fell as water was locked in glaciers and ice sheets, rising again as the ice melted**, creating waterways such as the English Channel
- Greenland and Antarctica lost 6.4 trillion tones of ice between 1992 and 2017, causing global sea levels to rise by 17.8mm
- Today, ice sheets contribute to about a third of all sea-level rise, whereas in the 1990s, their contribution was just 5%
- By 2100, polar temperatures could be as high as 7°C above pre-industrial levels
- **Sea levels are linked to global warming** and will have a **significant effect on many low-lying coasts and islands**
- Many Pacific Ocean islands, such as Kiribati and Tuvalu are at risk of being completely submerged by rising sea levels

## Coastal flooding

- Rising sea levels, attributed to climate change, can lead to coastal flooding and increased vulnerability to storm surges
- This can result in the loss of land, infrastructure, and the displacement of coastal communities
- This issue is made worse as many of the world's densely populated areas are located on coastal lowlands
- New York and Miami in the US are major cities vulnerable to sea-level rise as the cities are built at sea level
- Bangladesh is an extensive delta, where the river Ganges discharges into the Bay of Bengal. The delta, largely covered with a swamp forest, is one of the world's most densely populated countries and is particularly vulnerable to global warming and sea level rise



## Examiner Tips and Tricks

Ice melting in a glass of water does not change the density of the water, because they are both fresh water.

However, an iceberg (freshwater) melting in the ocean decreases the density of the salt water, and this raises the sea level very slightly.



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# Carbon Stores

## Carbon stored in ice

- Permafrost acts as a carbon sink by storing partially decomposed plant and animal matter
- Melting of the permafrost triggers methane release into the atmosphere, as the plant and animal matter begin to decompose
- Methane is a more potent greenhouse gas than CO<sub>2</sub> and acts as a positive feedback loop
- Currently, there are approximately 5 gigatons of methane in the atmosphere
- It is estimated that the Arctic permafrost holds hundreds of gigatons of methane
- Polar ice sheets and glaciers are also stores of carbon
- As global temperatures increase, these ice sheets and glaciers melt and release stored CO<sub>2</sub> back into the atmosphere

## Impact of ice change

- Increasing temperatures are causing the melting of ice in polar regions, mountain summits, the ocean and other inland areas with ice
- For example, glaciers in the Himalayas, Southern Alps, Rockies and the summits of Mt. Kilimanjaro are melting rapidly
- It releases fresh water for millions of people living along the rivers in the low-lying areas of these mountains

## Ocean acidification

- Oceans can absorb more carbon than it emits and are important in regulating the atmosphere
- It is a two-way relationship with carbon being moved both downwards and upwards through the oceans



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- Phytoplankton in the ocean use dissolved  $\text{CO}_2$  for photosynthesis
- This transports carbon from the oceans' surface to the deeper levels for storage
- As biological organisms die, their bodies sink and release  $\text{CO}_2$  into the deep water stores
- Some material sinks to the ocean floor and is transformed into rocks such as limestone
- This process locks up carbon in the long-term carbon cycle and prevents an easy return to the ocean surface and back into the atmosphere
- However, increasing levels of carbon dioxide in the atmosphere lead to higher levels of  $\text{CO}_2$  absorption by the oceans, resulting in ocean acidification
- This can have detrimental effects on marine life, including coral reefs, shellfish, and other organisms that rely on calcium carbonate for their shells and skeletons

## Carbon in the biosphere

- The **biosphere** is also a large carbon sink
- $\text{CO}_2$  is naturally released into the atmosphere through respiration and decaying organic matter
- However, human activities have released extra amounts of  $\text{CO}_2$  into the atmosphere
- Plants, forests and soils have absorbed about 25% of this human-released  $\text{CO}_2$  through photosynthesis
- Whilst an increase in the amount of  $\text{CO}_2$  in the atmosphere promotes improved growth of plants and carbon storage, eventually, too much  $\text{CO}_2$  and increased temperatures will have a detrimental effect on crop yields
- Furthermore, deforestation has resulted in  $\text{CO}_2$  being released into the atmosphere

## Water cycle/carbon cycle feedback loop

- Water has the ability to absorb and transfer carbon and oceans absorb 33% of  $\text{CO}_2$  emitted to the atmosphere
- The bulk of human-generated  $\text{CO}_2$  has been absorbed by oceans, although this rate of absorption is slowing down
- As ice sheets melt, carbon storage increases, although this process cannot continue indefinitely, as eventually, the pH levels of the oceans will drop creating higher levels of ocean acidification
- Warmer temperatures increase marine phytoplankton populations to a point
  - Phytoplankton release dimethylsulphide (DMS) leading to increased cloud formation and cloud cover

- Insolation is reduced to the oceans, reducing temperatures, reducing phytoplankton activity, which will lessen cloud cover over the oceans
- With rising ocean temperatures; photosynthesis is reduced, as phytoplankton prefer cooler waters
- Also, increasing ocean acidity means molluscs and shell-forming marine creatures are finding it difficult to extract bicarbonate ions needed to convert into calcium carbonate, which reduces their ability to be a carbon reservoir



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### Examiner Tips and Tricks

Note that while ocean acidification shares the same cause as global warming (increased atmospheric carbon dioxide), it is not a direct result of global warming.

## Extreme Weather Events

- Changes in climate patterns are likely to increase the **frequency and severity of weather events**
- Since the 1980s there has been an increase in extreme weather events
- Particularly floods, storms and extreme temperatures
  - The Atlantic hurricane season runs from 1 June to 30 November
  - This is when tropical storms are most likely to form in the North Atlantic Ocean
  - On average, 14 named storms occur each season, with an average of 6 becoming hurricanes (Cat 3) and 3 becoming major hurricanes (Cat 4+)
  - 2021 produced 21 named storms (winds of 62+ km/h), including 7 hurricanes (winds of 119+ km/h) of which 4 were major hurricanes (winds of 178+ km/h)
  - This was the 6th consecutive above normal season
- The **frequency and length of droughts** are increasing
- Droughts are an extended period of time when there is below average rainfall
- It varies from place to place and has a negative effect on vegetation, animals, and people
- Water supplies such as lakes, aquifers and rivers become depleted as people continue to abstract water during a drought
- Droughts are often accompanied by high temperatures, which increases the rate of evaporation, depleting water supplies faster



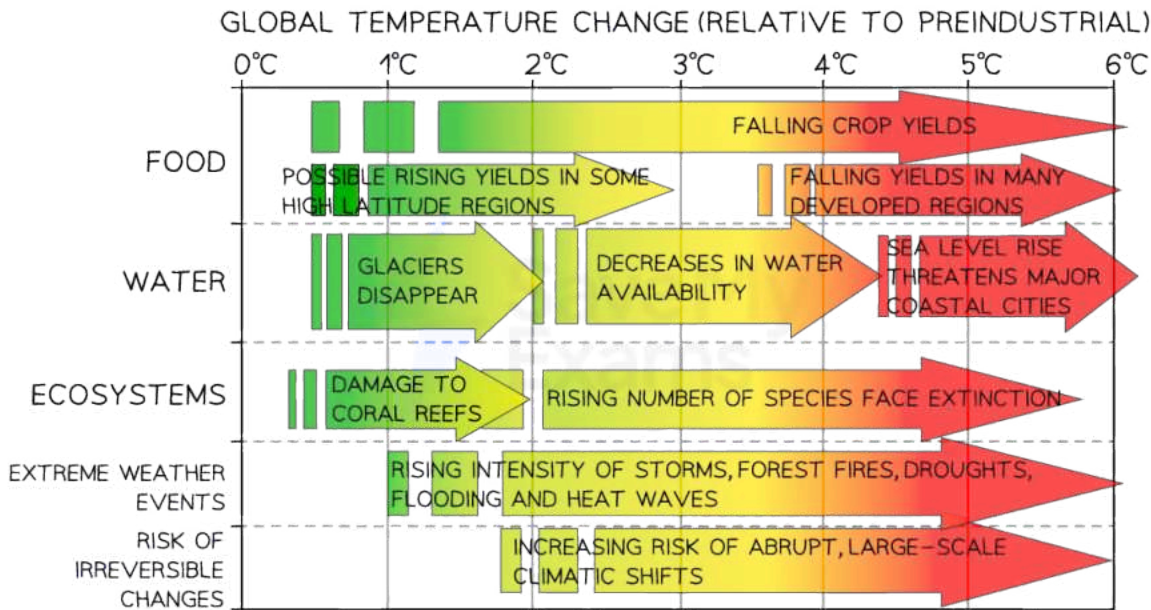
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- Length of a drought varies from place to place:
  - UK suffered a drought for 16 months between 1975 and 1976
  - In any given year, 14% of the USA is in a drought
  - Horn of Africa is experiencing its worst drought in 40 years
- Changes in atmospheric circulation can reduce the amount of precipitation to an area
  - An El Niño cycle will bring droughts to Indonesia and Australia
  - Annual monsoon rains can fail - India relies on the monsoon rains for water
- High pressure weather systems bring high temperatures which increases evaporation rates, but also block weather depressions of rain bearing clouds
- A **heat wave** is when temperatures are much higher than the average for a long period of time, in the UK that usually means 3 consecutive days
- The conditions of a heat wave varies from place to place - Spain has much higher temperatures than the UK
  - The Heat Wave of August 2018 became one of the hottest years since records began in 1960, reaching temperatures of 38.5°C in some parts of the UK
- **Extreme cold events** such as the '2018 Beast from the East' storm
  - Began in January 2018 when the **stratosphere** suddenly warmed
  - This generated a large rise in air temperature of around 50°C in an area approximately 29km above the Earth at the North Pole
  - This sudden warming weakened the jet stream (which usually brings in the warmer air) and allowed the cold air from western Russia to 'flood' over Europe

## Projected impacts of rising temperatures



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### Examiner Tips and Tricks

Remember that extreme weather events are dependent on temperature increases and therefore, each event will be worse with each degree C rise. Long-term changes are difficult to predict as we do not know the final temperature that our world will ultimately reach.





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## Effects on the Biosphere

# Impacts on Biomes, Habitats & Animal Migration

- **Ecosystems** and **biomes** play a key role in carbon cycling
- The availability of moisture for plant and animal distribution and growth is important
- Changes in temperature, rainfall, and habitats affect species' survival, migration patterns, and interactions
- This results in changes to ecosystem functions and services
- Some places will improve conditions for crops and ecosystems, while others will suffer
- Biomes may move north or south because they need specific climate conditions:
  - **Polar and tundra biomes** are at risk because they cannot move any further north or south
  - Rising sea temperatures and **ocean acidification** have caused **coral bleaching**
- As biomes move, **migration and behaviour patterns** also change
  - Animals will have to migrate longer distances to find cooler climates, reduced pests, diseases and predators so they can breed
  - Fish species are already moving further north and south of their usual habitats
  - Reduced hibernation time due to warmer winters
  - Migrations begin earlier every year, with the birds leaving their winter nesting sites and heading north for the summer
- **Soil erosion** reduces the fertility of the remaining soil
- Soil erosion increases when rainfall is higher and vegetation is low
- Warmer temperatures and increased rainfall increase soil loss on slopes
- Increased rates of drought slow plant growth, reduce carbon cycling and reduce nutrient transfer to the soil; lack of nutrients and water exposes soil erosion; soil erosion can lead to **desertification**
- Agricultural practices expose soil to increased run-off and erosion
  - **Overgrazing**: grazing animals destroy vegetation that binds soil particles
  - **Over-cultivation**: soil becomes exhausted
  - **Deforestation**: loss of roots to bind the soil



## Examiner Tips and Tricks

It's important to note that while some regions may experience certain benefits from climate change, such as increased agricultural productivity or longer growing seasons, the overall negative impacts tend to **outweigh** the positive ones.

## Changes on Agriculture

- Suitable areas for **agriculture** will change
  - Farmers may have to change their crops
  - Areas that could grow certain crops will have to change
    - Wheat grown in the USA will have to be grown in Canada
    - This will affect the USA's economy while boosting Canada's
- Coastal flooding may lead to **salt intrusion**
- Water shortages affect irrigation, limiting the choice of crops that can be grown
- Food shortages will lead to malnutrition and famine
  - A rise of 3°C would reduce crop yields by 35% across Africa and the Middle East
  - A 2°C rise would cause 200 million people globally to experience hunger



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## Impacts on Places & People



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# Effects on People & Places

- **Employment**
  - Loss of job opportunities due to changes in tourism and agriculture
  - Tourism may decline in some areas for example ski resorts may close due to the lack of reliable snow
  - Coastal resorts may be at risk of flooding leading to the closure
  - Decline in fishing in some areas due to changing ocean temperatures
  - Farmers either change the crop they grow or livestock they raise or face having to leave farming
- **Homes**
  - Increased flooding due to sea level rise and increased frequency and severity of storms will lead to **displacement** of large numbers of people
  - Homes in low-lying areas may have to be abandoned or need additional defences against sea level rise
  - Moving settlements or improving flood defences will be costly
- **Social**
  - Global warming is leading to increased human migration, particularly from low-lying islands
    - Some residents of Kiribati, South Pacific, have already abandoned their homes and claiming environmental refugee status
    - The UN's refugee agency, estimates that 1.2 billion people could be displaced globally by 2050 due to climate change and natural disasters
  - Problems such as hunger and conflict will increase as resources decline or change, which will also drive economic, social and cultural changes
    - LICs are more likely to be affected by changes as they are economically and technologically held back
    - 65% of workers in Bangladesh are involved in agriculture, however, this industry is threatened by floods and sea level rise

## Health Hazards



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- Climate change can impact human health in various ways
- Heatwaves, extreme weather events, changes in disease vectors (e.g. mosquitos), and reduced air quality can all have negative health consequences, including heat-related illnesses, respiratory problems, and the **spread of infectious diseases**
  - Just a 2°C rise in temperature would allow mosquitos to breed in previously cooler regions
  - Italy has experienced cases of malaria since 2017 when it was previously a malaria-free area
  - An additional **280 million** people may be affected by malaria
  - Water-borne diseases are more likely to spread
- Heat waves may lead to:
  - **Heat stroke**, dehydration and sunburn increase during heat waves
  - Stagnant air during heat waves increases air pollution levels:
  - **Respiratory** diseases increase and those suffering from respiratory illnesses such as asthma may be more affected
- Increased temperatures negatively affect people with **cardiopulmonary** diseases
- Diets may be restricted by food shortages leading to malnutrition and famine
- Milder winters may lead to fewer winter-related deaths

## Tourism & Ocean Transport Routes

- Ocean transport routes account for 90% of global trade
- New sea routes will open up as sea ice melts, although this will also cause geo-political issues in deciding on which country has sovereignty claims over the waters
- The new routes will reduce the time taken between ports
  - Until 2009, the Arctic ice pack stopped shipping between the Atlantic and Pacific oceans through the Arctic Ocean throughout most of the year
  - Global warming has made the Northwest Passage (NWP) more navigable through the ice, making the distance travelled up to 40% shorter than previously
  - Although, emissions from ships will impact the pristine Arctic environment
- However, existing routes will see a reduction in trade
  - Egypt could lose 60% of its trade through the Suez Canal from use of the Arctic NWP

- **Ports** will have to adjust to rising sea levels, some will be able to dock larger ships as they become deeper, whilst others will be engulfed
- Trade routes are threatened by intensifying storms through increased wind speeds, wave heights and precipitation
- **Tourism** will also change as:
  - Summer seasons are extended
  - Tourist resorts will have to move as sea levels rise
  - Extreme weather will damage infrastructure, erode and submerge beaches
  - Ocean acidification threatens natural attractions such as coral reefs
  - Winter sports decline as snow and ice disappear
  - Climate change leads to changes in biodiversity, affecting eco-tourism



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