Course Companion

International Baccalaureate · IB Diploma · Geography · SL

Every topic handout in one volume

全部专题讲义合集

exercises.lol

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Changing population (core: population distribution - changing population)

International Baccalaureate · IB Diploma · Geography · SL

Changing population

IB Diploma Programme Geography SL (first assessment 2019; 2017 guide). This topic covers the first unit of the **core** 核心部分, *Changing population*, which SL and HL students both study. It has three parts: where people live and why, how populations change, and the challenges and opportunities this brings. Paper 2 tests the core with structured questions, a visual source and an essay. The examiners like calculations from data, so each section below shows one.

In 2024, 9.54 million babies were born in China and 10.93 million people died. The population fell for the third year in a row, to 1.408 billion. Fifty years earlier, China's problem was the opposite: too many births. In one lifetime the country has moved from fast growth to decline. This topic gives you the tools to explain such a change and to judge what governments can do about it.

Must-know for this topic:

Part	Key content
distribution	physical and human factors; density; megacities; core and periphery
measures	birth and death rates; natural increase; doubling time; fertility
change	the demographic transition model; population pyramids; dependency ratio
policy	ageing and youthful populations; pro- and anti-natalist policies
migration	push and pull factors; refugees; internal migration; impacts

Where people live

Population distribution 人口分布 is the pattern of where people live. It depends on **physical factors** 自然因素 (climate, water, relief and soil) and **human factors** 人文因素 (jobs, transport, history and government policy). In China, about 94% of people live east of the "Hu Line", a line drawn from Heihe in the north-east to Tengchong in the south-west, on about 43% of the land. The west is high, dry and cold.

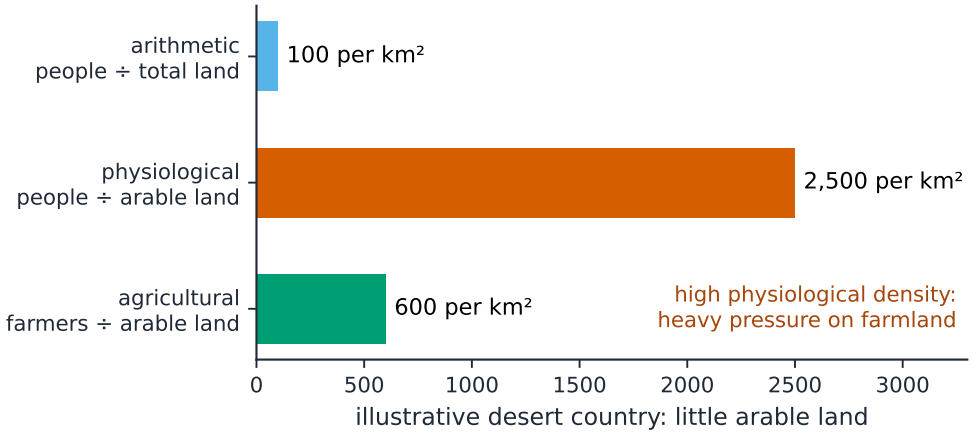


Shibuya Crossing, Tokyo: a photograph shows crowding at one moment, but population density is people per square kilometre

Population density 人口密度 is people per square kilometre:

$$\text{density} = \frac{\text{population}}{\text{area}}$$

Dividing by farmland instead of total area gives the **physiological density** 生理密度, which shows the pressure on the land that grows food.



The same population gives very different densities depending on which land you divide by

People also move towards cities. A **megacity** 超大城市 has more than 10 million people; there were 33 in 2018 (UN), including Shanghai, Beijing, Chongqing and Guangzhou. Inside a country, a rich, well-connected **core region** 核心区 (such as the Yangtze River Delta) attracts people, money and ideas from a poorer **periphery** 边缘区.

Measuring population change

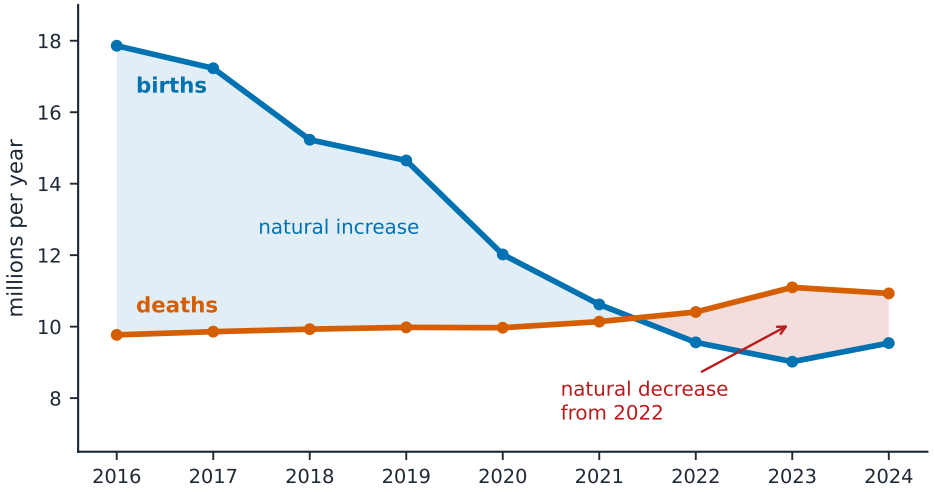
Measure	Meaning
crude birth rate 粗出生率 (CBR)	live births per 1,000 people per year
crude death rate 粗死亡率 (CDR)	deaths per 1,000 people per year
natural increase 自然增长	CBR minus CDR
total fertility rate 总和生育率 (TFR)	the average number of children a woman has

A TFR of about 2.1 is the **replacement level** 更替水平: each generation just replaces itself. China's TFR is about 1.0; Niger's is about 6.

> **Worked example.** A country has a CBR of 24 and a CDR of 8 per 1,000.

- Natural increase $= 24 - 8 = 16$ per 1,000 $= 1.6\%$ a year.
- **Doubling time** 倍增时间 $\approx 70 \div$ growth rate in $\% = 70 \div 1.6 \approx 44$ years.

Total change also includes **net migration** 净迁移: people arriving minus people leaving.



China's births and deaths, 2016–2024: natural decrease began in 2022

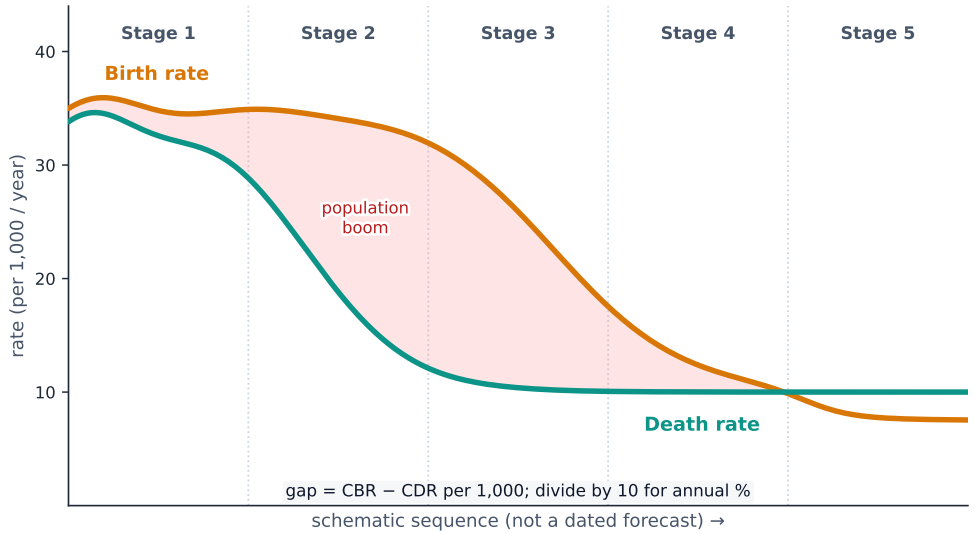
From the graph: in 2024, natural change in China was $9.54 - 10.93 = -1.39$ million.

How populations change

The demographic transition model

The **demographic transition model** 人口转变模型 (DTM) shows how birth and death rates change as a country develops:

Stage	Birth rate	Death rate	Growth	Reason
1	high	high	slow	disease, little medicine
2	high	falling fast	very fast	clean water, vaccines, more food
3	falling	low	slowing	education for women, cities, contraception
4	low	low	very slow	children cost a lot; people choose small families
5	very low	low or rising	falling	an ageing population (Japan, China)

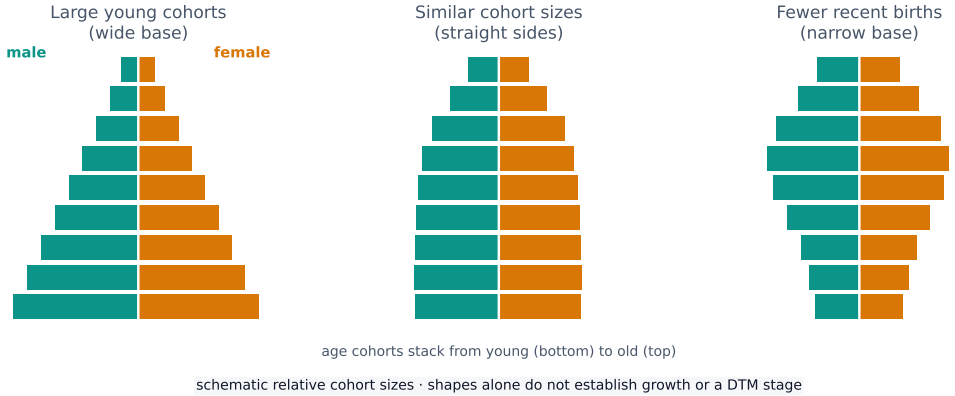


Demographic transition: death rates fall before birth rates, and the gap is population growth

The model is based on European history. It does not include migration, and it does not say how long each stage lasts: China passed through stages 2 to 4 in about 50 years, much faster than Britain.

Population pyramids and dependency

A **population pyramid** 人口金字塔 shows the number of males and females in each age group. A wide base means many young people; straight sides mean similar numbers at each age; a narrow base means few recent births.



A wide base means large young cohorts; straight sides mean similar cohort sizes

The **dependency ratio** 抚养比 compares people of non-working age with people of working age:

$$\text{dependency ratio} = \frac{\text{aged 0–14} + \text{aged 65 and over}}{\text{aged 15–64}} \times 100$$

> **Worked example.** A town has 20,000 people aged 0–14, 15,000 aged 65 and over, and 70,000 aged 15–64. Dependency ratio = (20,000 + 15,000) ÷ 70,000 × 100 = 50. Every 100 people of working age support 50 dependants.

When birth rates fall, a country for some years has many people of working age and few dependants. This can speed up growth: the **demographic dividend** 人口红利. China's fast growth from the 1980s used this dividend; it is now ending.

Challenges and policies

Ageing populations 人口老龄化 have more older people: Japan had about 29% of its people aged 65 and over in 2023. Problems: fewer workers, more spending on pensions and health care. Opportunities: older people care for grandchildren and volunteer, and "silver" industries grow. **Youthful populations** 年轻型人口 need schools and jobs; without jobs, young people may migrate or become frustrated.

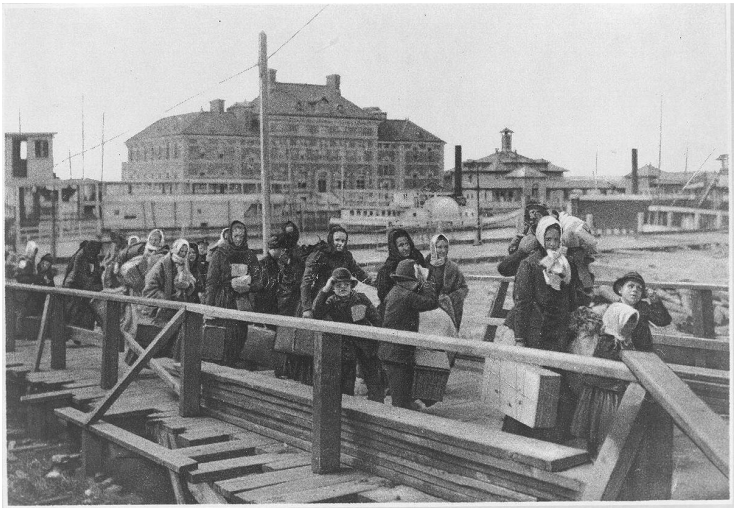
Governments respond with policies:

Policy	Aim	Example
anti-natalist policy 限制生育政策	fewer births	China's one-child policy, 1980–2015
pro-natalist policy 鼓励生育政策	more births	China's two-child (2016) and three-child (2021) policies; France's family payments
ageing policy	support an older population	China began slowly raising the retirement age in 2025

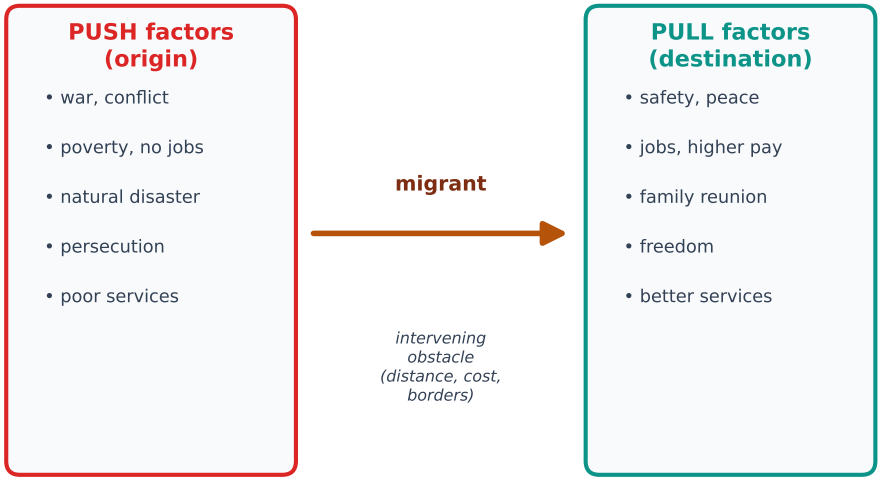
Policies on births work slowly. China allowed three children in 2021, but births kept falling, because housing, education and childcare are expensive and many young people marry later. China's **sex ratio at birth** 出生性别比 was also unbalanced: about 111 boys per 100 girls in the 2020 census, against a natural level of about 105.

Migration

Migration 迁移 is a long-term move from one place to another. It can be **internal** 国内的 or **international** 国际的, and voluntary or forced.



Migrants landing at Ellis Island, New York, c. 1900: economic pull factors drew millions across the Atlantic



Push factors at the origin, pull factors at the destination, and intervening obstacles between

Push factors 推力因素 drive people away; **pull factors** 拉力因素 attract them; **intervening obstacles** 中间障碍 such as cost, distance and borders stop some people. There were about 280 million international migrants in 2020 (UN). A **refugee** 难民 has crossed a border to escape persecution or war; an **internally displaced person** 国内流离失所者 (IDP) has fled but stayed inside their own country.

China has one of the largest internal migrations in history: the 2020 census counted about 376 million people living outside the area where their household is registered, most of them from villages to cities in the east. Under the **hukou** 户口 system, many migrants could not easily use schools and health care in their new city, which is slowly changing.

Migration has effects on both places:

	Place of origin	Destination
benefits	**remittances** 侨汇 (money sent home); less unemployment	workers for factories and services; younger population
problems	loss of young workers; children left with grandparents	pressure on housing and services; tension with local people

Checklist

- Distribution: physical and human factors; the Hu Line; arithmetic and physiological density; megacities; core and periphery.

- Measures: CBR, CDR, natural increase, TFR and replacement level 2.1; doubling time ($70 \div 1.6 \approx 44$ years); China's −1.39 million in 2024.
- The DTM: five stages with reasons, and two limits.
- Pyramids; the dependency ratio (worked example 50); the demographic dividend.
- Ageing and youthful populations; anti- and pro-natalist policies; the sex ratio at birth.
- Migration: push, pull and obstacles; refugees and IDPs; China's 376 million internal migrants and hukou; effects at origin and destination.

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

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Climate and resources

IB Diploma Programme Geography SL (first assessment 2019; 2017 guide). This topic covers the second and third units of the **core** 核心部分, 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** 尺度 (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:

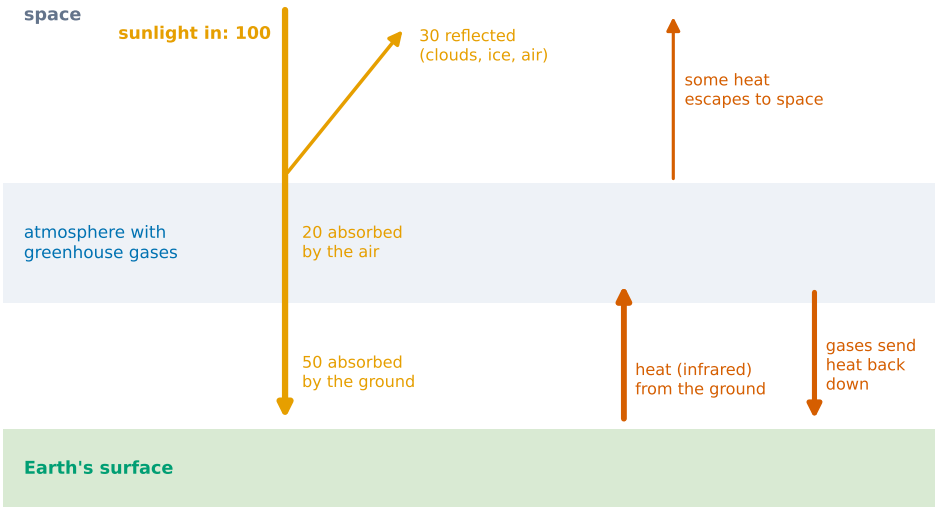
Unit	Key content
causes	the energy balance; the greenhouse effect; natural causes; feedback loops
consequences	warmer air and oceans, sea level, extreme weather; who is most vulnerable
responses	mitigation and adaptation; agreements, carbon trading, civil society
consumption	population and the middle 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** 能量平衡. 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 温室气体, 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** 温室效应. Without it, the Earth's average temperature would be about −18 °C instead of about 15 °C.

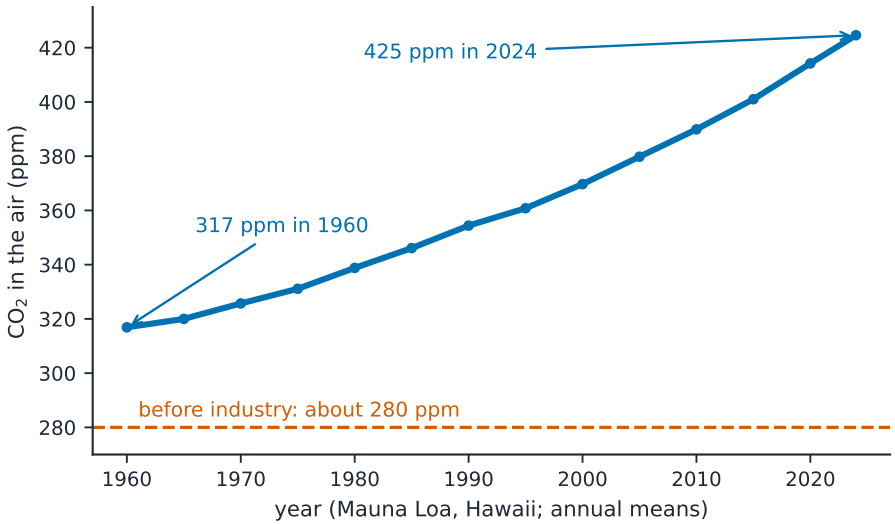


The energy balance: greenhouse gases keep part of the Earth's heat near the surface

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** 增强的温室效应.

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.

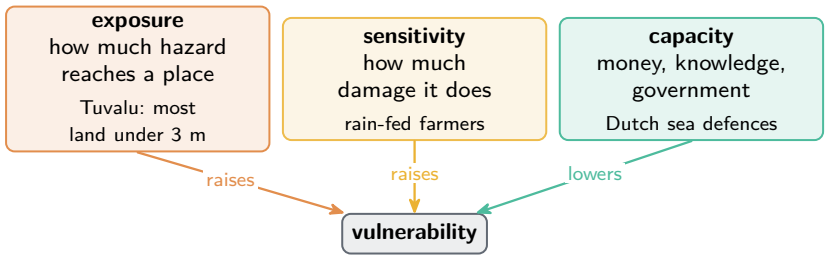
Natural causes and feedback loops

The climate also changes for **natural causes** 自然原因: 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** 反馈回路 makes a change bigger or smaller. In a **positive feedback** 正反馈, warming melts ice; dark sea and land absorb more sunlight than white ice, so warming increases. Thawing **permafrost** 永久冻土 releases methane, which adds more warming. Such loops may push parts of the climate past a **tipping point** 临界点, 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** 迁移, when people leave land that floods or dries.



Three factors decide who is hurt most.

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

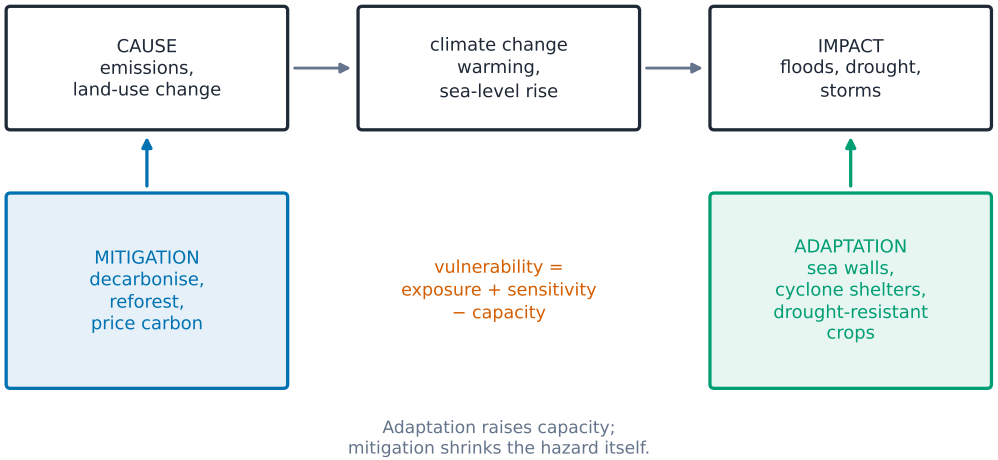
Factor	Meaning	Example
exposure	how much of the hazard reaches a place	Tuvalu's land is mostly less than 3 m above sea level
sensitivity	how much damage the hazard does	farmers who depend on rain, not irrigation
capacity	the money, knowledge and government to respond	the Netherlands can afford strong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

Resilience 恢复力 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** 减缓 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** 碳捕集与封存.
- **Adaptation** 适应 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.



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

Responses happen at every scale:

Scale	Example	Judgement
global	**Paris Agreement** 巴黎协定 (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** 碳交易 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** 地球工程, 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** 中产阶级 and buy more meat, cars and electronics.

The **ecological footprint** 生态足迹 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 可再生资源 such as fish, forests, wind and sunlight can be used again if we use them no faster than they renew. **Non-renewable resources** 不可再生资源 such as coal, oil and metals exist in a fixed amount.

Water, food and energy security

A country has **water security** 水安全 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).

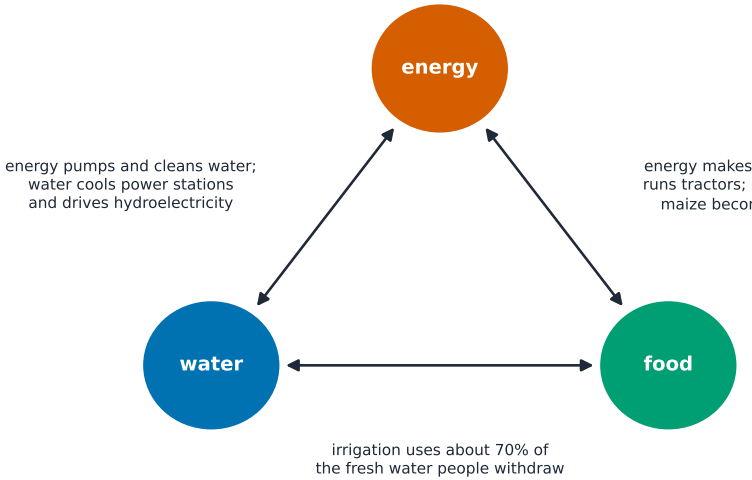


Solar panels: renewable energy can improve energy security, if storage and cost keep supply reliable

Food security 粮食安全 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 能源安全 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** 水-粮食-能源关联.



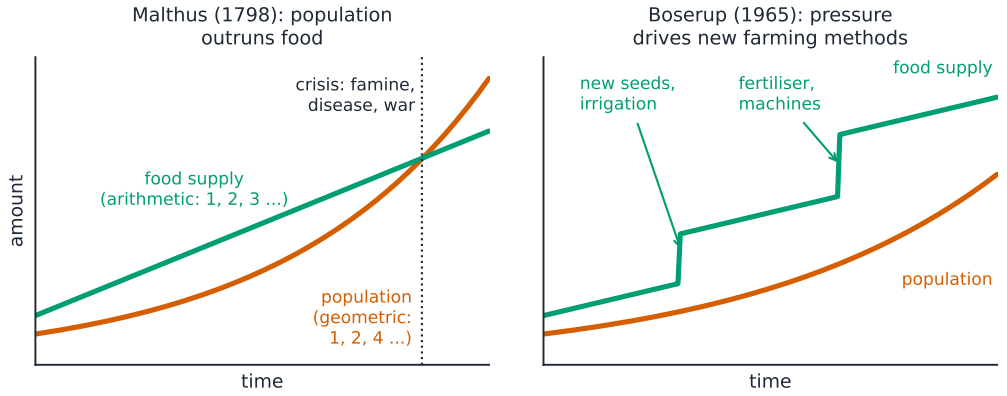
The water–food–energy nexus: using more of one resource changes the others

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** 绿色革命 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 资源管护 means using resources carefully so that they last. The United Nations' 17 **Sustainable Development Goals** 可持续发展目标 (2015) include clean water (Goal 6), clean energy (Goal 7) and responsible consumption (Goal 12). A **circular economy** 循环经济 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.

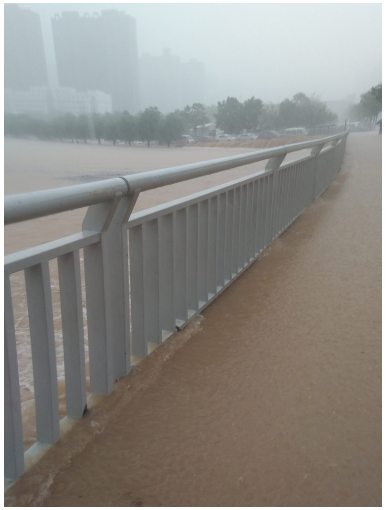
Options and fieldwork (option themes menu; geographic inquiry and sampling)

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Options and fieldwork

IB Diploma Programme Geography SL (first assessment 2019; 2017 guide). Besides the core, every student studies **optional themes** 选修主题: SL students study two of the seven options and HL students three. The options are examined in Paper 1. Every student also writes a **fieldwork** 野外考察 report on data they collect themselves: the **internal assessment** 内部评估 (IA). This topic gives each option's key ideas, processes and one case study, and then teaches the fieldwork method from question to conclusion.

In July 2021 more than 600 mm of rain fell on Zhengzhou in three days, close to the city's normal rainfall for a whole year. Water poured into underground train tunnels and roads became rivers. A few months later, coastal towns in England were still arguing about whether to build higher sea walls or let the sea take low farmland. The options study questions like these: how physical processes work, how they affect people, and how people manage them.



Floodwater pouring over a riverside path in Zhengzhou during the rain of 20 July 2021

Must-know for options and fieldwork:

Area	Key content
Paper 1	each option: structured questions (10 marks) and one essay from a choice of two (10 marks)
freshwater	drainage basin; storm hydrograph and lag time; hard and soft flood management
coasts	wave erosion and deposition; groynes, sea walls, managed realignment
extreme environments	glacial and hot-arid processes; opportunity against challenge
hazards	plate margins; risk depends on the hazard, exposure and vulnerability
tourism	Butler's model; carrying capacity; Venice's controls
food and health	famine as a failure of access; the epidemiological transition
urban	land-use models; megacities; urban stress and regeneration
fieldwork	question, hypothesis, sampling, analysis with r_s or χ^2, evaluation

How the options are examined

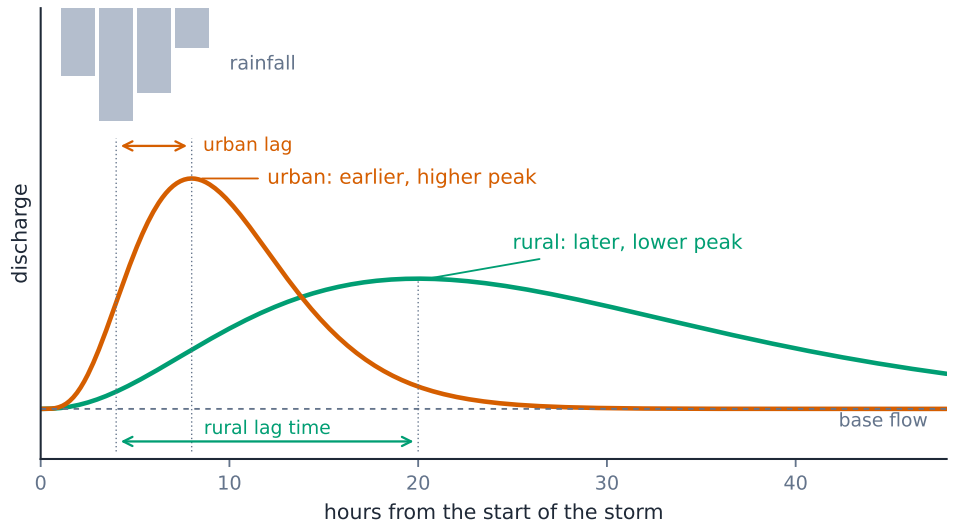
In Paper 1 each option has 20 marks. The first part is a set of short **structured questions** 结构化问题 (10 marks), often about a map, graph or table. Then you choose one of two essays (10 marks). SL students answer two options in 1 hour 30 minutes; HL students answer three in 2 hours 15 minutes.

The essays use the command terms *examine*, *discuss*, *evaluate* and *to what extent*. An essay answer needs a clear view, named examples with **specific detail** 具体细节 (places, dates, numbers), and a balanced judgement. "Floods are bad for people" earns little; "the 2021 Zhengzhou flood killed 380 people, including 14 passengers trapped in a flooded metro train" earns credit.

Freshwater

A **drainage basin** 流域 is the area of land that a river and its tributaries drain. Rain that falls on it can be stored (in soil, lakes and groundwater) or move to the river: over the surface (**surface runoff** 地表径流) or more slowly through the soil and rock.

A **storm hydrograph** 暴雨水文曲线 shows how a river's **discharge** 流量 (the volume of water passing a point each second) changes after a storm. Discharge rises along the **rising limb** 上升段 to a **peak** 洪峰 and falls along the falling limb. The time from peak rainfall to peak discharge is the **lag time** 滞后时间.



The same storm on two basins: the urban one peaks sooner and higher, so its lag time is shorter.

Cities shorten the lag time and raise the peak. Concrete and roofs do not let water soak in, and drains carry it quickly to the river. Steep slopes, saturated soil and a small, round basin have the same effect; forests and gentle slopes slow water down.

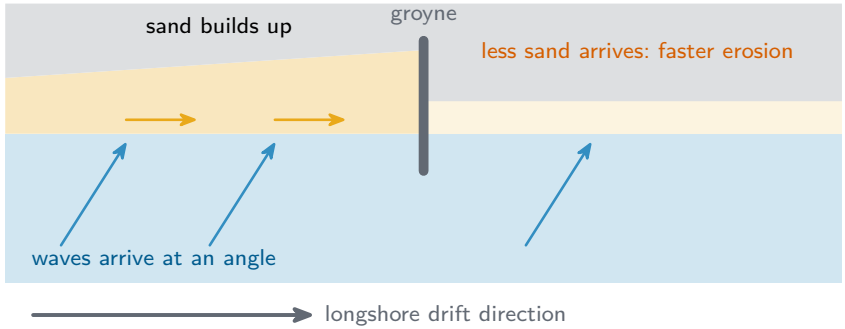
Flood management 洪水管理 can be hard or soft:

Type	Examples	Strengths	Weaknesses
hard engineering 硬工程	dams, embankments, straightened channels	protects a large area; can also store water and make electricity	expensive; changes the river ecosystem; can move the flood downstream
soft engineering 软工程	planting trees, wetlands, floodplain zoning, "sponge city" parks	cheaper; works with nature; better for wildlife	slower to work; needs land; may not stop a very large flood

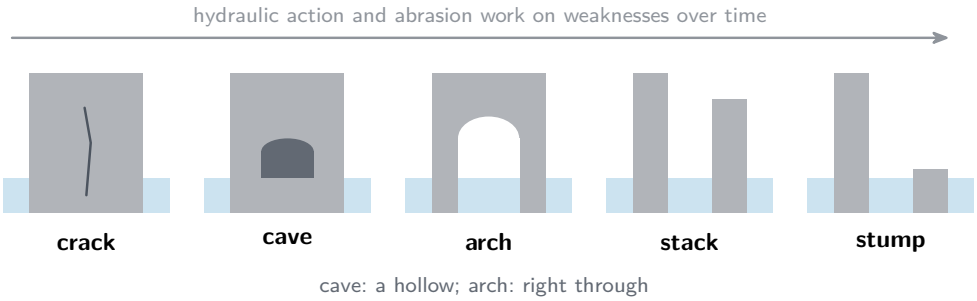
Case study: the Three Gorges Dam. The dam on the Yangtze (main body finished in 2006, fully working by 2012) stores flood water, generates about 22.5 GW of electricity and lets large ships reach Chongqing. About 1.3 million people were moved from the land the reservoir covered, and the dam traps sediment that once built up land downstream. China's **sponge city** 海绵城市 programme (started 2015) is a soft response for cities: parks, wetlands and porous pavements that hold rain where it falls.

Oceans and coastal margins

Waves shape coasts. They erode rock by **hydraulic action** 水力作用 (water and air forced into cracks) and **abrasion** 磨蚀 (rocks thrown against the cliff). Where waves lose energy, they deposit sand and shingle as beaches and **spits** 沙嘴. Where hard and soft rocks meet the sea, the soft rock is eroded into bays and the hard rock is left as headlands; caves, arches and stacks form at the headlands.



Defend one place and the next place pays.



Crack, cave, arch, stack, stump.

Longshore drift 沿岸漂移 moves sand along the coast in the direction of the main wind and waves. This is why coastal defences in one place affect the next place.

Strategy	How it works	Problem
sea wall	a concrete wall reflects waves	expensive; waves erode the beach in front of it
groyne 丁坝	a low wall across the beach traps drifting sand	the coast further along gets less sand and erodes faster
beach nourishment 海滩补沙	sand is added to the beach	must be repeated every few years
mangrove planting	roots hold mud and slow waves	needs warm, sheltered coasts and time to grow
managed realignment 有计划退让	old defences are removed and the sea floods low land, making a salt marsh	farmland and some homes are lost

Case study: the Holderness coast, England. Its soft clay cliffs lose about 2 m a year on average, one of the fastest rates in Europe. Groynes built at Mappleton in 1991 protected the village, but the cliffs to the south then eroded faster because they received less sand. At Medmerry (2013) the sea defences were moved inland, and the new salt marsh now protects homes and is a habitat for birds. A good essay weighs who gains and who loses from each choice.

Extreme environments

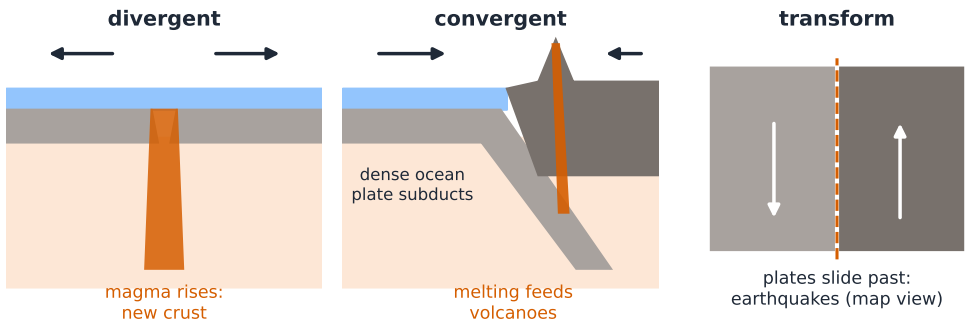
Extreme environments 极端环境 are cold (high mountains, polar and glacial areas) or dry (hot deserts). Ice erodes valleys into a U shape and leaves piles of rock called **moraines** 冰碛. In hot deserts, wind builds dunes and rare flash floods cut steep valleys called wadis.

People see these places as both **opportunities** 机遇 (minerals, tourism, solar energy, scientific research) and **challenges** 挑战 (cold or heat, little water, poor access, a fragile environment).

Case study: the Qinghai-Tibet Railway (opened 2006). Much of the line crosses **permafrost** 永久冻土, ground that stays frozen all year. Heat from a train track could melt it and make the track sink, so engineers built bridges and used pipes that carry heat out of the ground. The railway brings tourists and trade to Tibet; it also brings pressure on a fragile environment and on local culture.

Geophysical hazards

The Earth's surface is broken into **tectonic plates** 构造板块 that move a few centimetres a year. Most volcanoes and earthquakes happen at **plate margins** 板块边缘:



Constructive (divergent), destructive (convergent) and conservative (transform) margins.

Margin	Movement	Hazards	Example
constructive margin 建设性板块边缘	plates move apart	gentle volcanoes, small earthquakes	Iceland
destructive margin 破坏性板块边缘	one plate sinks under another	explosive volcanoes, large earthquakes, tsunamis	Japan
conservative margin 保守性板块边缘	plates slide past each other	earthquakes	California

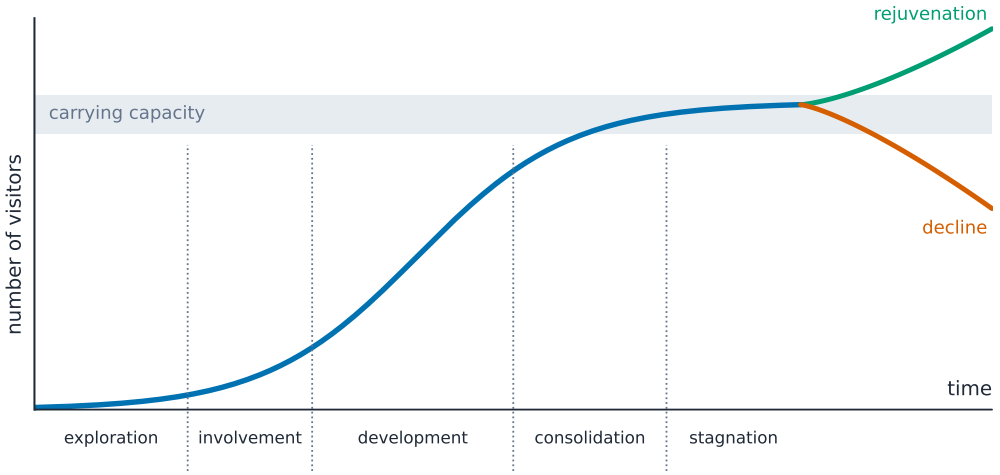
Hazard risk 灾害风险 grows with three things: how strong and frequent the hazard is, how many people and buildings are in its path (**exposure** 暴露度), and how easily they are harmed (**vulnerability** 脆弱性). Poverty, weak buildings and poor warning systems raise vulnerability.

$$\text{risk} = \text{hazard} \times \text{exposure} \times \text{vulnerability}$$

The model explains why similar events have very different results. The 2010 Haiti earthquake (magnitude 7.0) killed more than 100,000 people, because many buildings were weak and the capital was close to the **epicentre** 震中. The 2011 Tōhoku earthquake in Japan (magnitude 9.0) released about 1,000 times more energy. Strong buildings and early warnings saved many lives, but the tsunami was higher than many sea walls and about 18,000 people died or were never found.

Leisure, tourism and sport

The **Butler model** 巴特勒模型 describes how a tourist destination changes over time. A few visitors explore it; local people start to provide services; companies build hotels and visitor numbers grow fast. Growth slows as the place reaches its **carrying capacity** 承载力, the number of visitors it can take before the environment or visitor experience suffers. Then it stagnates, and either declines or is rejuvenated by new investment.



Butler's model: growth slows near the carrying capacity, then the destination is rejuvenated or declines

Case study: Venice. Fewer than 50,000 people live in the historic centre, but on busy days it receives far more visitors than residents. **Overtourism** 过度旅游 raises rents, pushes residents out and crowds the streets. Venice has stopped large cruise ships from sailing through the city centre (2021), limited tour groups to 25 people (2024) and charged day visitors an entry fee on the busiest days (since 2024). Critics ask whether a fee of a few euros changes behaviour or only raises money.

Food and health

Food security 粮食安全 means that all people can get enough safe and healthy food at all times. A **famine** 饥荒 often happens not because there is no food, but because people cannot afford or reach it. The economist Amartya Sen argued that in the Bengal famine of 1943 food was available, but prices rose far faster than the wages of the poor. This links to the "access" pillar of food security in topic 02.

As countries develop, the main causes of death change. This is the **epidemiological transition** 流行病学转变: deaths from infectious diseases (such as diarrhoea and tuberculosis) fall, people live longer, and **non-communicable diseases** 非传染性疾病 (heart disease, cancer, diabetes) become the main causes of death. Cheap high-calorie food and less physical work also raise **obesity** 肥胖. China has made this change within one lifetime: life expectancy rose from about 59 years in 1970 to about 79 years in 2023.

Urban environments

More than half of the world's people live in cities. A **megacity** 特大城市 has more than 10 million people. Shenzhen grew from a small border town in 1980 to about 17.6 million people in the 2020 census.



An informal settlement (favela) on a Rio de Janeiro hillside, built where formal housing and services could not keep up with growth

Land-use models 土地利用模型 describe how a city is arranged. Burgess's model shows rings around the centre; Hoyt's model shows sectors along transport routes. Use them as ideas to test against a real city, not as truths.

Fast growth causes **urban stress** 城市压力: housing shortages, traffic congestion, air pollution and waste. Responses include public transport, new housing and **urban regeneration** 城市更新, which turns old industrial land into new homes, offices and parks. A good evaluation asks who benefits: regeneration can raise rents and push poorer residents out.

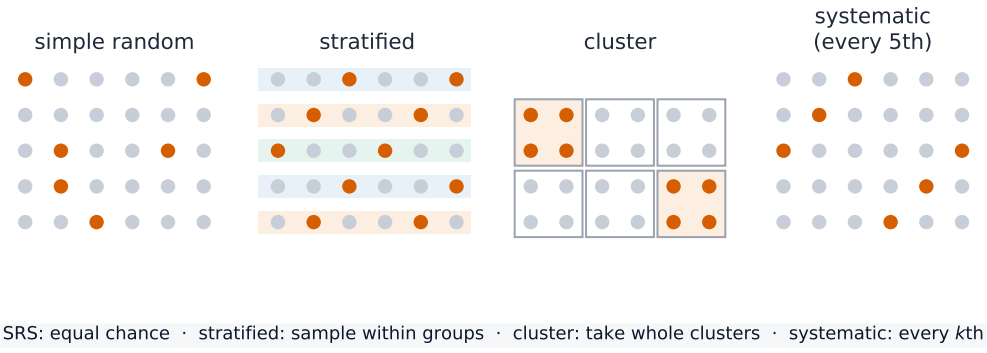
Fieldwork: geographic inquiry and sampling

The fieldwork report is worth 25% at SL and 20% at HL. It is a report of up to 2,500 words, marked out of 25, on **primary data** 一手数据 that you collect yourself in the field.

Stage	What you do
fieldwork question	a precise, local question you can answer with data you collect
hypothesis 假设	a testable statement; for a statistical test, also a **null hypothesis** 零假设 of no relationship
method	what you measure, where and when; a risk assessment and an ethics check
sampling	random, systematic or stratified (below)
presentation	maps, graphs and tables chosen to suit the data
analysis	describe the pattern, then test it, for example with Spearman's rank
conclusion and evaluation	answer the question; name the limitations and how to improve the method

You cannot measure everything, so you take a sample:

Sampling	How	Strength	Weakness
random sampling 随机抽样	random numbers choose each point	no bias from the student	may miss small areas
systematic sampling 系统抽样	every 100 m along a line, or every tenth person	covers the area evenly	can match a regular pattern by chance
stratified sampling 分层抽样	samples in proportion to known zones	every zone is represented	you must know the zones first



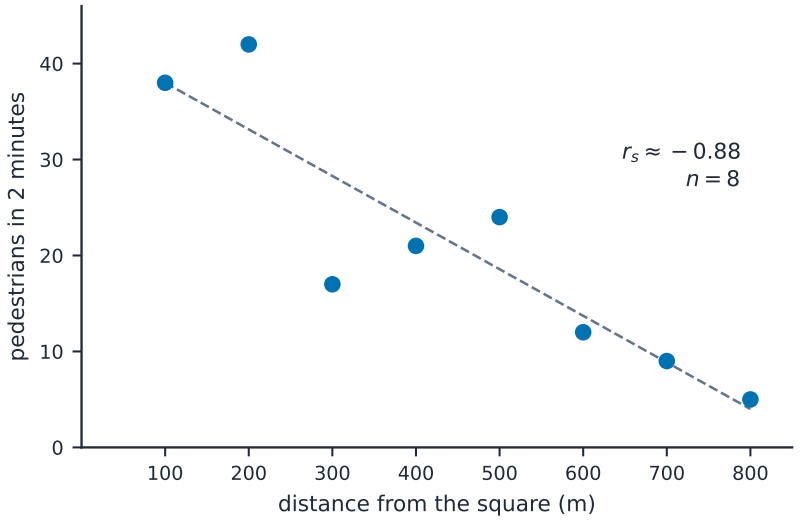
Random, stratified and systematic samples (and cluster, for comparison) on the same grid of sites

Worked example. Question: *Does the number of pedestrians fall with distance from the central square?* Hypothesis: pedestrian numbers fall as distance increases. Null hypothesis: there is no relationship. The student counted pedestrians for 2 minutes every 100 m along one street (systematic sampling).

Distance (m)	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**
pedestrians	38	42	17	21	24	12	9	5
rank of distance	1	2	3	4	5	6	7	8
rank of pedestrians (1 = fewest)	7	8	4	5	6	3	2	1
d^2	36	36	1	1	1	9	25	49

Here d is the difference between the two ranks, $n = 8$ and $\sum d^2 = 158$. **Spearman's rank correlation** 斯皮尔曼等级相关 is

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)} = 1 - \frac{6 \times 158}{8 \times 63} = 1 - \frac{948}{504} \approx -0.88$$



The eight counts fall with distance: Spearman's $r_s \approx -0.88$

The value is negative, so pedestrian numbers fall as distance rises. For $n = 8$, the critical value at the 5% level (two-tailed) is 0.738. Because 0.88 is bigger than 0.738, we reject the null hypothesis: the relationship is **statistically significant** 统计显著. This does not prove that distance causes the change: shops are also closer to the square.

For counts in categories, use a **chi-squared test** 卡方检验 instead. For a table with two rows and two columns there is 1 degree of freedom, and the critical value at the 5% level is 3.84; a result of 5.2 is above it, so the two variables are not independent.

Evaluation of the worked example: one street, one weekday morning and one 2-minute count per site. Better: several streets, counts at different times and days, and two or three counts at each site.

Criterion	**Marks**
A: fieldwork question and geographic context	3
B: method(s) of investigation	3
C: quality and treatment of information collected	5
D: written analysis	10
E: conclusion	2
F: formal requirements	2

Checklist

- Paper 1: 20 marks per option (structured questions and one essay); specific detail in every essay.
- Freshwater: the storm hydrograph and lag time; why cities flood faster; hard and soft management; the Three Gorges Dam and sponge cities.
- Coasts: hydraulic action and abrasion; longshore drift; the strategies and their problems; Holderness, Mappleton and Medmerry.
- Extreme environments: glacial and desert landforms; opportunity against challenge; the Qinghai-Tibet Railway on permafrost.
- Hazards: the three plate margins; risk from hazard, exposure and vulnerability; Haiti 2010 against Tōhoku 2011.
- Tourism: Butler's stages and carrying capacity; Venice's controls.
- Food and health: famine as a failure of access; the epidemiological transition.
- Urban: megacities; Burgess and Hoyt as models to test; urban stress and regeneration.
- Fieldwork: the inquiry stages; the three sampling methods; the Spearman's rank calculation and its critical value; chi-squared; the six IA criteria.