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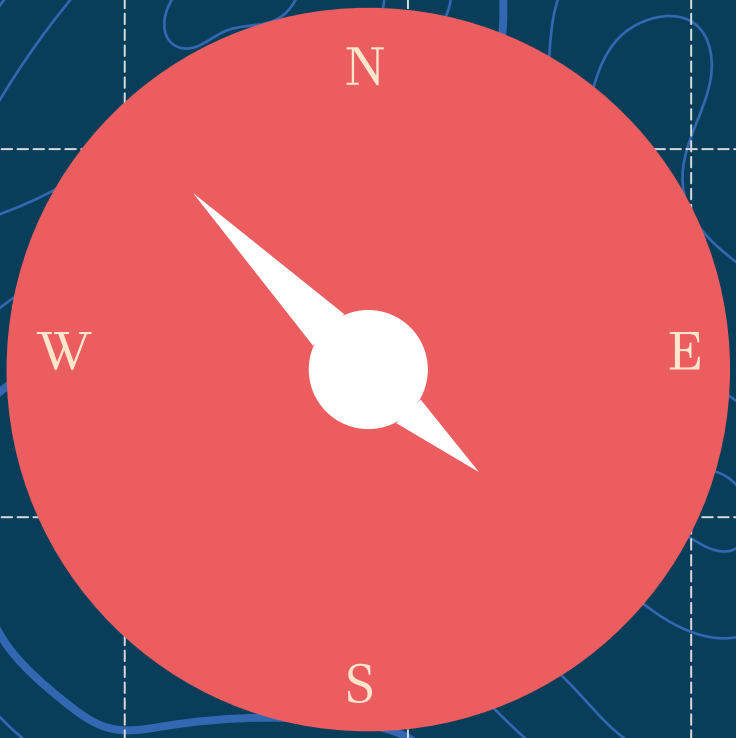

STUDY GUIDE:

GEOGRAPHY HL

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Geography HL
Study Guide

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Welcome to the IB.Academy guide for Geography HL.

Our Study Guides are put together by our teachers who worked tirelessly with students and schools. The idea is to compile revision material that would be easy-to-follow for IB students worldwide and for school teachers to utilise them for their classrooms. Our approach is straightforward: by adopting a step-by-step perspective, students can easily absorb dense information in a quick and efficient manner. With this format, students will be able to tackle every question swiftly and without any difficulties.

We distinguish between two aspects: *skill* and *understanding*. Skill is fostered when students practice the syllabus material and can identify variations within the steps even if the same general principle may be applied throughout. In doing so, understanding will soon follow since the student has applied the steps several times. It is a simple yet effective method that has helped many students and we hope it will aid you as well.

The best way to apply what you have learned from the guides is with a study partner. We suggest revising with a friend or with a group in order to immediately test the information you gathered from our guides. This will help you not only process the information, but also help you formulate your answers for the exams. Practice makes better and what better way to do it than with your friends!

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INTRODUCTION

Important command terms and their definitions

Agree or disagree. Support or refute a statement; give the positive or negative features; express an informed opinion one way or the other; list the advantages for or against.

Analyse. Break down in order to bring out the essential elements or structure. To identify parts and relationships, and to interpret information to reach conclusions.

Assess the degree. Command words such as these strongly suggest to the student that two schools of thought exist about a given subject. These questions often involve weighing the relative merit of conflicting points of view; e.g., negative vs. positive, strong vs. weak, fundamental vs. immediate.

Compare. Give an account of the similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.

Describe. Give a detailed account or picture of a situation, event, pattern or process.

Discuss. Offer a considered and balanced review that includes a range of arguments, factors or hypotheses. Opinions or conclusions should be presented clearly and supported by appropriate evidence.

Distinguish. Make clear the differences between two or more concepts or items.

Evaluate. To assess the implications and limitations; to make judgements about the ideas, works, solutions or methods in relation to selected criteria.

Examine. Consider an argument or concept in a way that uncovers the assumptions and interrelationships of the issue.

Give the significance of. Present information which determines the importance of an event or issue. Quite often used to show causation.

Support/Refute. Give the points in favour of, or opposed to, a predetermined point of view or particular position.

To what extent. Consider the merits or otherwise of an argument or concept. Opinions and conclusions should be presented clearly and supported with appropriate evidence and sound judgement.

CHANGING POPULATION

1

1.1 Population and economic development patterns

How does population vary between places?

Physical and human factors affecting population distribution at the global scale.

- Proximity to water (soil fertility, infrastructure, trade).
- Altitude and latitude (temperate climates, accessible, resources available).
- Hemispheres and landmasses.

Global patterns and classification of economic development in LICs, MICs, emerging economies, and HICs.

- 5 billion people live in MICs and 1/3 of global GDP is produced there.
- However, the number of countries classified as MICs has also been declining, and people tend to migrate to higher-income countries when possible.

1. Provide some examples of MICs.
2. Why is it hard to classify countries based upon their economies?

Population distribution and economic development at the national scale, including voluntary internal migration, core-periphery patterns, and megacity growth.

Case study.

In China

- 90% of the population lives of 30% of the land, majority concentrated by the coast and on friendlier, more productive terrain, while less than 4% of the population lives on 50% of the land (e.g., Tibet and Inner Mongolia).
- Internal migration: 160 million people have left rural areas for urban ones, this has also increased inequalities, creating urbanization and mega-regions.
- Largest cities: Beijing, Tianjin, Shenzhen, Hong Kong, Guangzhou, and Shanghai.

Case study.

In South Africa

- Uneven distribution, in general, the population decreases from the south-east to the north-west
- Depends on agricultural activities, mining (blacks moved to cities to work as labourers in gold and diamond mines), rainfall distribution, mountains
- Economic migration due to industrial development until 1950, forced migration during apartheid (4 million black people forcibly removed from "white" areas and relocated to "homelands" (outskirts) and "influx control", preventing blacks from entering "white" towns), blacks' voluntary migration to large cities after the collapse of the apartheid system in search of work
- Circular migration: when a worker moved repeatedly between home and host areas – frequently take poorly paid and insecure jobs in the informal economy, grandparents usually stay in rural areas and take care of the children due to the high cost of living in cities

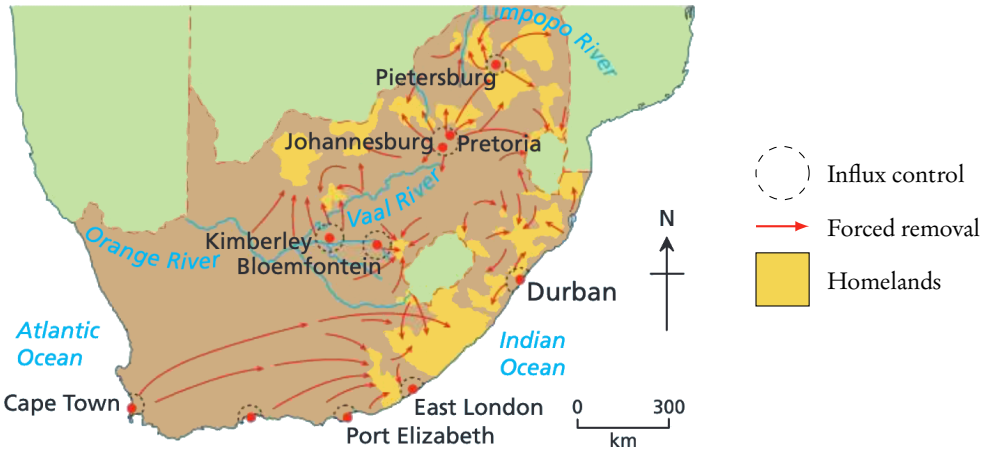

Figure 1.1: Forced migration within South Africa during apartheid.

Check your understanding.

1. Identify three physical factors that affect the distribution of population at the global scale.
2. Identify two human factors that affect the distribution of population at the global scale.
3. Briefly explain two physical reasons for the distribution of population in China.
4. Explain two contrasting reasons for the distribution of population in South Africa.

1.2 Changing populations and places

What are the processes of population change and their effect on people and places?

Population change and demographic transition over time, including natural increase, fertility rate, life expectancy, population structure and dependency ratios, and contrasts between countries.

Natural increase crude birth rate – crude death rate, expressed as a percentage, migration not taken into account.

Doubling time the number of years needed for a population to double in size, divide years by rate of natural increase.

Population momentum the tendency for population to grow despite a fall in birth rate of fertility levels, occurs because people are in the pre-childbearing and childbearing years, as they grow older, the greater number of births will exceed the number of deaths in the older populations, so the population will continue to grow.

Population projections predictions about future population based trends on fertility, mortality, and migration.

Total fertility rate (TFR) the average number of births per 1000 women of childbearing age, highest generally found among poorer countries, although some have transitioned to low fertility rates – changing fertility rates are due to sociocultural and economic factors for example:

- the status of women;
- level of education and material ambition;
- location of residence;
- religion;
- health of mother;
- economic prosperity;
- the need for children.

How do the above-listed factors influence fertility rates? (pg. 398)

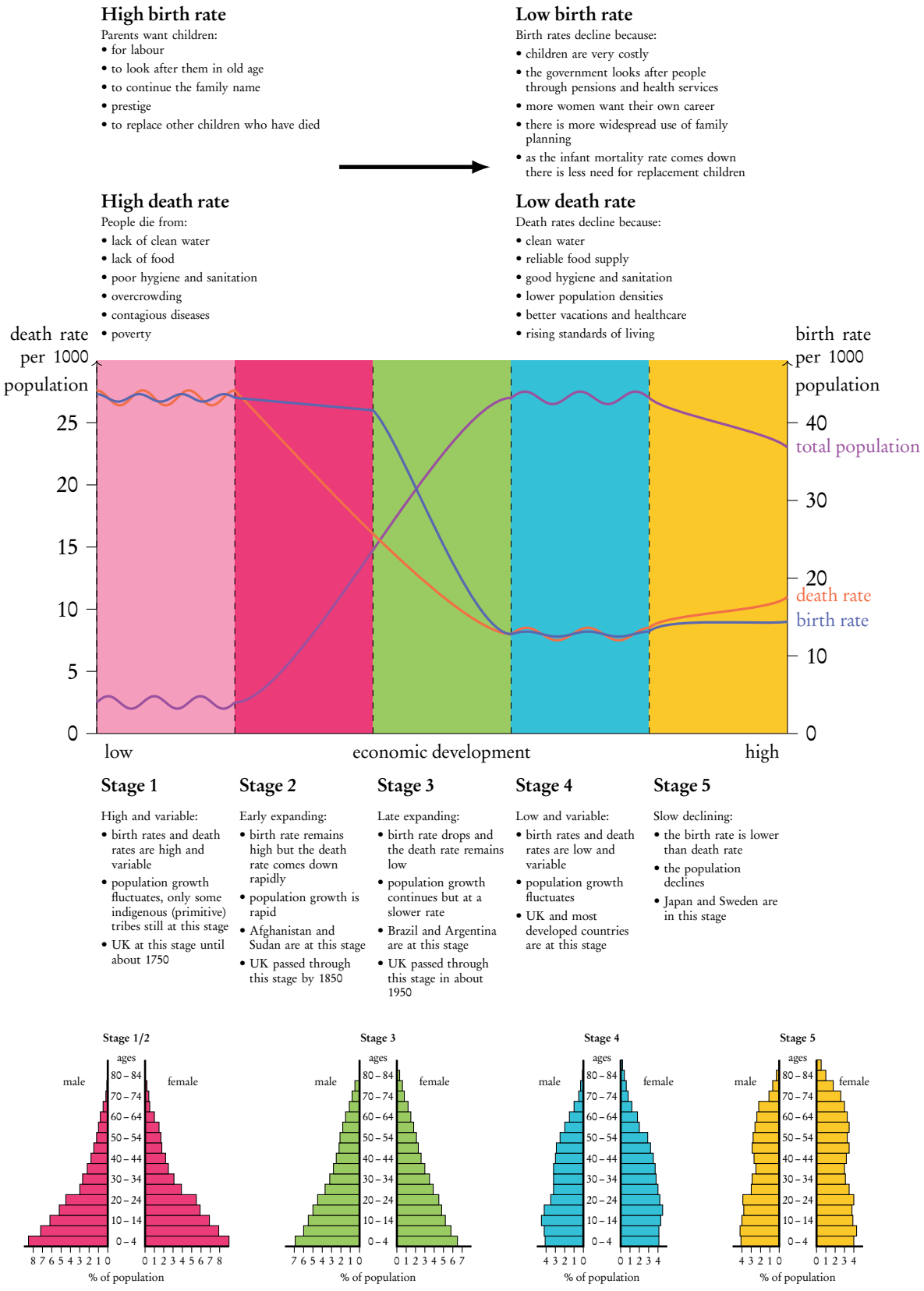

Figure 1.2: The demographic transition model (DTM).

Life expectancy the average number of years that a person can be expected to live, usually from birth, assuming that demographic factors remain unchanged.

Age/sex pyramids used to show the characteristics of a certain population:

- a wide base indicates a high birth rate;
- a narrowing base suggests a falling birth rate;
- straight or near-vertical sides reveal low death rate;
- concave slopes characterize high death rate;
- bulges in the slope suggest high rates of immigration or in-migration;
- "slices" in the slope indicate emigration or out-migration, or age-specific or sex-specific deaths (epidemics, war);
- plunger/Hershey's kiss shape indicates HIV epidemic – high death rates in child-bearing population, declining birth rates, and low death rate in younger populations.

Dependency ratios measures the working population and the dependent population and their relation to each other. It is a crude measure, but it is useful for comparing countries or tracking changes over time. In the developed world, there is a high proportion of elderly, while in the developing world there is a high proportion of youth.

$$\frac{\text{Population aged} < 15 + \text{population aged} > 64}{\text{Population aged 16–64}} \times 100$$

Triangular graphs used to show data that can be divided into three parts.

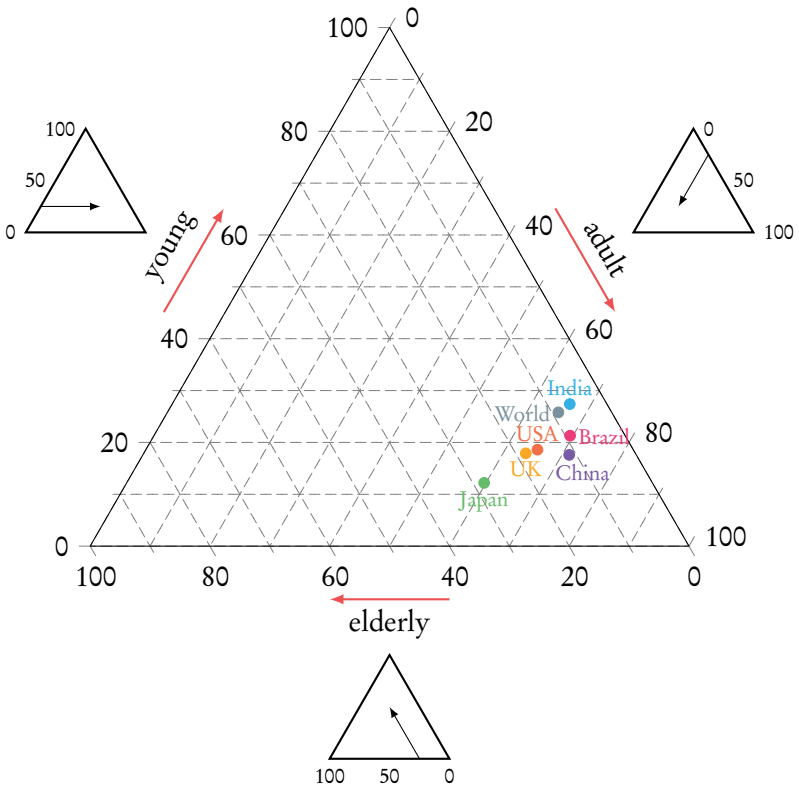

Figure 1.3: A triangular graph showing the age structure of populations

1. From Figure 1.3, work out the population structure for China, the USA and the world.
2. On a copy of Figure 1.3, add a dot to locate the population age structure for Ethiopia, Vietnam, and Zimbabwe, using the information in this table:

	Youthful	Adult	Elderly
Ethiopia	46	51	3
Vietnam	26	68	6
Zimbabwe	44	52	4

The consequences of megacity growth for individuals and societies.

- Megacity growth is associated with expansion of the built area, increased traffic congestion, air pollution, and declining water quality.
- Potential place of economic benefits for migrants.

Case study.

Mumbai as a megacity

- India's largest city, with 18 million people
- Economy has diversified from 1970s textile-based to aerospace, engineering, computers, and electronic equipment.
- Now it is the financial, commercial, and entertainment center of India – 40% of its trade accounted for, 6% of its total GDP, Mumbai's per capita income is 3 times the national average.
- Large disparities of wealth between those living in the city, many billionaires and millionaires, but more than half the population living in slums (Dharavi), slum near financial district, no secure tenure for inhabitants as it might be destroyed any moment to make way for infrastructural developments.
- More men than women living in the city (male migration common), informal economy quite large.
- Problems resulting from rapid city growth: poverty, unemployment, underemployment, limited access to healthcare and education, poor sanitation, poor sewage system, unequal access to electricity.

The environmental and political causes and consequences for people and places of forced migration and internal displacement.

Forced migration general term that refers to "the movement of refugees and internally displaced people as well as people displaced by natural or environmental disasters, chemical or nuclear disasters, famine, or development projects.

- Conflict-induced displacement: People who are forced to move due to armed conflict (civil war, violence or persecution on the basis of their nationality, race, religion, political opinion, or social group). In 2015, there were around 15 million refugees and approximately 40 million IDPs.
- Development-induced displacement: People who are forced to move as a results of large-scale infrastructure projects such as dams, motorways, airports, urban redevelopment, mining, deforestation, and even the creation of conservation schemes.
- Disaster-induced displacement: Natural disasters resulting in large numbers of displaced people including volcanoes, hurricanes, landslides, environmental change (global warming, desertification, land degradation) and human-induced disasters such as releases of radiation and chemicals.

Types of forced migrants:

Refugees: a "person residing outside his or her country of nationality, who is unable or unwilling to return because of a well-founded fear of persecution on account of race, religion, nationality, membership in a political social group or political opinion."

Asylum seekers: a person who has left their country of origin in search of protection in another country, under the 1951 UN Refugee Convention, but whose claim for refugee status has not been decided.

Internally displaced persons (IDPs): IDPs are grounds of people who have been "forced to flee their home suddenly or unexpectedly in large numbers, as a result of armed conflict, internal strife, systematic violation of human rights or natural or man-made disasters, and who are within the territory of their own country."

Development displacees: people compelled to move as a result of policies and projects to promote development.

Environmental and disaster displacees: sometimes referred to as environmental or disaster refugees.

Smuggled people: people moved illegally for profit. May include those who have been forcibly displaced as well as those who have left their homes in search of a better standard of living.

Trafficked people: people moved by deception or coercion for the purpose of exploitation and profit.

Case study.

Forced migration in and from Syria

- The ruling Assad regime in Syria and the emergence of the fundamentalist Islamic group ISIS have led to the displacement of over 10 million people.
- The conflict began as a civil war, but extended to parts of Iraq when ISIS declared Syria and Iraq and Islamic "caliphate".
- People in Damascus feared that government forces were being used on their own people, and it other parts of Syria, people feared they would be killed, captured, or forced to live under a sever and harsh Islamic rule.
- The result has been as stream of refugees and displaced people into neighbouring countries and other parts of Syria.
- In 2015, there were about 1.4 million Syrian refugees in Lebanon, around half of them children, most of them not attending school (1/4 of Lebanon's population).
- Most refugees depend on aid for their survival.
- The country has suffered sever economic and environmental consequences.
- Strain on its health and education services, electricity, water, and sanitation systems.

Case study.

Forced migration in Nigeria

- In 2014, Boko Haram kidnapped 276 schoolgirls in northern Nigeria.
- 3 million people have been internally displaced in Nigeria as a reaction to the violence.
- Created strained relations between Nigeria and its neighbours Cameroon, Chad, and Niger.
- 60% of the region's farmers were displaced, leading to less land being farmed and less produce harvested.
- One third of healthcare facilities closed own, and health workers have been abducted or killed.
- People lack access to fresh water and sanitation.
- Homes, services, and infrastructure have been extensively damaged, Boko Haram has also made many attacks on schools.

Check your understanding.

1. Describe the main changes shown by the demographic transition model.
2. Define the term "natural increase".
3. Suggest reasons for the growth of megacities.
4. Outline three different types of forced migration and their impacts.

1.3 Challenges and opportunities

What are the population possibilities and power over the decision-making process?

Global and regional/continental trends in family size, sex rations and aging/graying.

- Aging populations have certain advantages: the elderly might have skills and training, and some employers prefer them to younger workers.
- Elderly can look after grandchildren and allow the parents to work.
- The "gray economy: e.g., holiday companies, healthcare providers developed strategies for this specific market.
- By 2035, over-65s will be 14% of the world's population – shift due to a combination of the time-delayed impact of high fertility levels after WWII and more recent improvements in health that are reducing death rates at older ages.
- The contrast in life expectancy between rich and poor nations is stark: a person born in an HIC can expect to outlive their counterpart in an LIC by 14 years.
- The older dependency ratio (ODR): acts as an indicator of the balance between working-age people and the older population that they must support.

Case study.

Japan's aging population

- Decrease in both birth and death rates since 1945.
- In 2015, 26% of the Japanese population were aged over 65 years.
- Huge burden on pension funds and social welfare programs, especially healthcare:
  - inadequate nursing facilities;
  - depletion of the labour force;
  - deterioration of the economy;
  - a trade deficit;
  - migration of Japanese industry to other countries;
  - the high cost of funding pensions and healthcare;
  - falling demand for schools and teachers;
  - new jobs needed for the elderly;
  - new leisure facilities needed for the elderly;
  - an increase in the burden on the working population to serve the dependent population;
  - reduced demand for goods from the smaller working population;
  - a need for in-migration to fuel any increase in the workforce.
- Government can therefore e.g., raise taxes, raise the retirement age, cut back on social welfare programs, and increase care in people's homes.

Policies to manage population change that focus on policies related to aging societies and pro-natalist or anti-natalist policies.

- Countries and governments can either aim to increase or decrease population size and fertility rates.
- Family planning methods include contraceptives such as the pill and condoms, as well as drastic methods such as forced sterilization, abortion, and infanticide.

Case study.

China's one-child policy

- Imposed in 1979, one of the most severe and controversial family planning programs.
- Prevented around 400 million births.
- Changed in 2015 to allow couples to have two children.
- 118 male to every 100 female births: female infants valued less, they were aborted or neglected, abandoned, or killed (infanticide).
- Couples living in rural areas could have a 2nd child if the first one was a girl.
- Fertility rate dropped to 1.6 births per woman, thus easing food security fears, but labour force was shrinking and aging population was growing.
- A bit more relaxed now, but children seen as an expensive luxury.

Case study.

Pro-natalist policies in Russia

- Low fertility for a number of decades due to poor reproductive healthcare services, a relative lack of modern contraceptives, widespread and unsafe abortions, high divorce rates, an aging population structure, infertility and women choosing to have fewer children.
- Government tax of childlessness from 1941 to 1990, and families rewarded for having a 3rd or 4th child, then later for having two children.
- By 2006, fertility had dropped to less than 1.3 births per woman, so Putin announced measures to increase birth rate.
- Increase in pregnancy, birth, and child benefits according to the number of children a family had.
- Increased parental leave following the birth of a child.
- Increased payments to mothers of second and third children.
- Between 2006 and 2011, fertility increased by 21%, but after 5 years of the policy, women ended up still not wanting another child.

Policies to manage population change that focus on gender equality policies and anti-trafficking policies.

Case study.

Literacy and gender equality policies in Kerala

- A state in south-west India, with an even spread of population and no large cities.
- Successes in improving health, literacy, and education, as well as decreasing birth rate.
- Autonomy and stability of the government.
- Long-standing and continuing social reform.
- The status of women in society – enabled large sections of the population to give voice to their views and needs.
- Tradition of female employment in Kerala, with girls educated to the same standard as boys.
- There is open access to universities and college where women often study to be doctors and nurses.
- Jobs have been open to women in health and education since the early 20th century.
- Women have autonomy in their personal life, where there is no tradition of dowries and there are no obstacles to remarriage.
- Low TFR (1.9, just below replacement level), high life expectancies, high levels of literacy, low infant mortality rate.
- But women are marginalized in the economic process and have lack of control over resources.
- Women's participation rate in work is only 18% compared to males' 53%, women are concentrated in low-paid jobs such as farming, cottage industries, domestic services, and informal economies.
- Women organize self-help groups and micro-financing for themselves, but their roles in decision-making are limited.
- Legal system dominated by males, violence and sexual harassment against women is still common, and often related to their husbands' alcohol consumption.

Human trafficking: a trans-border, multinational phenomenon; refugees and migrants more at risk, as are LGBTI, religious, disabled, or stateless people.

Case study.

Trafficking of Nigerian women to Europe

- Women trafficked between Nigeria and Western Europe for sexual exploitation.
- Women believe they will have a prosperous new life, but are then forced into prostitution to pay back a large debt.
- Threats made to family members, corruption and blackmail are common.
- Women are controlled by "madams", older Nigeria women who have themselves been victims in the past.
- Gangs may also be engaged in distributing drugs on Europe's streets.

The demographic dividend and the ways in which population could be considered a resource when contemplating possible futures.

Demographic dividend a bulge in the number of adults in a population.

Occurs when fertility rates decline, allowing faster economic growth. Decline in fertility follows a decline in infant and child mortality rates, as well as increased life expectancies. Families will slowly begin to have fewer children, but the bulge in the population surges through age groups, and for a period of time, the dependency ratio is increased. It will then fall and the largest segment of the population will be of working age, therefore the dependency ratio declines dramatically, leading to the demographic dividend.

After the demographic dividend, the dependency ratio begins to increase once more, as the population that created the dividend grows old and retires. Then, a disproportionate amount of old people will be relying upon a smaller generation following behind them, making the demographic dividend a liability. (Currently seen in Japan, with younger generations abandoning many parts of the country.)

Benefits:

- increased labor supply if the economy can productively employ the new workers;
- increase in savings due to number of dependents decreasing;
- decrease in fertility rates, resulting in healthier women and fewer social and economic pressures at home – family planning methods important to instill in people and make available for those who want it (e.g., in Sub-Saharan Africa where the TFR is 5.1);
- more resources can be invested into children, leading to better health and educational outcomes – gender equality in education (helps delay marriage and pregnancy), healthy timing of pregnancies (good for both mother and baby), female participation in the labor force;
- economic growth from increasing GDP per capita and decreasing dependency ratio.

Actions to take:

- invest in child survival and health programs;
- commit to voluntary family planning to achieve the demographic transition;
- invest in the reproductive health needs to both married and unmarried youth;
- prioritize education – especially secondary education for girls.

Case study.

Ethiopia's demographic dividend

- Since 2000, infant and maternal mortality are on the decline, under 5 mortality has been halved, literacy has almost doubled, women's reproductive health improving – contraceptive use at 27% in 2012, while it was 6% in 2000.
- TFR now 4.8 children per women, used to be 6.5 a decade ago, in the capital, Addis Ababa, women have just over two children.
- But more than 40% of Ethiopia's population is under age 15, remains nearly two decades away from a possible demographic dividend.

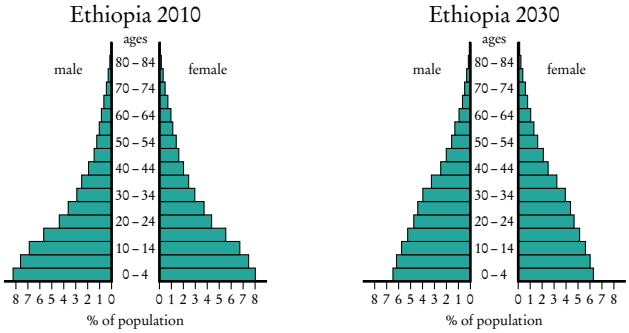

Figure 1.4: Ethiopia's age and sex structure, in 2010 and 2030.

Case study.

South Korea's demographic dividend

- South Korea rapidly transitioned to low fertility between 1960 and 1990, allowing for economic growth.
- Success due to: afforesting population issues while also investing in reproductive health programs and health centres, education and economic policies to create infrastructure and manufacturing.
- Fertility in 2005 was 1.2 children per woman.
- Focus on education: universal schooling, with a production-oriented education to provide people with the knowledge and skills they needed to achieve economic development – 97% if school-age children were attending school in 1990.
- Comprehensive economic planning also helped the economy of Korea, before it was largely based on farming and fishing, but then improved relations with Japan, leading to investment capital, unemployment tackled by a rural construction program that provided minimum wages for workers involved in the construction of infrastructure, contributing to both the development of a national infrastructure and economic growth.

Check your understanding.

1. Distinguish between pro-natalist and anti-natalist policies.
2. Briefly describe the impact of China's one-child policy.
3. Outline the main methods of tackling the trafficking of people. (pg. 416)
4. Define the term "demographic dividend". What are its advantages?

Key terms

North-South divide. The increasing inequality in levels of development between the North and the South or between HICs and LICs.

Development gap. The difference in wealth between the developed and developing world.

OPEC. The Organization of Petroleum Exporting Countries, representing the interests of oil exporters. Its position is undermined by some oil-producing countries such as the UK, which does not agree with OPEC-controlled oil prices.

The G7/G8. A group of the world's wealthiest and most powerful countries.

The G10 or Paris Club. A group representing the wealthiest members of the IMF.

Gross National Income (GNI) per capita. Measured by dividing a country's gross national income by its mid-year population.

Key questions.

1. How does population vary between places?
2. What are the processes of population change and what is their effect on people and places?
3. What are the population possibilities and power over the decision-making process?

2 GLOBAL CLIMATE – VULNERABILITY AND RESILIENCE

2.1 Causes of global climate change

How do natural and human processes affect the global energy balance?

The atmospheric system, including the natural greenhouse effects and the energy balance.

The atmosphere is 78% nitrogen, 21% oxygen, and the rest is made up of argon, carbon dioxide, helium, and ozone. There is also dust, ash, and soot (water vapours and solids/aerosols).

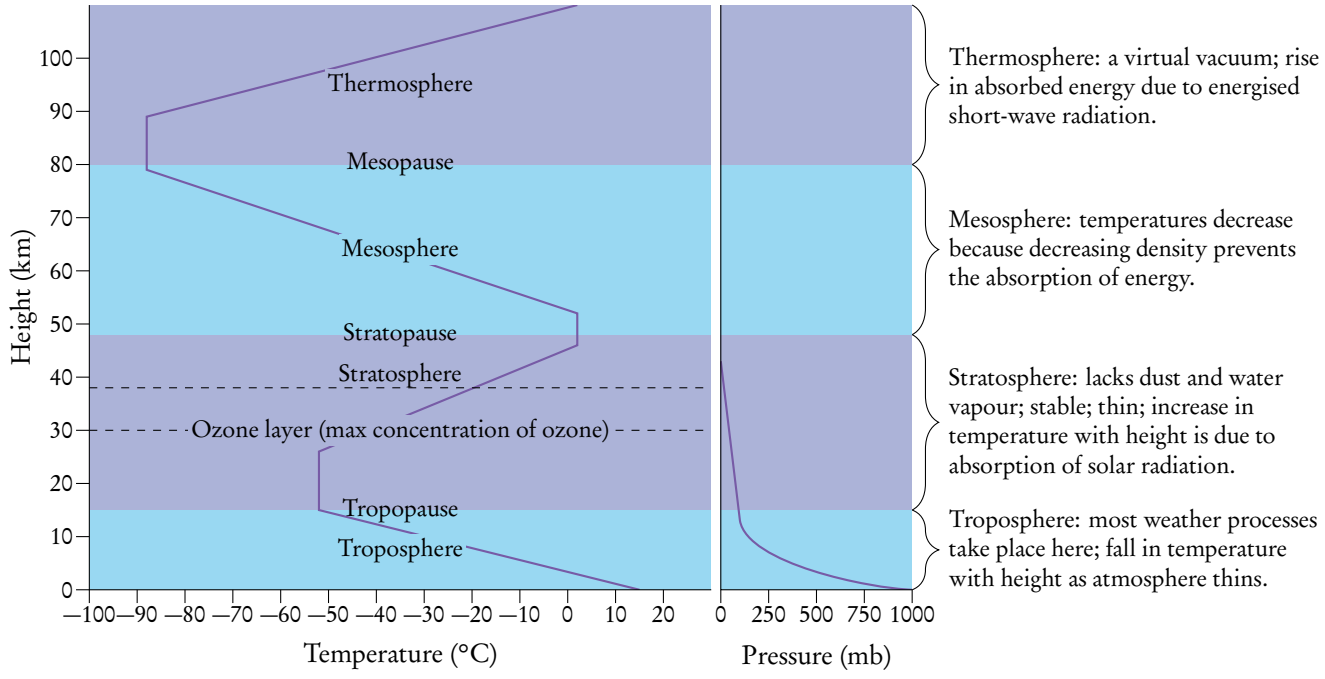

Figure 2.1: Atmospheric composition at various altitudes.

Insolation incoming solar radiation (short wave). All weather systems and climates are driven by the Sun. Earth absorbs most of its energy in the tropics, and the least at the poles. To compensate for this, energy from lower latitudes gets redistributed to higher latitudes with the help of wind circulation and ocean currents. Insolation is affected by latitude, season, and cloud cover.

There is a balance between insolation (input) and re-radiation (output) within the atmosphere. If everything stays the same, the climate long-term should not vary as quickly as it is doing now. The climate change we experience today has been linked to human activity.

Without human activities knocking the Earth's balance out of kilter, balance is achieved through radiation, convection, and conduction. Radiation refers to the emission of electromagnetic waves, both short-wave (from the sun, ultraviolet radiation or visible light) and long-wave radiation. Visible wavelengths are not absorbed by the Earth's atmosphere, instead they heat the Earth's surface, which in turn emits LW radiation. Convection is the transfer of heat by the movement of a gas or a liquid. Conduction is the transfer of heat by contact.

Only around 46% of the Sun's insolation gets to the Earth's surface. 31% of it is reflected back into space, and 19% is absorbed by atmospheric gases (oxygen and ozone at high altitudes and carbon dioxide and water vapor at low altitudes). Clouds can reflect 80% of total insolation (high albedo). Earth's surface itself can reflect 6% of insolation (planetary albedo).

Incoming short-wave radiation (insolation) turns into long-wave radiation once Earth re-radiates it, because Earth is a cold body. Clouds and the atmosphere absorb some of the energy and re-radiate it back to Earth (they act as an insulator, this is why cloudless nights in the desert are so cold). The less cloud cover there is and/or the higher the cloud, the more radiation reaches Earth's surface. Evaporation and condensation account for a 22% heat loss.

The greenhouse effect the atmosphere is heated from below, most of the incoming SW radiation is let through, but CO_2 traps the outgoing LW radiation, warming the atmosphere. Greenhouse gases include water vapor (50% of the greenhouse effect), CO_2 (20% of the GH effect), methane, and chlorofluorocarbons (CFCs).

Changes in the global energy balance, and the role of feedback loops.

Due to variations in solar radiation (Milankovitch cycles, solar flares), volcanic eruptions and global dimming (air pollution has a cooling effect, therefore it might be masking what would be been faster global warming that what is currently happening), and feedback loops.

Changes in the global energy balance resulting from terrestrial albedo changes and methane gas release and feedback loops.

Positive feedback includes albedo decreasing as ice caps melt, thawing permafrost raising methane levels, biomass decomposing more due to heat, and increased forest cover in higher latitudes thus decreasing albedo. These all have very long time lags, might be past the tipping point before it's noticed. Negative feedback can be increased evaporation at low latitudes, as a result of higher levels of precipitation, which may lead to increased snowfall on polar ice caps, thus reducing mean global temperature. Additionally, an increase in carbon dioxide can lead to more plant growth, which can in turn reduce atmospheric concentrations of carbon dioxide.

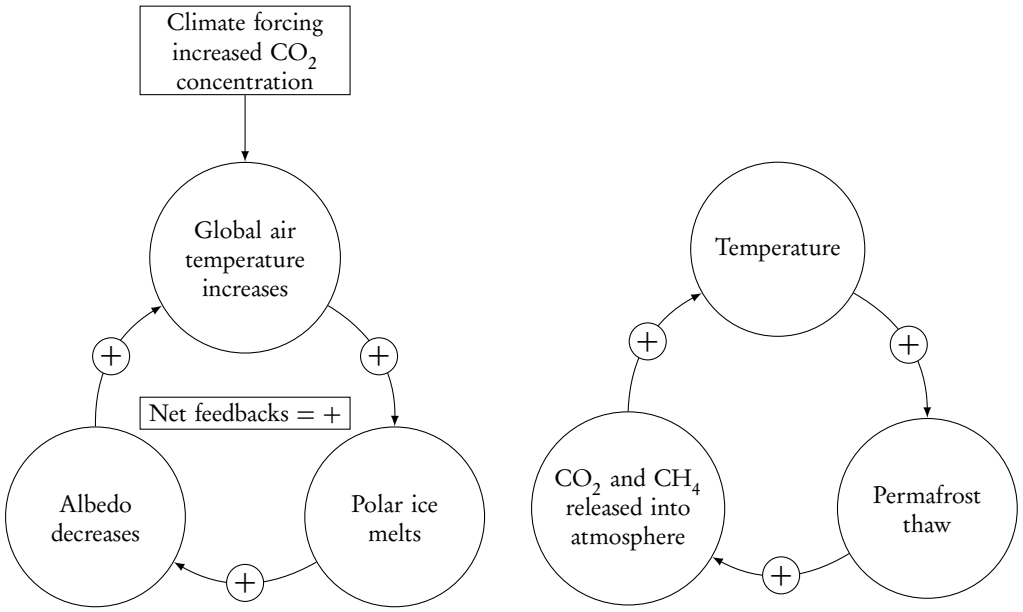

Figure 2.2: Showing positive feedback of melting ice reducing the planet's albedo and methane enhancing GCC.

Case study.

Negative feedback in Greenland

Increased melting of the ice sheet in Greenland could mean the return of very cold winters to Britain, as well as the shitting off of the currents of the Gulf Stream, allowing depressions to bring snow instead of rain, making its climate colder and more continental, such as that of Eastern Canada. This is a good example of why saying "global warming"instead of "climate change" is somewhat euphemistic and misleading.

The enhanced greenhouse effect and international variations in greenhouse gas sources and emissions, in relation to economic development, globalization, and trade.

The enhanced greenhouse effect is due to increasing levels of GHGs in the atmosphere as a results of human activity. It includes changes in global patterns of rainfall and temperature, sea level, habitats and drought, floods and storms, resulting from changes in the Earth's atmosphere.

The increase in the world's GHG emissions is linked to industrialization, trade, and globalization. Atmospheric carbon dioxide levels have increased as the world became more industrialized and more countries adopt a consumer culture.

The natural and enhanced greenhouse effect are not to be confused with each other, the first is needed for life to exist on Earth, while the latter has a lot of serious impacts on many societies in the form of a changing climate.

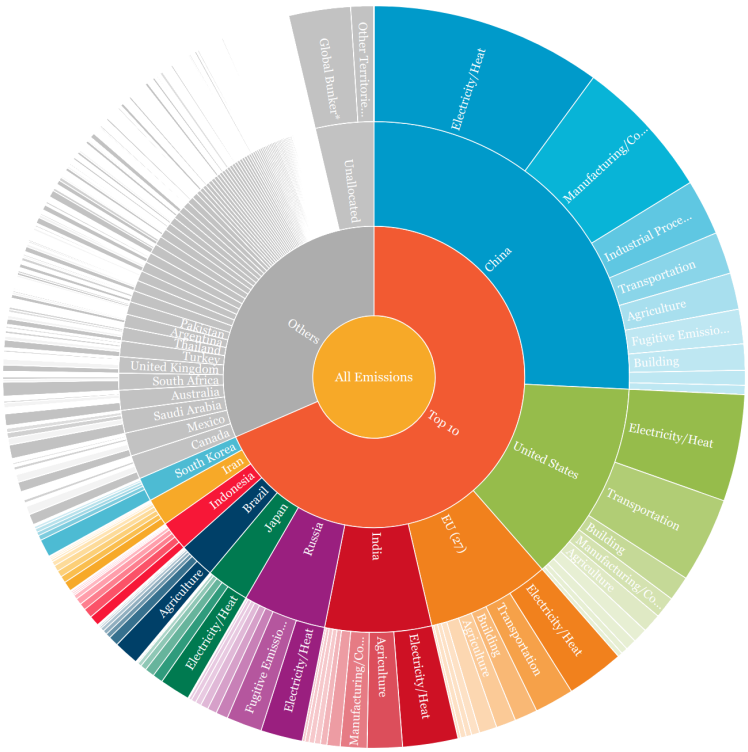

Figure 2.3: The main contributors to GHG emissions worldwide.

Check your understanding.

1. Distinguish between the greenhouse effect and global warming.
2. Suggest how globalization is linked to the enhanced greenhouse effect.
3. Draw the types of radiation coming from the Sun, and what happens with them on Earth, with both the natural and enhanced greenhouse effects.

2.2 Consequences of global climate change

What are the effects of global climate change on places, societies, and environmental systems?

Climate change and the hydrosphere, atmosphere, and biosphere.

GCC (global climate change) is predicted to have various, far-reaching effects on the natural, social, and economic environment. Effects and impacts on ice and snow, coastlines, water cycle, ecosystems, water resources, agriculture, coastal residences, and human health. Elaborate on these!

The changes include water stored in ice and oceans, and changing sea levels, and carbon stored in ice, oceans, and the biosphere. These can cause more floods and storms, a change in growing patterns and productivity, changes in rainfall, and the extinction of wildlife species (up to 40% predicted). However, the predictions cannot be entirely accurate, it is therefore difficult to know what exactly will happen and when regarding the climate.

Changes to the hydrosphere (freshwater, seawater, and ice/glaciers): flooding in low-lying areas could displace up to 200 million people, and floods from melting glaciers would present a threat to 5% of the world's population. Sea level rise is due to melting ice gaps and glaciers but also due to thermal expansion of water (steric effect). On average, by 2100, sea levels will have risen by 40 cm. The level of high tides and storm surges will also rise, and coastal cities will have a higher risk of flooding.

Changes in sea ice: Longer melting seasons, warmer temperatures, overall volume, thickness, and extent have been declining for decades. Less ice allows for bigger waves, which also helps break up the sea ice (positive feedback). Methane emissions from the tundra will increase because of the release of chlorine atoms from the sea. Some research linked the decline in Arctic sea ice to wet summers in Northern Europe, as a result of a weakened jet stream. Less ice also affects polar bears, as they are forced to spend more time on land and less time hunting. They have reduced in body size and reproductive success.

Changes in glaciers and ice caps: Many Himalayan glaciers are retreating, which can impact the Hindu Kush region, the source of many of Asia's major river systems, providing water for drinking, irrigation, and industry for about 1.5 billion people. For higher-elevation glaciers, glacial retreat could alter stream-flow characteristics in many basins.

Case study.

The retreat of Swiss glaciers

Predicted to recede at an accelerated rate, leading to massive changes in the landscape and changes in water balance, glacial lake outbursts, mudslides, and debris slides. The Gorner Glacier has retreated 2.5 km in the last 130 years, and since 1892, has been in continuous decline.

Changes in carbon stored in ice, oceans, and the biosphere: Due to human activity, some carbon sinks have become carbon sources. Most of it is stored in rocks, but this is largely unavailable in the natural carbon cycle due to the slow turnover rate. For the rest, 2% of carbon is stored in the atmosphere, 5% in biomass, 8% in fossil fuels, and 85% in the oceans. Before the industrial revolution, the main changes were due to volcanic eruptions, sea floor spreading, and meteorite impacts, but since, humans have greatly altered the carbon cycle by burning fossil fuels.

Oceans: They contain around 50 times more carbon than the atmosphere. However, with climate change, atmospheric carbon is driving changes in ocean carbon content. Both are rising. Increased carbon in the atmosphere warms they Earth and can make plants grow more and store more carbon, while increased carbon in the oceans acidifies the water, endangering marine life. Around 30% of carbon dioxide that humans have put into the atmosphere has diffused into the oceans. This makes the water more acidic, and when the excess carbon dissolves, it becomes carbonic acid. It reacts with carbonate to create bicarbonate. Shell-building organisms relying on carbonate are more likely to be weak.

The biosphere: Terrestrial plants have absorbed 25% of the carbon dioxide that humans have released into the atmosphere. Soils are also important carbon sinks and contain about 75% of land-based carbon. Deforestation leads to the release of carbon from trees and soils into the atmosphere. Additionally, by preventing wildfires, human prevent carbon from entering the atmosphere and allow carbon to build up in plants instead.

Ice: Permafrost contains large deposits of carbon, accumulated over thousands of years, in dead organic matter. In many regions, permafrost is beginning to thaw, which can increase decompositions of DOM and release more nutrients, increasing methane emissions. Decreased snow also reduces the reflectivity of the surface, causing it to warm up more and release more methane. If 10% of permafrost were to thaw, it could release enough methane to raise temperatures by an extra 0.7 °C.

Spatial changes in biomes, habitats, and animal migration patterns; and changes to agriculture, including crop yields, limits of cultivation, and soil erosion.

Biome changes: Models suggest a north-to-south shift in biomes relative to the equator (latitudinal). They will also move up slopes (altitudinal). Low-lying biomes (mangroves) may be lost as a result of changes in sea level. Species composition is also likely to change, but with such quick changes, animals are less able to adapt. They might not be able to migrate or have no suitable habitat at all, and go extinct. Up to 40% of wildlife species could become extinct in temperatures rise by 2 °C.

Agricultural changes: If temperatures rise by 3 °C, there will be a 35% drop in crop yields across Africa and the Middle East and 550 million may be affected by hunger. Changes in the location of crop-growing areas is expected, with movements away from the equator. Grapes for wine, wheat, and corn will move towards the poles. This shift would have a large impact on the US economy. Drought will also make it difficult for farmers to irrigate, and crop types will have to change depending on local weather patterns.

Case study.

The destruction of forests in the USA

- Dense American forests absorb 13% of GHGs that the US emits. Fire, insect infestations, and drought are threats that come with a warming climate and are being experienced. In 2015, 10 million of America's 766 million acres of forest were burning. It cost the US government $2 billion.
- Wildfires have become more common and costly around the world. They can be helpful and are an important part of the natural system. They clear away disease, remove leaf litter, and create space for new growth. However, since 1910, the US has suppressed wildfires and planted dense forest to replace what was lost to logging. GCC made droughts more severe, and the fire season was made longer due to hotter temperatures.
- Insects can also be devastating to forests. Drought-stressed trees lose their ability to repel insects (e.g., bark beetles). Insect numbers are surging due to warmer, drier weather, milder, shorter winters, the same reasons why trees are stressed. This makes it hard for the trees to regenerate. Mitigating the effects of forest devastation require a large intervention to clear dead trees and plant new ones. Most of the budget is spent on firefighting rather than prevention. Nearly 60% of trees are experiencing a contraction in their environmental range.

The impacts of climate change on people and places, including health hazards, migration, and ocean transport routes.

Much of the impacts depend on the scale of the changes. Tropical diseases are expected to spread as warmer conditions extend to higher latitudes. GCC can lead to more migration and environmental refugees (e.g., people from Kiribati or the South Pacific abandoning their homes due to sea level rise). Shipping routes on the sea can open up between Russia's Arctic coastline and the North-West Passage. However, there is a lot of geopolitical conflict in the area. Tourism may also grow, with longer summers and northerly locations becoming more friendly and welcoming for those going on vacation. Winter sports holidays are likely to decrease.

Social problems might come from hunger and conflict, which also in turn impact economic development. Natural resource bases will also change, impacting LICs more as they are less able to cope. Coastal flooding will affect large cities on the coast and those under sea level, e.g., the Netherlands. This can lead to economic and social stress due to loss of land and resources. Ecosystem services might also be lost, such as primary productivity, pollination, flood control, and climate regulation. The incidence and severity of extreme weather events, including drought.

More frequent and unpredictable extreme weather events can be expected as atmospheric patterns are disturbed. For example, 200 million people are at risk of losing their homes to flood or drought by 2050. There will be an increase in storm activity, with more frequent and intense hurricanes. Widespread drought will be all over the USA and southern Europe due to reduced rainfall. Lastly, if temperatures rise by 2 °C, 4 billion will suffer from water shortages. (See pg. 447 for the potential impacts of temperature increase at a 1, 2, or 4 °C increase.)

Case study.

Climate change and the UK

For the 2020s and beyond, temperatures are expected to increase at a rate of 0.2 °C per decade. It is equivalent of about a 200 km northward shift of the UK climate. By the 2050s, annual precipitation is expect to increase by 10%. There will be more intense rainfall events and extreme wind speeds, especially in the North. The contrast in the UK's climate will likely become exaggerated: the dry south-east will get drier and the wet north-west will get wetter. By 2050, more than 180,000 homes will be at risk of flooding. Sea levels will rise about 5 cm per decade. Places where the land is sinking will feel this more severely. By 2050, average sea levels will be about 35 cm higher, with a higher probability of storm surges as well.

Potential effects of a changing climate the in the UK.

Positive effects

- An increase in timber yields (up 25% by 2050), especially in the north, with perhaps some decrease in the south.
- A northward shift of farming zones by about 200–300 km per °C of warming, or 50–80 km per decade, which will improve some forms of agriculture, especially pastoral farming in the north-west.
- Enhanced potential for tourism and recreation as a result of increased temperatures and reduced precipitation in the summer, especially in the south.

Negative effects

- Damage from increased storminess, flooding and erosion to natural and human resources and human resource assets in coastal areas.
- An increase in insects, resulting from northward migration from the continent and as small decrease in the number of plant species as a result of loss of northern and montane (mountain) types.
- An increase in soil drought, soil erosion and shrinkage of clay soils.

Check your understanding.

1. Distinguish between a carbon sink and a carbon source.
2. Briefly explain the potential impact of GCC on agriculture.
3. Explain how GCC affects sea levels.
4. Outline the links between GCC and migration.

2.3 Responding to global climate change

What are the possibilities for responding to climate change and who has power over the decision-making process?

Disparities in exposure to climate change risk and vulnerability, including variations in people's location, wealth, social differences, and risk perception.

Climate change risk and vulnerability vary according to a person's location (altitude, proximity to water, island nations), wealth, social differences (age, gender, education, status, way of life), and risk perception. Vulnerability refers to the degree to which people are susceptible to, or unable to cope with the adverse impacts of GCC. It depends on exposure (the degree to which people are exposed to GCC), sensitivity (the degree to which they could be harmed by exposure to GCC), and adaptive capacity (the degree to which they could mitigate the potential harm by taking action to reduce their exposure or sensitivity). It is also not just people that are affected, but also institutions such as emergency services, schools, transport services, physical infrastructure, political organizations, and economic activities.

Case study.

Flooding in Bangladesh Most of the country forms a delta from 3 main rivers, which periodically flood the land, watering crops and increasing soil fertility. Since 1970, the frequency, duration, and intensity of these floods have increased. A 2.6 °C rise in temperatures will lead to widespread, repeated flooding. The densely populated coastal zone is also vulnerable to rising sea levels. Monsoon rainfall is also predicted to increase by 14–40% by 2030, and 52–135% by 2090. Since 1990, the frequency of extreme precipitation has increased. Normal floods have become catastrophic due to higher vulnerability and reduced resilience in Narayanpur island.

The government has developed its Flood Action Plan: sluice gates were built on a number of rivers, which also provide protection from flooding by tidal waves and storm surges. Embankments mostly along the coast have been built, as well as drainage channels, aimed at diverting floodwater away from buildings. Flood shelters on stilts have been built, as well as brick toilets with septic tanks to reduce water contamination.

The livelihoods of people are very vulnerable due to frequent flooding. These include their personal security such as deaths from drowning, deaths from water-borne diseases, loss of income, or an unavailability of fuelwood or gas. Additionally, their houses and places of worship as well as factories might be washed away. Lastly, there is a frequent loss of livestock, shortages, and damage done to the vegetation.

Fragile construction materials (sand, mud) cause the buildings to withstand less. Income levels are usually very low, and its sources are not very diverse. Pre-disaster people increase their savings, raise their houses on stilts, and move important items to safer places. Post-disaster, they sell assets to buy food and equipment.

Case study.

Coping mechanisms of communities along the Padma River, Bangladesh.

Coping mechanism	Period of use*
Economic coping strategies	
Saving money	Pre
Searching for relief materials	Post
Selecting flood-resilient crop varieties	Pre
Diversifying income sources	All
Repairing damage to the house	Post
Borrowing money	Post
Selling assets	Post
Adjusting consumption	Post
Social coping strategies	
Preparing to shelter at a friend's or relative's house	Pre
Evacuating family, especially children and the elderly, to a safe place	During
Evacuating important items to a safe place	Pre and during
Helping other community members	During and post
Preserving food and fuel on the selling of the house	Pre and during
Technological or structural coping strategies	
Getting flood warnings via TV, radio or other means	Pre
Building dykes in front of house with sandbags	Pre
Building house with transferable construction materials	Pre
Raising the base of the house	Pre
Building *Machan* for saving properties	Pre and during

* pre, during or post disaster
Source: Sultana, R., Rumi, S Rafiqul Alam and Hanif Sheikh, MA. 2013. "Climate change induced flood risk and adaptation in the Padma River Islands, Bangladesh: a local-scale example" Journal of Life and Earth Science, volume 8, pages 41–8.

Case study.

Vulnerability and adaptation in Ghana

See more in video lesson on or pg. 456.

Adaptation an adjustment in response to actual or predicted aspects of climate change. Types of adaptation include infrastructure development (building dams, levees, sea walls), ecosystem-based measures (preserving and restoring natural habitats to provide ecosystem services e.g., mangroves, swaps, and wetlands), and capacity development (education and extension services to teach people new techniques to empower them).

Government-led adaptation and mitigation strategies for global climate change.

Geopolitical efforts, recognizing that the sources of GHG emissions may be spatially distant from the countries most affected

The fossil fuel industry is the most powerful lobby group in the USA, where coal, oil, and gas interests have managed to veto climate control regulations.

The UN Framework Convention of Climate Change, 1992: to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Rio de Janeiro Earth Summit). In 1994 it failed, but the Kyoto Protocol was signed in 1997, in which high-income countries were required to cut their carbon emissions by 20% by 2012. The US did not sign the treaty, and although Canada and Australia signed, they did not implement it. The UNFCCC urged high-income countries to sign, as they have better technology, can bear the costs of low-carbon technology, have historically caused more GHG emissions, and let low-income countries develop their economies first.

The Paris Agreement, 2015: France is an HIC that decarbonized its energy production, 90% of its energy is from nuclear, hydroelectric, or wind power. 174 countries signed the agreement to limit global warming to 2 °C compared with pre-industrial levels. There are no country-specific goals or a detailed timetable, just for countries to reduce their carbon usage as soon as possible. It is not legally binding, or penalized if the targets are not met.

Case study.

The "three amigos" summit

In 2016, the leaders of the USA, Canada, and Mexico agreed on certain climate actions, involving an integration of their domestic policies with regard to the electricity sector, transport, and pollution. They pledged to achieve 50% clean energy by 2025.

Mitigation the reduction and/or stabilization of GHG emissions and their removal from the atmosphere. For example, by reducing energy consumption, emissions from agriculture, and fossil fuel use, as well as encouraging geo-engineering. Carbon dioxide removal techniques are done through protecting and enhancing carbon sinks through land management, using biomass as a fuel source, using carbon capture and storage (CCS), and enhancing carbon dioxide absorption by the oceans.

Methods to prevent further increases in mean global temperature include: controlling or reducing atmospheric pollution, stopping forest clearance or actively increasing forest cover, developing alternative renewables, improving public transport, setting limits on national carbon emissions, developing CCS methods, and encouraging recycling.

Decarbonization a large reduction of carbon dioxide per value of a gross world production. Done by increasing energy efficiency, reducing emissions per MWh of electricity, and shifting fuel sources to something renewable.

Reducing emissions of oxides of nitrogen and methane from agriculture can be achieved if fewer chemical fertilizers are used and livestock farming was less intense.

Geoengineering can help by dimming incoming sunlight with sulphate aerosol particles in the air, which in tern would cool the planet to offset the warming caused by carbon dioxide. Another idea is to place giant mirrors in space to deflect some incoming solar radiation.

Carbon capture and sequestration (CCS) strives to either capture the CO_2 at the site where it is produced and the store it underground in a geologic deposit, or allow it to enter the atmosphere and remove it using a special method, such as collecting it with special chemical sorbents that attract CO_2 . For now, there is little research and development to test the economic and geologic potential for large-scale CCS.

Carbon taxes carbon dioxide emissions are taxed for some producers to incentivize them to lower their emissions from the burning of fossil fuels. Carbon dioxide has a high cost to society, but those producing it are often not the ones that pay the price. Therefore, by introducing this market incentive, the costs of coal, oil, and gas are higher than those of wind and solar, which causes a shift towards low-carbon options. Economists suggest $25–$100 per ton.

Carbon trading a market in which permits issued by governments to emit carbon dioxide can be traded. Plants that exceed their limit can buy permits from those that do not exceed their limit. This is done to reduce pollution through a market system by putting a limit on total emissions. The targets have been said to be too generous.

Carbon offset schemes designed to neutralize the effects of the carbon dioxide human activities produce by investing in projects that cut emissions elsewhere. Carbon credits can be bought from companies that plant trees or use more renewables. However, this can be dangerous, as it does not help in the long-term with changing peoples' behaviour.

Ocean fertilization this happens with Iron, Nitrogen, and Phosphorus, to increase marine food production and thus remove carbon dioxide from the atmosphere. It can also trigger an algal bloom, which trap it and cause the carbon dioxide to sink to the ocean floor. However, iron fertilization on a large scale could have negative impacts on the marine environment and human health. Additionally, devices that help pump water to produce an artificial upwelling (bringing nutrients to the surface, supporting plankton blooms) are costly to build and run.

Adaptation strategies carbon dioxide and warming will continue to increase even with some measures implemented, so humans must also think about adapting to the changes they will be facing. These are flood defenses, vaccination programs, or desalination plants. The capacity for these depends on financial and technological resources of places. Crop varieties need to be more temperature-resistant and resilient to different precipitation patterns. Cities need to be protected from flooding, storms, and sea level rise. Vaccination programs are needed to deal with malaria and other outbreaks that thrive in warmer climates.

Civil society and corporate strategies, and the actions of non-governmental stakeholders, to address global climate change.

WWF, Greenpeace, and Climate Action Network are all civil societies attempting to tackle climate change. They pressure major economies, call on governments to sign up to international agreements, and try to encourage people to live in a greener way.

Case study.

Corporate change mitigation efforts in the USA

- State and corporate initiatives are helping the US perform better on the Climate Change Performance Index. In California, Florida, and New York, corporate legislation is in place to help reduce GHG emissions by 80% by 2050, compared to 1990 levels.
- In 2007, 28 companies formed the US Climate Action Partnership, including Chrysler, General Electric, General Motors, Rio Tinto, Shell, and Siemens. They have lobbied to the government to set legally binding emissions targets and has called for a reduction target of 80% by 2050. They suggested a "cap and trade" system, CCS, and technological advances to increase efficiency in buildings and transport.
- Many US corporation are calling for climate mitigation. Many continue to lobby the government to block such measures, as many citizens do not want their government to pursue policies that they feel would lead to a decline in US competitiveness and job losses.

Check your understanding.

1. Outline the groups of people most vulnerable to GCC. Why?
2. Compare pre, during, and post-disaster coping mechanisms for communities along the Padma River in Bangladesh.
3. Distinguish between adaptation and mitigation.
4. Explain how carbon taxes operate.

Key terms

Adaptation. Initiatives and measures to reduce the vulnerability of human and natural systems to climate change.

Albedo. The amount of incoming solar energy reflected back into the atmosphere by the Earth's surface.

Anthropogenic. Human-related processes and/or impacts.

The enhanced greenhouse effect. The increasing amount of greenhouse gases in the atmosphere, as a result of human activities, and their impact on atmospheric systems, including global warming.

Global warming. The increase in temperatures around the world that have been noticed since the 1960s, and in particular the 1980s.

The greenhouse effect. The process by which certain gases (water vapor, carbon dioxide, methane, and chlorofluorocarbons) allow short-wave radiation from the sun to pass through the atmosphere and heat up the Earth, but trap and increasing proportion of long-wave ration from the Earth. This radiation leads to a warming of the atmosphere.

Mitigation. Attempts to reduce the causes of climate change.

Resilience. The ability of a population or a human or natural system to absorb change without having to make a fundamental change.

Vulnerability. The degree to which a human or natural system is susceptible to and unable to cope with the adverse impacts of climate change.

Key questions.

1. How do natural and human processes affect the global energy balance?
2. What are the effects of global climate change on places, societies and environmental systems?
3. What are the possibilities for responding to climate change and who has power over the decision-making process?

3

GLOBAL RESOURCE CONSUMPTION AND SECURITY

3.1 Global trends in consumption

How do global development processes affect resource availability and consumption?

Global and regional/continental progress towards poverty reduction, including the growth of the "new global middle class".

Globally, people that belong to the middle class are increasing due to a rise in average incomes and a fall in the number of people living in absolute poverty. This means that those now living a better life can contribute to the growth of the economy more, by consuming more (e.g., cars, phones, electrical goods). Sales of cars and motorbikes have increased by over 800% since 2009.

There has been uneven progress in reducing poverty, 800 million people still live in extreme poverty. People are disadvantaged on account of their gender (e.g., Latin America, pay gap), ethnicity, disability, and geographic location.

Case study.

Economic growth in Vietnam

Developed quickly from one of the world's poorest to a middle-income country thanks to its proximity to China, giving it a competitive advantage as firms relocated to Vietnam for cheap and young labour.

The Vietnamese government has invested a lot in development (education, trade), helping the country grow its economy. It exports mainly to the US (20%), China and Japan (10% respectively) and South Korea (5%). It gets 30% of its imports from China.

Measuring trends in resource consumption, including individual, national, and global ecological footprints.

As population and wealth grow, more resources are being used, and some are close to being used up. The capacity of Earth to sustain the current use of resources is diminishing.

Ecological footprint the hypothetical area of land required by a society, a group, on an individual to fulfill all their resource needs and assimilate all their wastes. It is measured in global hectares (gha), with net carbon dioxide emissions taken into account. It can act as a model for monitoring environmental impact, also useful for comparisons. Earth Overshoot Day is when humanity has used up all the resources that it takes the planet to regenerate. Every year it comes earlier; in 2000, it was in September 23rd, in 2019, it was July 29th.

Calculated using bioproductive land, bioproductive sea, energy land, built (consumed) land, biodiversity land, and non-productive land. Therefore the calculation ignores the amount of land or water that is required to provide aquatic and atmospheric resources and assimilate waste that is not CO_2 , and the replacement of productive land lost through urbanization. Additionally, a lot of the figures are approximations or generalizations.

Increases with: fossil fuel use, higher energy use, more imports, meat-rich diets.

Decreases with: recycling, reusing, decreasing resource use, improving efficiency, lowering pollution, lower population numbers.

HICs have much larger ecological footprints compared to LICs, because they have more disposable income and consumption and demand for energy resources are high and often wasteful. Diet, agricultural practices, fossil fuel use, and extent of carbon dioxide uptake all influence ecological footprint size.

An overview of global patterns and trends in the availability and consumption of:

Water: 780 million people don't have access to clean water, and increased demand for hydroelectric power will further strain water resources. Water availability is likely to decrease in Sub-Saharan Africa and Southern Europe due to climate change creating water stress.
Virtual (embedded) water refers to the way water is transferred from one country to another through exports. It can be in food or manufactured goods, and even flowers. It allows countries with limited water resources to "outsource" their water from countries that have more water resources. It also allows a country to reduce the use of its own water resources by importing goods.

Land/food: food intake (calories) has increased steadily on a global scale. There has also been a change in diet away from cereals towards a more varied diet of meat, vegetables, and dairy products, especially in LICs turning into MICs. Diets have

changed in MICs by increasing meat consumption (150% increase) and milk and dairy products (60% increase). Urbanization has also been a factor in influencing meat consumption, by making fast food more widely available. The growth rates of food production have been falling due to climate factors and natural hazards.

Energy: energy insecurity has risen in recent years due to increased demand from NICs especially, deceasing reserves, geopolitical developments and motivations, terrorist activity in Syria, Russia/Ukraine conflict, and climate change, which has increased awareness about the misuse of energy resources. The Middle East controls about 50% of the world's remaining oil reserves, with Saudi Arabia controlling over 25%. With the US relying on Middle Eastern (ME) oil, this gives the Middle East an economic and political advantage. Countries that depends on the region for oil need to ensure political stability in the ME, maintain good political links with the ME, and involve the ME in economic cooperation. However, shortages can also be an incentive to invest in other types of energy sources or make steps to reduce current energy consumption levels.

Non-renewable energy: fossil fuels (coal, gas, oil), they cannot be renewed at the same rate at which they are used, resulting in depletion of the stock. Nuclear power can be considered non-renewable as the source of the fission produced Uranium, which is non-renewable. Most of the world's fuel comes from non-renewable sources, and its use is even expected to increase in LICs in the future because of their increasing population, income, and technologies. They are used more because the infrastructure is already in place, and energy companies are also powerful lobbyists.

Renewable energy: solar, hydroelectric, geothermal, biomass, and tidal schemes. There is no depletion of natural capital in this case and the carbon dioxide emissions are lower. They are currently more expensive than non-renewable energy sources. Both types have advantages and disadvantages. (See online lecture or pg. 481–484.)

Check your understanding.

1. Explain how ecological footprints can be reduced.
2. Explain why the ecological footprint of HICs is greater than that of LICs.
3. Outline how the use of water varies between HICs and LICs.
4. Explain the term "virtual water".

3.2 Impacts of changing trends in resource consumption

How does pressure on resources affect the future security of places?

The water-food-energy "nexus" and how its complex interactions affect national water security, national food security, and national energy security.

The water-food-energy nexus refers to the very close links between the three sectors and how they all impact each other. The nexus approach stresses the need for stewardship of these resources. The growing demand for all three is intensified by the uncertainties of climate change. The nexus also offers possibilities for the circular economy, by turning waste outfits from food production into useful inputs to energy generation. Any strategy that focuses on one part of the nexus without considering the risk to the rest of its interconnections can have serious unintended consequences.

Water security access to safe drinking water and sanitation.

Food security availability and access to sufficient, safe, and nutritious food to meet the dietary needs and food preferences for an active and healthy life.

Energy security access to clean, reliable, and affordable energy sources for cooking, heating, lighting, communications, and productive uses.

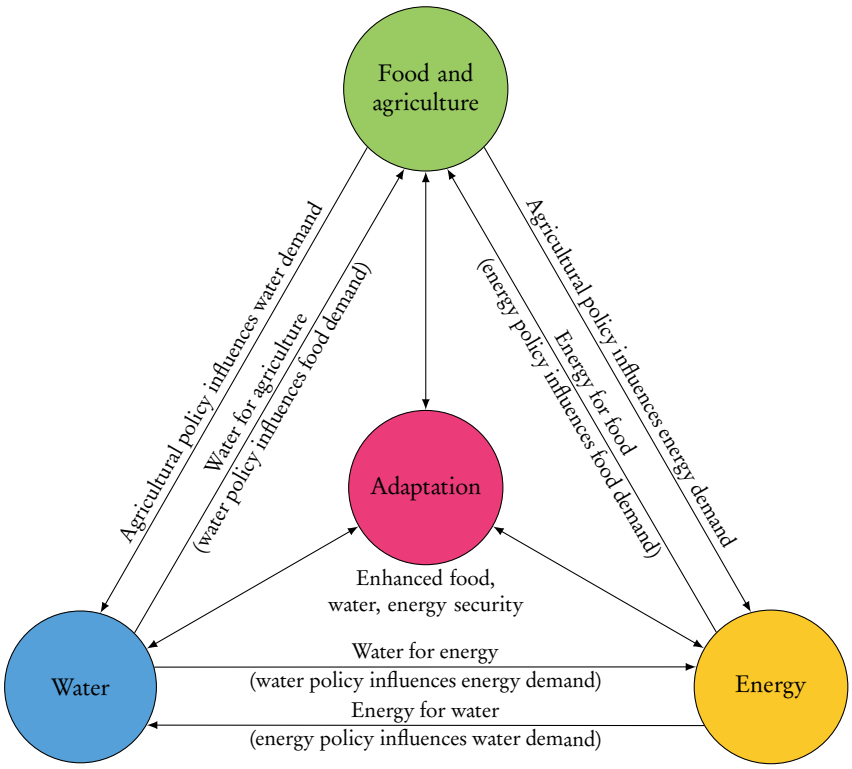

Figure 3.1: The interaction between water, food, energy, and adaptation.

The implications of global climate change for the water-food-energy nexus.

Climate change will have varying effects on all 3 parts of the nexus, and the 3 parts will influence each other as well. It will influence food availability, crop yields, water availability, the need for irrigation, pests and diseases, and might reduce water supplies in some places. Attempts to limit GCC will also impact the nexus, for example, the production of biofuels and hydroelectric power may create new demands for water resources. However, drip irrigation, desalinization, and increased groundwater pumping are very energy-intensive.

Table 3.1: Climate change adaptations and their knock-on effects on the nexus.

Sector-specific adaptation measures	Positive implications for the sector	Potential for synergies across the nexus
Water		
Increasing water use efficiency	Reduced water per capita	Increased availability of water for energy and agriculture
Switching from use of freshwater to waste water	Reduced freshwater use per capita	Increased availability of freshwater for food, energy and other uses
Switching from wet to dry cooling at thermoelectric power plants	Reduced water use and associated thermal pollution	Increased availability of water for energy and agriculture
Desalinization	Increase in brackish and freshwater supplies	Increased availability of freshwater and overall water supply for energy and agriculture and other uses
New storage and conveyance of water to serve new demands	Increased water supplies to meet demand	Increased availability of fresh water and overall water supply for energy and agriculture and other uses
Watershed management	Increased water supplies to meet demand	Increased water supply for energy and other uses, improved water quality, reduction in flood potential
Land		
Switching to drought-tolerant crops	Increased/maintained crop yields in drought areas	Reduced water demand
Using waste or marginal lands for biofuels	Increase in renewable energy	Reduced pressure on non-renewable energy as some fossil fuels are replaced with biofuels
Energy		
Increasing transmission capacity	Reduced economic and social impacts	Potential for reduced emissions if new transmission and wind/solar power supplied to the grid
Increasing renewable energy, e.g. solar, wind, biogas, bioenergy	Increased clean energy and reduced pressure on energy	Reduced GHG emissions, reduced water demand for cooling, thermal power

Source: Rasul, G. and Sharma, B. 2015. "The nexus approach to water-energy-food security: an option for adaptation to climate change". http://www.sciencedirect.com/science/article/pii/S2211464515300646

Countries with contrasting levels of resource security.

Case study.

Food, water, and energy security in the Hindu Kush Himalayan region

South Asia faces the challenge of proving enough water and energy to grow enough food for the increasing population. The HKH ecosystem is vital for the promotion of food, water, and energy security downstream (e.g., water for irrigation, HEP, and drinking water). The issues within the area and further downstream are interrelated and need to be managed by integration.

South Asia has 3% of the world's land but 25% of the world's population. Water and food security are very important. Around half the population in the area is food-energy deficient, and 20% of the population lack access to safe drinking water. 1.3 billion people rely on fresh water for the HKH region.

Issues that are present in and around the area: large (and still growing) population, many of whom are chronically undernourished, declining croplands and their productivity, deforestation, soil erosion (increased severity of flooding without ecosystem management), overgrazing, sensitivity to climate change in the area, water stress, water-dependent crops (rice and wheat), upstream-downstream dependence on water, increasing dependence on groundwater for food production, high energy poverty, and under-utilized potential for hydropower and clean energy.

Case study.

Improving food security in South Africa

Maize and potato production in South Africa is likely to decrease with climate change due to less rainfall and higher temperatures. Farmers have already begun to diversify their crops, changing planting times, soil conservation, and changing from flood irrigation to sprinkler irrigation. Water is the main limiting factor for agriculture in SA.

Crops will be overall less productive due to changes in the timing, amount, and frequency of rainfall. Yields could increase for rice, sorghum, and sugarcane, the latter is the most resilient to climate change. For barley, hops, and apples, yield and quality are likely to decrease. Livestock farming will be negatively affected by water shortages and more aridity.

The disposal and recycling of consumer items, including international flows of waste.

Solid domestic waste can be managed by: altering human activity to reduce consumption and compost food waste, controlling the release of pollutants through government legislation, and reclaiming landfill for restoration programs. The factors influencing the strategies are cultural, economical, political, and technological.

HICs generate more waste than LICs and there is now more non-biodegradable water. The world's largest garbage dumps pollute rivers, groundwater, air, and soil, and have a negative impact on those who live and work nearby or on the dump.

Waste increases as countries develop and also during certain festivities. Why do you think this is?

Exporting waste: China imports 3 million tonnes of waste plastic and 15 million tonnes of paper and cardboard each year. Due to low wages and a large workforce in China, this can be done much more cheaply, despite having to transport it a long distance.

An increase in e-waste is also taking place due to the technological innovations in our globalised world. The workers dealing with e-waste at certain sites are at high risk for various toxic substances such as lead, mercer, cadmium, arsenic, and flame retardants.

Case study.

The hazards of working with rubbish

Many people (around 1% of the global urban population) in developing countries make some money by collecting, recycling, and selling materials recovered from waste dumps. Around 20,000 people doing this live in Calcutta, many of them women and children. They often face scorn, harassment, and even violence. Middlemen may also exploit them and waste pickers only end up getting 5% of the prices that industries pay for the recyclables, with most of the money going to the middlemen. Due to their low income, they often live in deplorable conditions and are vulnerable to health and safety risks, including exposure to dangerous waste.

Case study.

Waste management options for solid domestic waste and the methods of waste disposal.

Waste management options	How it works
Reduce the amount of waste	• Producers think more about the lifespan of goods and reduce packaging • Consumers consider packaging and lifespan when buying goods
Reuse goods to extend their lifespan	• Bring-back schemes where containers are refilled (e.g. milk bottles) • Refurbish/recondition goods to extend their useful life (e.g. using old car tyres to stabilize slopes/reduce soil erosion) • Used goods put to another use rather than thrown out (e.g. plastic bags used as bin liners; old clothes used as cleaning cloths) • Charity shops pass on goods to new owners
Recover value	• Recycle goods such as glass bottles and paper • Compost biodegradable waste for use as fertilizer • Incinerate (burn) waste – collect electricity and heat from it
Dispose of waste in landfill sites	• Put waste into a hole (natural or the result of quarrying) or use to make artificial hills

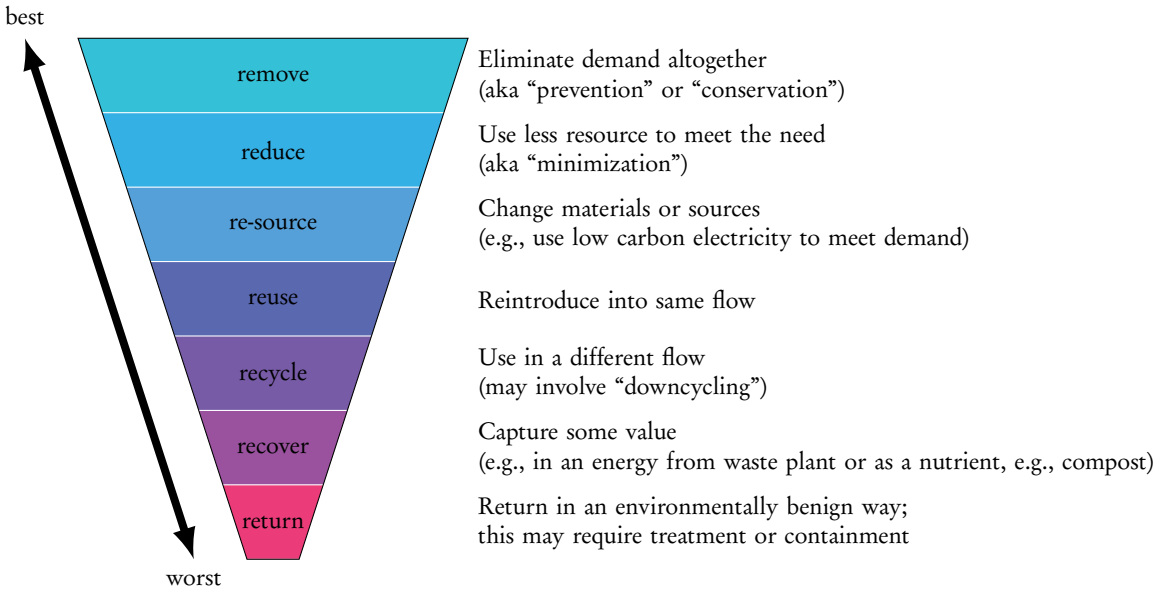

Figure 3.2: Waste management options for solid domestic waste and the methods of waste disposal.

Check your understanding.

1. Briefly explain the water-food-energy nexus.
2. State two examples of goods that can be a) recycled, b) reused, or c) reduced.
3. Briefly explain the problems associated with landfill.
4. Outline the problems of trying to feed Asia's growing population.

3.3 Resource stewardship

What are the possibilities for managing resources sustainably and who has power over the decision-making process?

Divergent thinking about population and resources consumption trends.

Pessimistic view: Thomas Malthus's theory of population: Published his *Essays on the Principle of Population Growth* in 1798. He believed the optimum population in relation to food supply was finite. According to him, any increase after this would lead to war, famine, and disease. Population grows at a geometric or exponential rate, while food supply grows at an arithmetic rate. Lack of food was therefore argued to be the ultimate check on population growth. However, his principles were based on potential, and not actual growth figures for both. In real life, there is a limit to how much food can be produced, and it determines a "ceiling" to the population growth. Malthus suggested preventive (abstinence, reducing TFR) and positive checks (lack of food, disease, war, directly affecting death rates) to curb population. Since his time, food production has increased through intensification of labor and land.

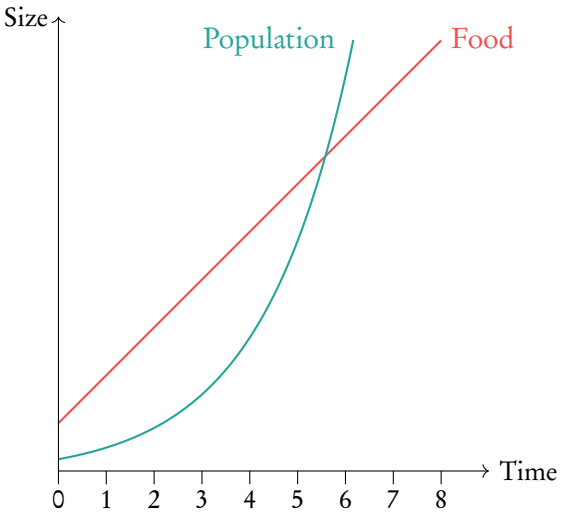

Figure 3.3: Malthus' views on the relationship between population growth and availability of resources.

Optimistic view: Esther Boserup: In 1965, she proposed the idea that people have the resources to increase food production; when the need arises, someone will find a solution. "Necessity is the mother of invention." She argued that population growth had enabled agricultural development to occur.

Emile Durkheim's theory of population (1893): he thought an increase in population density would lead to a greater division of labor, which would allow greater productivity to be attained. Population pressure was necessary to increase the division of labor, according to him. He noted that labor differentiation tended to increase in proportion to the social complexity and size of the population.

The Limits to Growth model (1970): also referred to as the Club of Rome model, it is a Neo-Malthusian model, examining 5 basic factors that determine and limit growth on the planet: population, agricultural production, natural resources, industrial production, and pollution. Many of these grow exponentially until the diminishing resource base forces a slowdown in industrial growth. Additionally, technological innovation (positive factors) grow only at a constant (arithmetic) rate. The limits of growth were found to be physical necessities that support all physiological and industrial activity, for example food, raw materials, and fuels and social necessities such as peace, stability, and education.

Paul Ehrlich: The population bomb (1968): he was a modern Neo-Malthusian who believed that population control is essential, and increase in food supply is necessary, and the redistribution of wealth is also needed to address the world's population problem. He argued that the growth of the population was outstripping the growth of food and resources.

Carrying capacity: a population ceiling, 1) reached by an increase that drops to zero once the ceiling is reached, 2) or the population increase beginning to taper off and eventually leveling off at the ceiling (S-curve, for large population, long lives, and low fertility rates) 3) or a rapid rise in population causing an overshoot, a sudden check, followed by recoveries and fluctuations, eventually settling at the carrying capacity (J-curve, for small populations with short lives and high fertility rates).

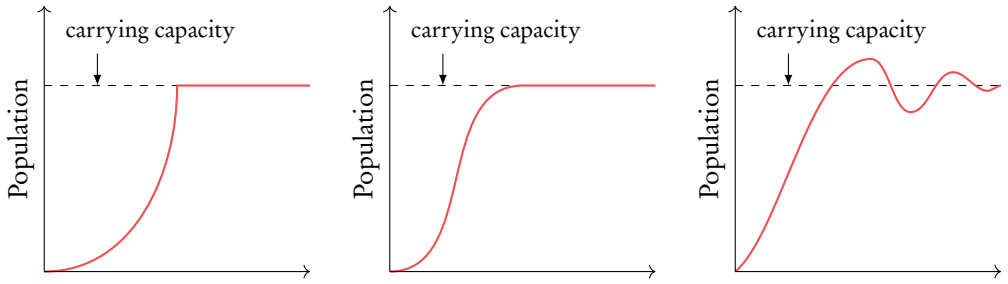

Figure 3.4: Illustrations of the 3 models of carrying capacity.

Optimum population: the number of people who, when working with all the available resources, will produce the higher per-capita economic return. It is the highest standard of living ($\frac{\text{natural resources} \times \text{technology}}{\text{population}}$) and quality of life.

Overpopulation: when there are too many people, relative to the resources and technology locally available, to maintain an adequate standard of living (Bangladesh, Somalia, and parts of Brazil and India). They suffer due to insufficient food and materials, from natural disasters such as drought and famine, and are characterized by low incomes, poverty, poor living conditions, and a high levels of emigration.

Underpopulation: when there are far more resources in an area that can be used by the people living there (Canada, Australia). They have a high levels of immigrants.

Balanced views about population and resource consumption.

Resource stewardship: a concept that suggests that humans can use resources in such a way that they will be available to future generations. There will be not only environmental sustainability, but also social equity over access to resources.

The global commons refers to areas that lie outside the political reach of any nation state: the high seas, Antarctica, the atmosphere, and outer space. They require management and protection. If resources become over-exploited, depletion and degradation will lead to scarcity (e.g., fish).

The tragedy of the commons: in 1968, Garrett Hardin suggested this metaphor to explain the lack of control over the way common resources are used and how the selfish acts of a few individuals can destroy the resource for others. If one country takes more fish from the oceans, their profits will increase, and other countries will feel compelled to match their catch to not lose to their competitors. At this rate, they all exceed the maximum sustainable yield and the resource may become depleted.

Resource stewardship strategies.

A circular economy: it preserves natural capacity, optimizes resources use, and reduces loss through managing finite stocks and renewable flows. It restores and regenerates resources, and keeps products, materials, and components at their highest utility and value at all times, aiming to rebuild capital (financial, manufactured, natural, social, or human). It aims to preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, to optimize resource yields by circulating products, and to develop system effectiveness by eliminating negative externalities such as pollution, waste, and climate change.

The role of the UN Sustainable Development Goals.

17 SDGs were introduced in 2015, set to exist until 2030. They replaced the Millennium Development Goals that existed between 2000 and 2015.

Figure 3.5: The UN Sustainable Development Goals.

Case study.

Resource use in three industries

- Car manufacturing: Accounts of 60% of global lead use, which is predicted to run out by 2030. Some places send no car parts to landfill, instead, they are all repurposed and remanufactured (e.g., Choisy-le-Roi in Paris produces 70% less waste).
- Mobile phones: Most people in the Western world change their phone every two years. Components of mobile phone have considerable economic value e.g., of gold, silver, and rare earth elements. In the EU, 160 million phone are discarded per year, meaning a loss of $500 million. 15% of phone are currently recycled. If this was increased, remanufacturing would be easier, cheaper, and less wasteful.
- Washing machines: Energy efficiency could be improved if households used machines that were higher quality, such as those designed for hotels or launderettes. General machines wear down quickly and easily, and only around 10% of them are refurbished.

Check your understanding.

1. Outline the views of Neo-Malthusians.
2. Explain the term "carrying capacity".
3. Identify the four global commons and explain the term "the tragedy of the commons".
4. Outline the aims of the SGDs and their progress so far. Why have the goals been difficult to achieve?

Key terms

Biocapacity. The land and water to provide resources for humanity.

Ecological footprint. The hypothetical area of land required by a society, a group, or an individual to fulfill all their resource needs and assimilate all their waste. It is measured in global hectares (gha).

Energy security. Access to clean, reliable, and affordable energy sources for cooking, heating, lighting, communications, and productive uses.

Food security. The "availability and access to sufficient, safe, and nutritious food to meet the dietary needs and food preferences for an active and healthy life." (FAO)

Nexus. The interrelationship, interdependence, and interactions between water, food, and energy.

Virtual/embedded water. The way in which water is transferred from one country to another through its exports.

Water security. Continued access to safe drinking water and sanitation.

Key questions.

1. How do global development processes affect resource availability and consumption?
2. How does pressure on resources affect the future security of places?
3. What are the possibilities for managing resources sustainability and who has power over the decision-making process?