Climate and resources (core: global climate; global resource consumption and security)

International Baccalaureate · IB Diploma · Geography · SL

Climate and resources

IB Diploma Programme Geography SL (first assessment 2019; 2017 guide). This topic covers the second and third units of the **core**, which SL and HL students both study: *Global climate – vulnerability and resilience* and *Global resource consumption and security*. Paper 2 tests the core. It asks short structured questions on each unit, a question on a visual source such as an infographic, and one essay. Good answers name real places at a stated **scale** (local, national or global) and give numbers.

In July 2021, a storm dropped 201.9 mm of rain on Zhengzhou in one hour, the highest hourly total ever recorded in mainland China. Streets and a subway line flooded, and almost 400 people died across Henan. One storm cannot prove climate change, but warmer air holds more water, so very heavy rain is becoming more common. This topic asks three questions: what is changing the climate, who is hurt most, and what can people do?

Must-know for this topic:

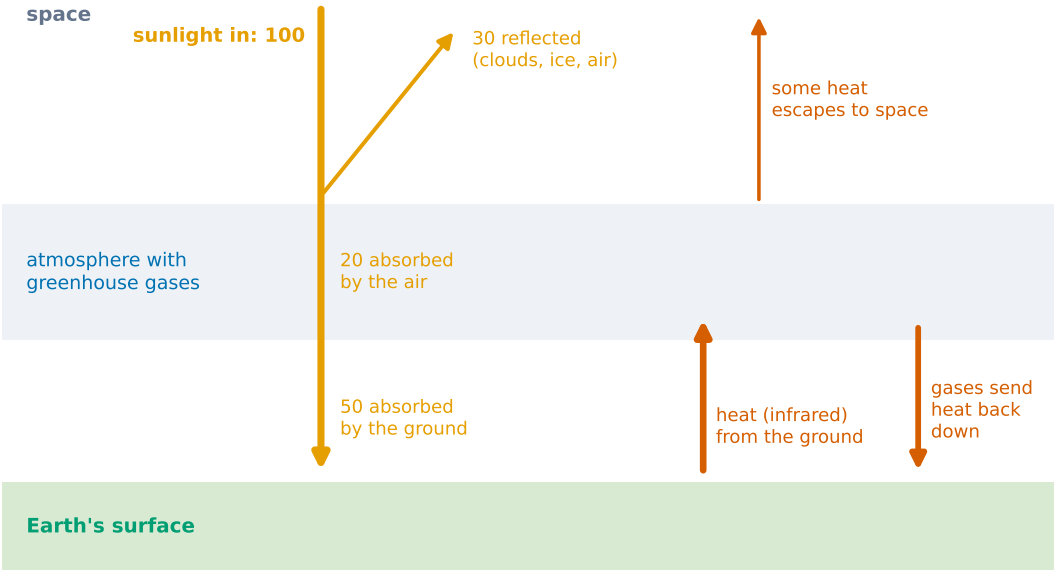
Unit	Key content
causes	the energy balance; the greenhouse effect; natural causes; feedback loops
consequences	warmer air and oceans, sea level, extreme weather; who is most vulnerable
responses	mitigation and adaptation; agreements, carbon trading, civil society
consumption	population and the middle class; the ecological footprint
security	water, food and energy security; the water–food–energy nexus
stewardship	Malthus and Boserup; the SDGs; the circular economy

Why the climate is changing

The energy balance and the greenhouse effect

The Earth gets energy from the Sun and loses energy as heat. If the two are equal, the average temperature stays the same. This is the **energy balance**. About 30% of the sunlight is reflected back to space by clouds, ice and the air. The rest warms the air and the ground. The warm ground gives off heat (infrared). **Greenhouse**

gases , such as carbon dioxide (CO_2), methane and water vapour, absorb much of this heat and send part of it back down. This is the **greenhouse effect** . Without it, the Earth's average temperature would be about −18 °C instead of about 15 °C.

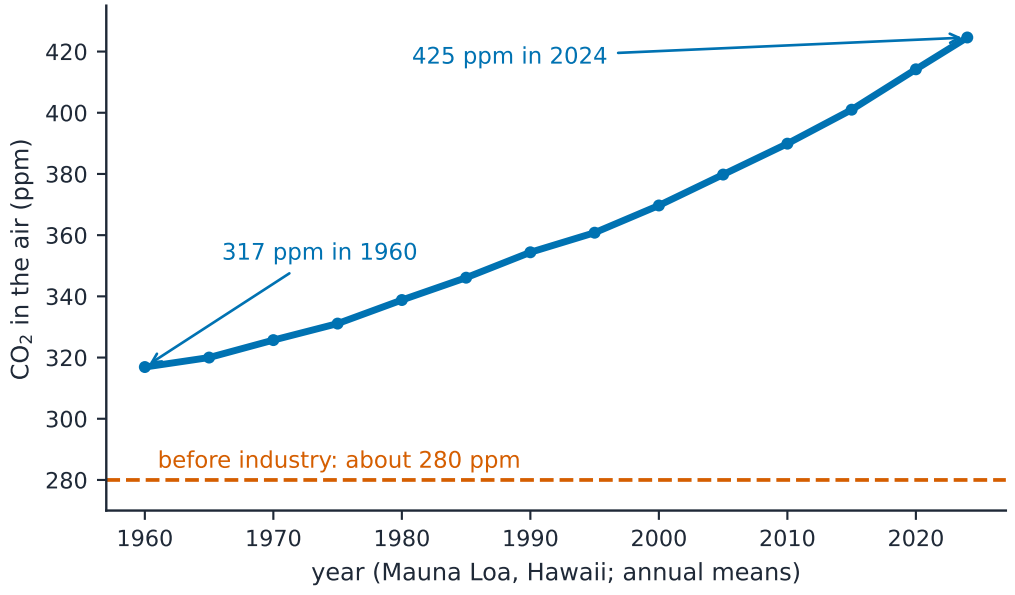


The energy balance: greenhouse gases keep part of the Earth's heat near the surface

People add greenhouse gases by burning coal, oil and gas, by cutting forests and from farming (cattle and rice fields release methane). This makes the greenhouse effect stronger: the **enhanced greenhouse effect** .

The evidence

The CO_2 level in the air has been measured at Mauna Loa in Hawaii since 1958. Air bubbles in old ice show that for 800,000 years before industry, CO_2 stayed between about 180 and 300 parts per million (ppm).



CO_2 at Mauna Loa: from 317 ppm in 1960 to 425 ppm in 2024

Worked example. *Calculate the percentage increase in CO_2 from 1960 to 2024.*

$$\frac{425 - 317}{317} \times 100 \approx 34\%$$

The increase from the pre-industrial level is larger: $(425 - 280) \div 280 \times 100 \approx 52\%$.

The world was about 1.1 °C warmer in 2011–2020 than in 1850–1900 (IPCC), and 2024 was the first calendar year more than 1.5 °C above that level. Global sea level rose by about 20 cm from 1901 to 2018, because water expands as it warms and because glaciers and ice sheets melt.

Natural causes and feedback loops

The climate also changes for **natural causes** : small changes in the Earth's orbit over tens of thousands of years (Milankovitch cycles), changes in the Sun's output, and large volcanic eruptions, which cool the Earth for a year or two. These cannot explain the fast warming since 1950.

A **feedback loop** makes a change bigger or smaller. In a **positive feedback** , warming melts ice; dark sea and land absorb more sunlight than white ice, so warming increases. Thawing **permafrost** releases methane, which adds more warming. Such loops may push parts of the climate past a **tipping point** , after which the change cannot easily be reversed.

Consequences and vulnerability

Climate change affects the whole Earth system: hotter heatwaves, heavier rain, longer droughts, warmer and more acidic oceans, coral bleaching, and rising seas. It affects people through health (heat stress, the spread of diseases such as dengue), food (lower yields in hot regions) and **migration** , when people leave land that floods or dries.

Not everyone is affected equally. **Vulnerability** depends on three things:

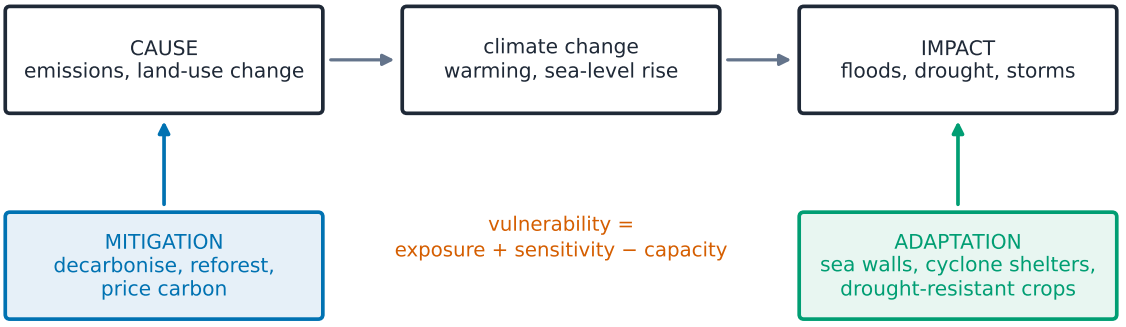
Factor	Meaning	Example
exposure	how much of the hazard reaches a place	Tuvalu's land is mostly less than 3 m above sea level
sensitivity	how much damage the hazard does	farmers who depend on rain, not irrigation
capacity	the money, knowledge and government to respond	the Netherlands can afford strong sea defences

Resilience is the ability to cope and recover. In 1970 the Bhola cyclone killed about 300,000 to 500,000 people in what is now Bangladesh. Since then Bangladesh has built thousands of cyclone shelters, trained volunteers and set up warnings by radio and phone. When Cyclone Amphan hit in 2020, a few dozen people died in Bangladesh. The hazard was similar; the capacity was very different.

Responding to climate change

There are two kinds of response:

- **Mitigation** reduces the cause: fewer greenhouse gases, or more carbon taken out of the air. Examples: solar and wind power, electric vehicles, planting forests, **carbon capture and storage** .
- **Adaptation** reduces the damage: living with the change. Examples: sea walls, heat-resistant crops, "sponge cities" that soak up rain, early-warning systems, moving people away from danger.



Adaptation raises capacity; mitigation shrinks the hazard itself.

Mitigation acts on the cause; adaptation reduces the damage from the impact.

Responses happen at every scale:

Scale	Example	Judgement
global	**Paris Agreement** (2015): keep warming well below 2 °C and try for 1.5 °C	nearly every country joined, but pledges are voluntary and not enough
national	China: CO_2 emissions to peak before 2030 and carbon neutrality before 2060; a national **carbon trading** scheme since 2021	large effect because China emits about a third of the world's CO_2
city	sponge city pilots in 30 cities from 2015, including Wuhan	helps with floods, but the 2021 Zhengzhou rain was far beyond the design
civil society	Fridays for Future school strikes from 2018	raised attention; hard to measure its effect on emissions

Some scientists also discuss **geoengineering**, for example spraying particles into the upper air to reflect sunlight. It might cool the Earth fast, but it does not stop CO_2 making oceans more acidic, and it could change rainfall in other countries.

> **Worked example.** *Evaluate one mitigation strategy.* Use four moves: name the strategy and its scale, say how it reduces the cause, measure it with a number, then give a limit. For the Paris Agreement: global; countries pledge to cut emissions and review the pledges every five years; the target is well below 2 °C; but the pledges are voluntary and, even if all are met, warming is still expected to pass 2 °C.

Resource consumption

The world population passed 8 billion in November 2022. Consumption grows faster than population, because more people join the **middle class** and buy more meat, cars and electronics.

The **ecological footprint** is the area of land and sea needed to supply what a person uses and absorb their waste, in global hectares (gha). The world average is about 2.6 gha per person, but the Earth can supply only about 1.6 gha per person. So humanity uses about $2.6 \div 1.6 \approx 1.6$ to 1.7 Earths. In 2024 "Earth Overshoot Day", the day by which we had used a year's supply of nature, was 1 August.

Renewable resources such as fish, forests, wind and sunlight can be used again if we use them no faster than they renew. **Non-renewable resources** such as coal, oil and metals exist in a fixed amount.

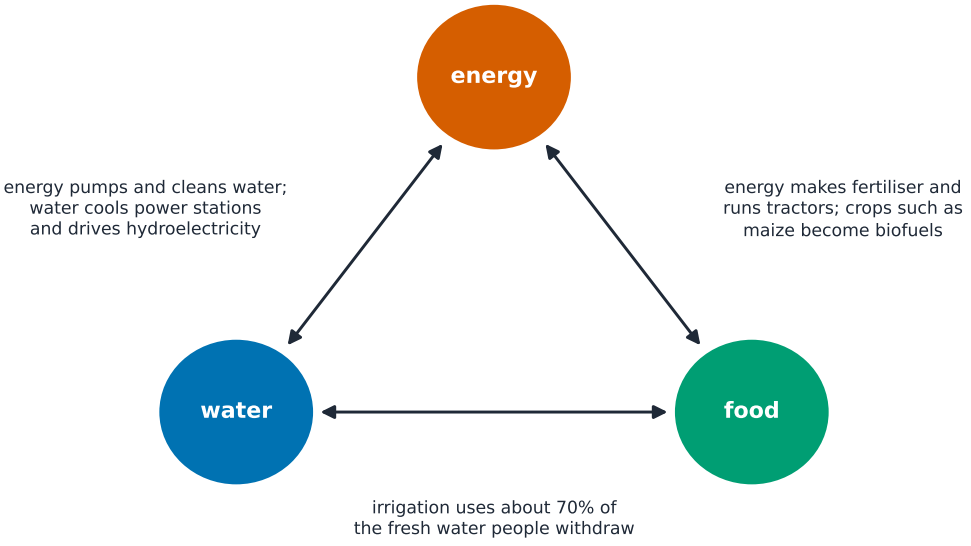
Water, food and energy security

A country has **water security** when people have enough safe water at a fair price. Farming takes about 70% of the fresh water that people withdraw. Water insecurity can be **physical** (too little water, as in the Middle East) or **economic** (water exists but people cannot afford the pipes and pumps, as in parts of sub-Saharan Africa).

Food security has four pillars: **availability** (enough food is produced or imported), **access** (people can afford it and reach it), **utilisation** (the food is safe and nutritious) and **stability** (all three last through bad years). A famine can happen even when there is enough food in a country, if poor people cannot afford it.

Energy security means a reliable supply of energy at an affordable price. China imports about 70% of the crude oil it uses, much of it by sea, which is one reason it invests heavily in solar, wind, nuclear power and electric cars.

The three resources depend on each other: the **water–food–energy nexus** - - .



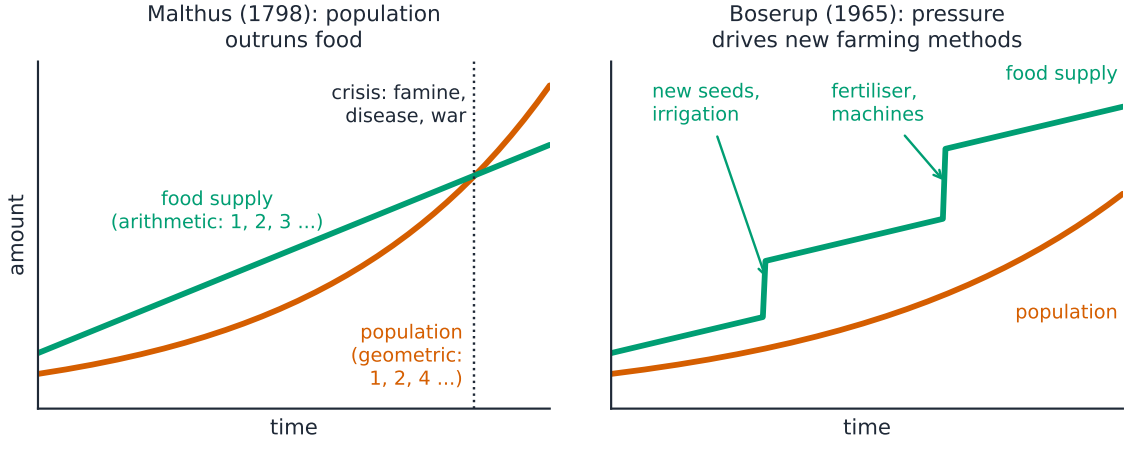
The water–food–energy nexus: using more of one resource changes the others

For example, growing maize for biofuel saves oil but uses farmland and water that could grow food.

Resource stewardship

Will the Earth run out of resources? Two classic views disagree:

- Thomas Malthus (1798): population grows faster than food, so famine, disease and war will stop growth.
- Ester Boserup (1965): when population grows, people find new ways to grow more food: "necessity is the mother of invention".



Malthus and Boserup: two views of population and resources

So far Boserup has been closer to the truth: the **Green Revolution** of the 1960s and 1970s, with new seeds, fertiliser and irrigation, raised world grain production much faster than population. But it used a lot of water and fertiliser, so a Malthusian limit may come from the environment instead of from food.

Resource stewardship means using resources carefully so that they last. The United Nations' 17 **Sustainable Development Goals** (2015) include clean water (Goal 6), clean energy (Goal 7) and responsible consumption (Goal 12). A **circular economy** keeps materials in use by repairing, reusing and recycling, instead of the "take, make, throw away" of a linear economy. China passed a Circular Economy Promotion Law in 2008.

Checklist

- The energy balance (30% reflected); the greenhouse and enhanced greenhouse effect; CO_2 280 → 317 → 425 ppm and the percentage calculation; 1.1 °C warming and 20 cm sea-level rise.
- Natural causes; positive feedback loops (ice, permafrost); tipping points.
- Consequences for the Earth and for people; vulnerability as exposure, sensitivity and capacity; resilience (Bangladesh 1970 and 2020).
- Mitigation and adaptation with examples at global, national, city and civil-society scales; geoengineering.
- Population and the middle class; the ecological footprint (2.6 against 1.6 gha); renewable and non-renewable resources.
- Water, food (four pillars) and energy security; the water–food–energy nexus.
- Malthus and Boserup; the Green Revolution; the SDGs; the circular economy.