DP IB Environmental Systems & Societies (ESS): HL

Your notes

5.2 Agriculture & Food

Contents

Land Use & Agricultural Systems

Your notes

Land Use

Land as a finite resource

- Land is limited and cannot be expanded (i.e. it is a finite resource)
- Efficient land use is crucial to meeting growing food requirements
- About 70% of ice-free land is used for agriculture and forestry
    - Agricultural land is used to grow **crops** (arable) and raise **livestock**
- As the human population grows, the demand for food increases
    - This puts **pressure** on available land for food production
- **Urbanisation** leads to the conversion of agricultural land into urban areas
    - This further reduces the availability of land for food production per capita

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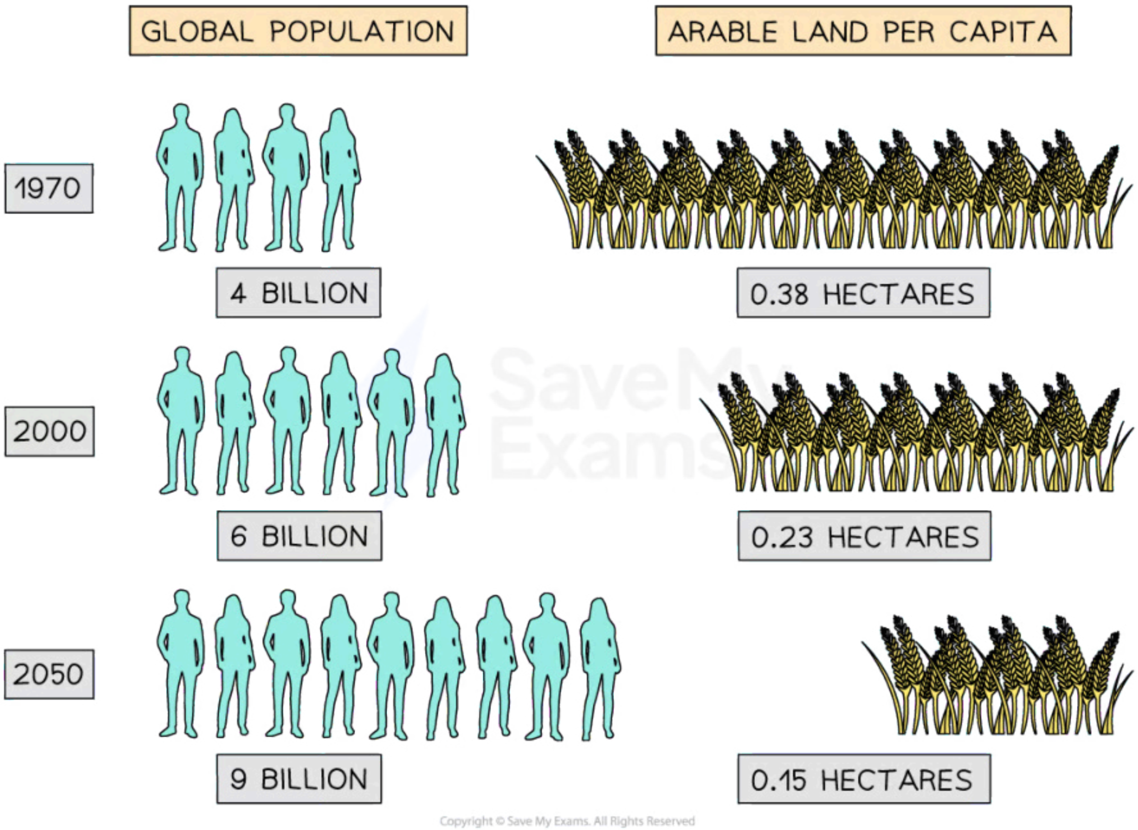

Historical and predicted arable land per capita

Agricultural land use

- Not all land is suitable for crop production
  - land must be **fertile**, **flat**, and have **adequate water supply**
- **Unsuitable land for crops**:
  - Steep slopes:
    - Risk of erosion
    - It is difficult to use machinery
  - Nutrient-poor soils:
    - Cannot support crop growth without significant fertilisation
- These lands are often used for livestock production instead

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- For example, in the UK, hilly areas like Eryri (Snowdonia, Wales) and the Scottish Highlands are used for sheep grazing due to **unsuitable conditions for arable farming**

Vulnerability of marginalised groups

- **Marginalised groups**:
  - These include:
    - Indigenous peoples
    - Low socio-economic status groups
    - Women farmers
    - People in low-income countries
  - Often have limited access to land and resources
- **Impact of land-use decisions**:
  - Land-use policies can **increase inequalities**
  - Marginalised groups are more vulnerable to changes and restrictions
  - For example, in India, many Dalits (members of a lower caste) face significant barriers to land ownership and agricultural resources
    - This is limiting their ability to improve their economic status and sustain their livelihoods
- **Indigenous peoples**:
  - Indigenous groups often depend on land for their livelihoods
  - **Indigenous land rights** are often **ignored** in favour of large-scale agricultural projects
  - For example, the Maasai in Kenya and Tanzania have faced **land encroachment**
    - This is due to expanding agriculture and tourism projects
    - This is threatening their traditional way of life

Other examples of land-use impacts on marginalised groups

- **Deforestation in the Amazon**:
  - Driven by agricultural expansion
  - It affects Indigenous tribes like the Yanomami
  - Leads to loss of biodiversity and traditional lands
- **Land grabs in Africa**:

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- Foreign investors acquire large areas of land for industrial-scale agriculture
- Displaces local farmers and communities
- Impacts their food security

- **Urban sprawl in China**:
  - Rapid urbanisation consumes agricultural land
  - Affects rural communities' access to arable land

Examiner Tips and Tricks

Make sure you know the difference between agricultural land and arable land

Agricultural land is used for all types of farming, including both crops and livestock. It includes pastures, orchards, and vineyards.

Arable land is specifically used for growing food crops. It requires fertile soil and suitable conditions for planting.

Key point: all arable land is agricultural land, but not all agricultural land is arable.

Agricultural Systems

Variability in agricultural systems

- **Global variation:**
  - Agriculture systems vary globally due to differences in soil and climate
  - Soils in different biomes support different crop types and productivity levels
- **Soil and climate influence:**
  - Tropical soils may be nutrient-poor, affecting crop choices
    - This **limits** the types of crops that can be grown successfully without heavy fertilisation
    - For example, in Brazil, nutrient-poor tropical soils require heavy fertilisation for crops like soybeans
  - Temperate climates with fertile soils can support **diverse crops**
    - For example, in the UK, temperate climates support a variety of crops like wheat and barley

Classification of agricultural systems

- Agricultural systems can be classified in a number of ways, including:
- **Outputs from the farm system**:
  - **Arable farming**: growing crops (e.g., wheat, rice)
  - **Pastoral/livestock farming**: raising animals (e.g., cattle, sheep)
  - **Mixed farming**: combining crops and livestock
  - **Monoculture**: growing a single type of crop
  - **Diverse farming**: growing multiple types of crops
- **Reasons for farming**:
  - **Commercial farming**: producing food for sale
  - **Subsistence farming**: producing food for the farmer's own use
  - **Sedentary farming**: farmers stay in one place
  - **Nomadic farming**: farmers move with their livestock
- **Types of inputs required**:
  - **Intensive farming**:
    - High inputs of labour, capital and technology
    - E.g. dairy farming in the Netherlands
  - **Extensive farming**:
    - Low input per unit area
    - E.g. sheep farming in Australia
  - **Irrigated farming**:
    - Requires artificial water supply
    - E.g. Central Valley, California: large-scale irrigation systems support the cultivation of crops such as almonds, grapes and tomatoes in this semi-arid region
  - **Rain-fed farming**:
    - Relies on natural rainfall
    - E.g. wheat farming in Canada
  - **Soil-based farming**:

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    - Traditional farming in soil
    - E.g. vegetable farms in the UK
- **Hydroponic farming**:
    - Growing plants without soil, using nutrient solutions
    - E.g. hydroponic lettuce farms or vertical farms in urban areas
- **Organic farming**:
    - Avoids synthetic chemicals
    - E.g. organic tea plantations in India: many use natural fertilisers, compost and biological pest control methods to maintain soil fertility and produce high-quality tea without synthetic pesticides or herbicides
- **Inorganic farming**:
    - Uses synthetic chemicals and fertilisers
    - E.g. large-scale corn farms in the US

Implications of agricultural systems

- **Economic sustainability**:
    - Varies with farming type and market access
    - Monoculture can be profitable but risky due to **crop failure,** e.g. due to disease
    - Diversified farming **reduces risk** and can be more economically sustainable
- **Social sustainability**:
    - Agricultural systems affect community stability and employment in different ways
    - Subsistence farming supports local communities but can limit economic growth
    - Commercial farming can create jobs but may displace small farmers
- **Environmental sustainability**:
    - Intensive farming can lead to **soil degradation** and **pollution**
    - Organic farming promotes **biodiversity** and **soil health**
    - Extensive farming generally has a lower environmental impact

Examiner Tips and Tricks

Make sure you are familiar with the different ways to classify agricultural systems (outputs, reasons and inputs). You need to understand and be able to define agricultural terms like monoculture, subsistence, intensive and extensive farming.

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Traditional & Modern Agricultural Practices

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Traditional Agricultural Practices

Nomadic pastoralism

- Nomadic pastoralism is a form of agriculture where **livestock** is herded to different pastures in a **seasonal cycle**
  - For example, Bedouin tribes in the Middle East traditionally move their camels, goats and sheep across desert regions to find grazing land
- **Characteristics:**
  - Relies on natural pasture and water sources
  - Adapted to **arid** or **semi-arid** environments
  - Minimal permanent settlements
  - **Seasonal changes** control movement

Slash-and-burn agriculture (shifting cultivation)

- Slash-and-burn agriculture is a method of agriculture where forests are cut down and burned
- Crops are grown on the cleared land for a **few years** until the soil is **depleted of nutrients**
  - For example, Indigenous tribes in the Amazon rainforest traditionally practice slash-and-burn to grow crops like cassava and maize
- **Characteristics:**
  - Sustainable in **low-density** populations
  - Allows **regeneration** of forest over time
  - Relies on a rotating cycle of land use

Challenges with traditional practices

- **Environmental impacts:**
  - Deforestation and loss of biodiversity from slash-and-burn
  - Overgrazing and soil erosion can occasionally result from nomadic pastoralism
- **Modernisation and population growth:**

- Traditional agricultural methods become **unsustainable** as populations grow and land becomes scarce
- Indigenous cultures are increasingly transitioning to more **sedentary lifestyles**
- This leads to **overuse** of land and resources

The Green Revolution

What was the Green Revolution?

- The Green Revolution refers to a series of **research**, **development** and **technology initiatives** that took place between the 1950s and 1960s
  - These initiatives aimed to increase agricultural production and food security globally
- It is also known as the Third Agricultural Revolution

Key initiatives of the Green Revolution

- **High-yielding varieties (HYVs):**
  - Breeding of crops like wheat, rice and maize to produce higher yields
  - E.g. IR8 rice, known as 'Miracle Rice', developed in the Philippines
- **Improved irrigation systems:**
  - Development and expansion of irrigation infrastructure
  - Helped transform arid and semi-arid lands into highly productive agricultural areas
  - E.g. the Indus Basin Irrigation System in Pakistan
- **Synthetic fertilisers:**
  - Use of chemical fertilisers to provide essential nutrients to crops
  - The production of synthetic fertilisers is dependent on nitrogen fixation
    - This means their production relies on fossil fuels
- **Pesticides:**
  - Application of chemical pesticides to protect crops from pests and diseases

Positive consequences of the Green Revolution

- **Increased food production:**
  - Significant increase in crop yields and food availability

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- Helped alleviate hunger and food shortages in many regions
- **Economic growth:**
  - Boosted agricultural economies and increased farmer incomes
  - For example, Mexico became a major wheat exporter due to Green Revolution practices
- **Technological advancements:**
  - Led to further agricultural research and innovation

Negative consequences of the Green Revolution

- **Environmental impacts:**
  - The overuse of chemical fertilisers and pesticides led to **soil degradation** and **water pollution**
  - **Loss of biodiversity** due to intense monoculture practices
- **Economic inequality:**
  - Resulted in greater economic benefits for larger, wealthier farmers compared to small-scale farmers
  - Increased debt for farmers who could not afford new technologies
- **Sociocultural effects:**
  - Displacement and loss of traditional farming practices
  - Increase in **rural to urban migration** due to changes in agricultural labour demands
- **Selective implementation:**
  - The Green Revolution was not universal
  - It did not reach all developing nations
  - Regions without access to necessary resources and infrastructure saw limited benefits

Synthetic Fertilisers & Sustainable Methods

Synthetic fertilisers

- Synthetic fertilisers are chemical compounds applied to soil to supply **essential nutrients** for plant growth
  - Their purpose is to maintain high commercial productivity in intensive farming systems
- **Advantages:**
  - Immediate nutrient supply to crops

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- Increased crop yields and faster growth
- **Disadvantages:**
  - Soil degradation over time
  - Water pollution from runoff
  - Dependency on fossil fuels for production

Sustainable methods for improving soil fertility

- In sustainable agriculture, there are many alternative methods for improving soil fertility

Sustainable Methods for Improving Soil Fertility

Method	Definition	Benefits
Fallowing	Leaving land uncultivated for a period	Allows soil to **recover** and **regain nutrients** Reduces need for synthetic fertilisers
Organic Fertiliser	Using manure from farm animals or human waste (humanure)	Improves **soil structure** and **fertility** Reduces need for synthetic fertilisers
Herbal Mixed Leys	Planting a mixture of herbs and grasses	Provides **diverse nutrients** to the soil Improves **soil health** and **biodiversity**
Mycorrhizae	Symbiotic fungi that enhance plant nutrient uptake	Increases plant **access to nutrients** Reduces need for synthetic fertilisers
Continuous Cover Forestry	Maintaining a continuous canopy of trees	**Prevents soil erosion** due to root systems binding soil and interception of rain by forest canopy Increases **soil organic matter** and **fertility**
Agroforestry	Integrating trees and shrubs into agricultural landscapes	Improves **soil health** Reduces soil erosion Provides **additional sources of income** (e.g. fruit, timber)

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Soil Conservation

Soil Conservation Techniques

- Soil conservation techniques are used to maintain the **health** and **productivity** of our soils
- As soil **fertility declines**, various detrimental processes can occur, such as:
  - Soil erosion
  - Toxification
  - Salinisation
  - Desertification
- These processes lead to significant **environmental** and **agricultural challenges**
- Soil conservation techniques can be used to:
  - Mitigate soil degradation
  - Preserve the important characteristics of fertile soils
- Soil conservation techniques can be classified in several ways, including:
  1. Techniques that reduce soil erosion
  2. Techniques that increase soil fertility (using soil conditioners)
  3. Cultivation techniques

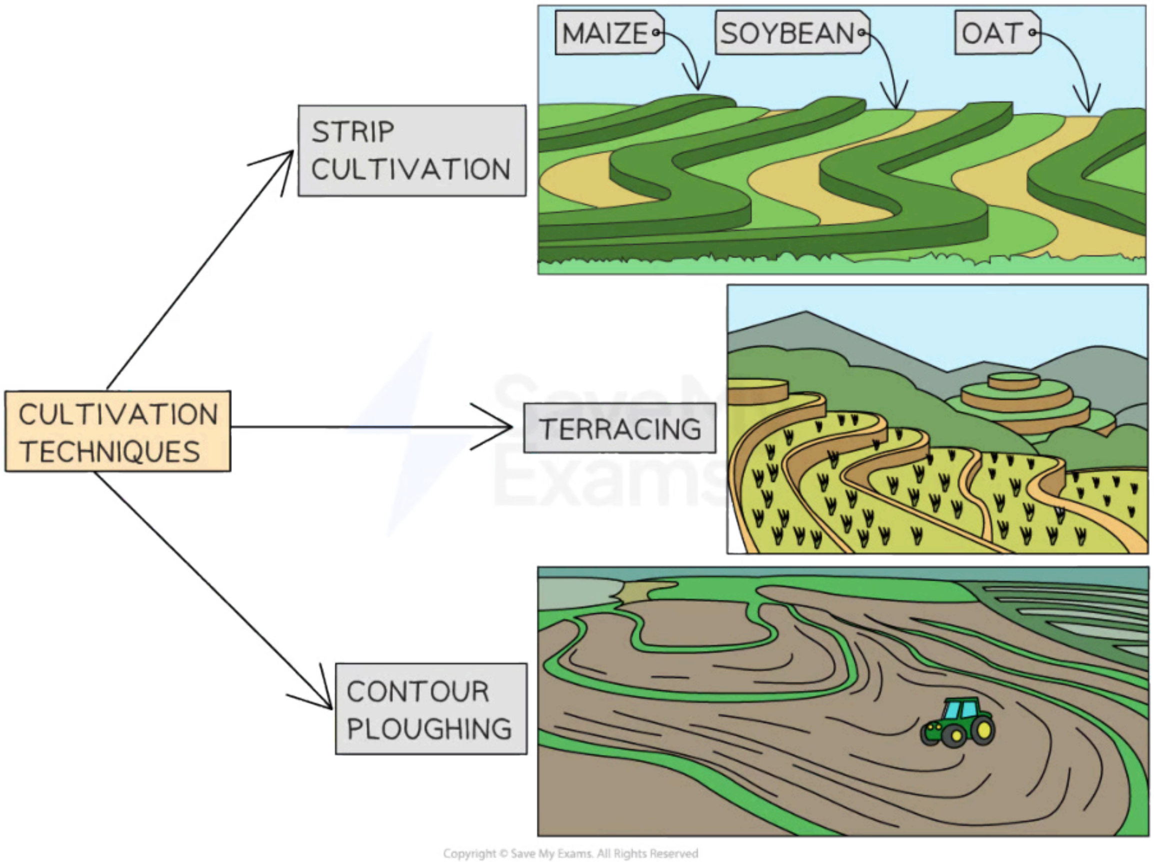
Conservation from Erosion

Soil conservation technique	Type of erosion reduced	Description	Effect
Strip cultivation	Water	Planting crops in alternating strips or bands, leaving natural vegetation between the strips	Reduces soil erosion by trapping water, slowing down runoff and increasing infiltration while still allowing for crop production in the cultivated strips Increases biodiversity

Terracing	Water	Creating levelled steps on sloped lands	Reduces soil erosion by slowing down water movement and increasing infiltration Minimises soil loss on steep slopes
Contour ploughing	Water	Ploughing parallel to the contour lines of the land instead of up and down slopes	Minimises soil erosion by reducing length and speed of water flow downhill Prevents gully formation and increases infiltration
Bunding	Water	Building embankments or barriers along fields	Controls water flow Prevents soil erosion and waterlogging
Drainage systems	Water	Installing systems to manage excess water	Prevents waterlogging Reduces erosion and nutrient loss
Cover crops	Water	Planting crops that cover the soil	Reduces water erosion Improves soil structure
Windbreaks	Wind	Planting trees or hedges to block and reduce wind speed	Provides physical barrier to wind Reduces wind erosion Protects topsoil Protects crops from wind damage
Cover crops	Wind	Planting crops to cover soil	Reduces wind erosion Adds organic matter to soil

Your notes

Your notes



Strip cultivation, terracing and contour ploughing all help to conserve soils by slowing the speed of water runoff, which allows water time to infiltrate the soil, minimising soil erosion

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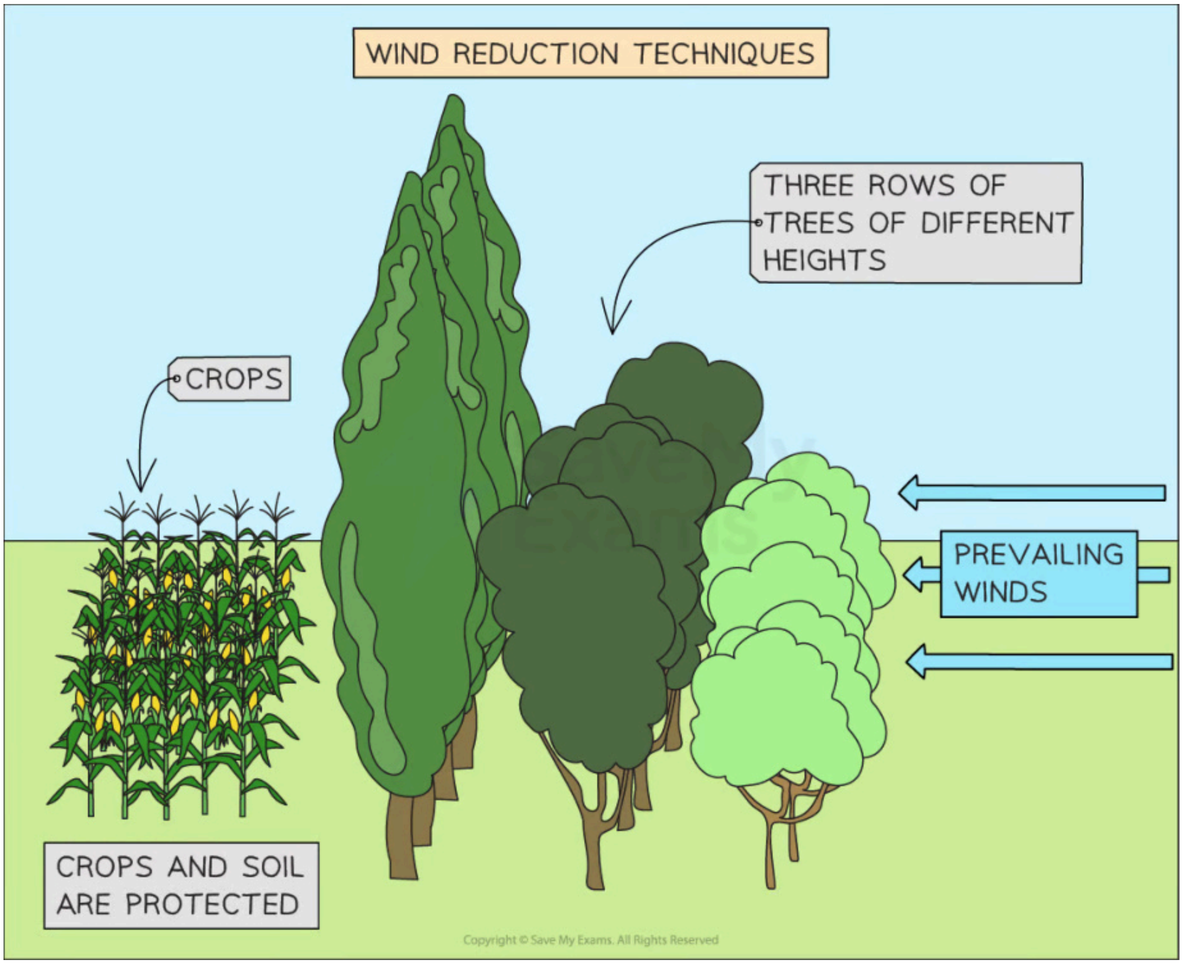
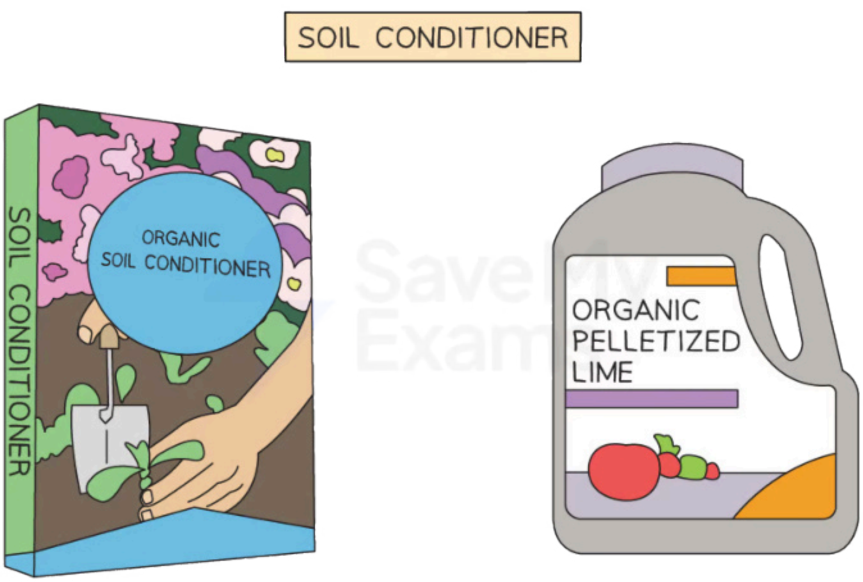


Wind reduction techniques help to minimise soil erosion and protect crops from wind damage

Conservation of Fertility with Soil Conditioners

Soil conservation technique	Description	Effect
Lime	Adding lime to soil	Improves soil pH, reducing soil acidity Enhances nutrient availability Promotes beneficial microbial activity

Compost	Using decomposed organic matter	Enriches soil with nutrients Improves soil structure Increases water-holding capacity Promotes beneficial microbial activity
Green manure	Growing plants (e.g. cover crops) specifically to be ploughed into the soil	Increases organic matter Enhances soil fertility



Organic soil conditioners can be used to improve overall soil health, whilst the addition of lime helps to reduce soil acidity

Cultivation Techniques

Soil conservation technique	**Description**	**Effect**
Avoid marginal land	Not farming on land that is vulnerable to erosion or poor in nutrients	Protects fragile ecosystems

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Your notes

		Prevents soil degradation Maintains soil health
Avoid overgrazing / overcropping	Managing livestock and crop levels to prevent depletion	Maintains soil cover Prevents soil erosion and compaction
Mixed cropping	Growing different types of crops together	Improves soil health Reduces pest and disease issues
Crop rotation	Rotating different crops on the same land	Maintains soil nutrients Reduces disease and pest buildup
Reduced tillage	Minimising ploughing and soil disturbance	Preserves soil structure Maintains moisture levels
Agroforestry	Integrating trees and shrubs into farming systems	Enhances soil structure Provides shade and wind protection
Reduced use of heavy machinery	Minimising the use of heavy equipment on fields	Prevents soil compaction Maintains soil structure

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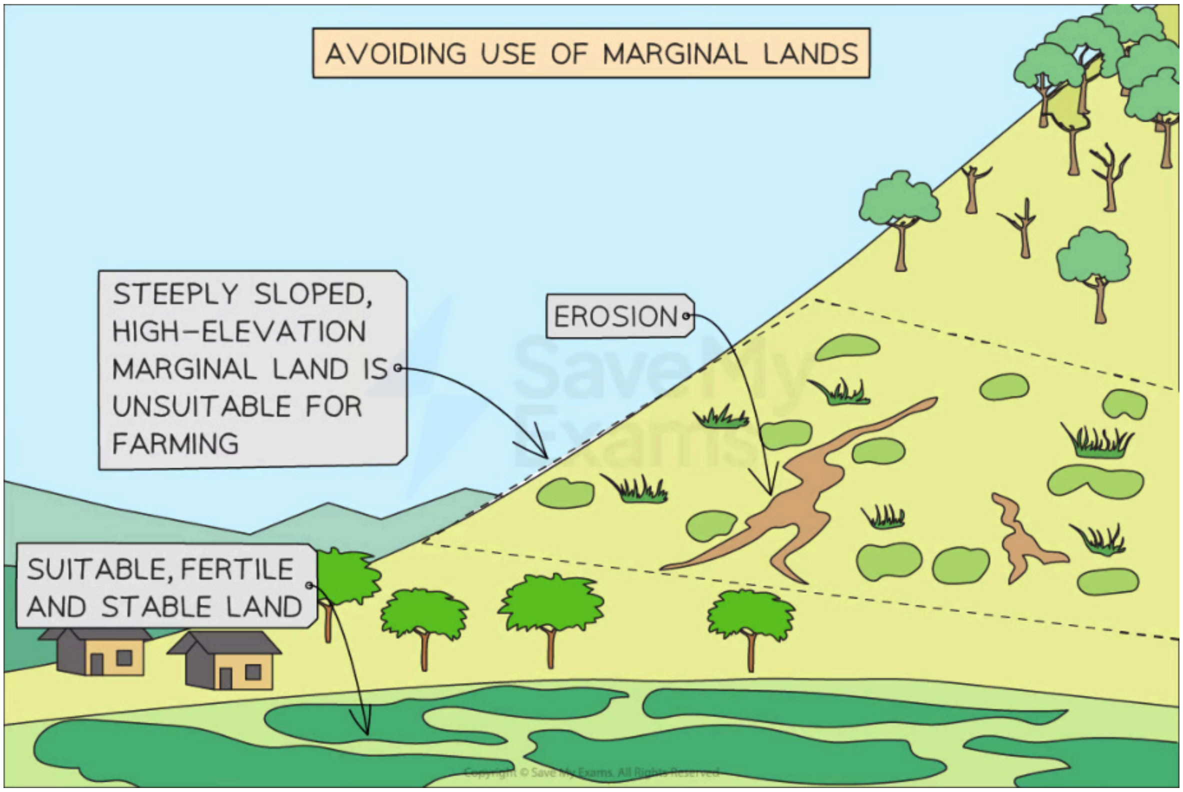

Marginal lands (usually steep land with poor soil structure and low fertility) are already vulnerable to soil erosion, so should not be used for agricultural purposes as this will quickly result in significant soil degradation in these areas

Examiner Tips and Tricks

You should note that many of these techniques help conserve soils in multiple ways. For example, cover crops protect the soil from wind and water erosion, but they can also ploughed into the soil to become green compost.

Sustainability of Food Production Systems

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Increasing Sustainability of Terrestrial Food Production

- Humans are omnivores, consuming a variety of foods, including:
  - Fungi
  - Plants
  - Meat
  - Fish
- Diets that include more food from **lower trophic levels**, such as plant-based diets, are generally **more sustainable**
  - This is due to their reduced environmental impact

Crop vs. livestock production

- **Yield and cost:**
  - Crops:
    - The yield of food **per unit of land area** is significantly **higher** with crops than with livestock
    - Crop production also has **lower financial costs** associated with it
  - Livestock:
    - Producing food through livestock requires **more land** and **resources**
    - It is usually **more expensive**

Plant-based diets

- Increasing the proportion of plant-based foods in diets can make agriculture more sustainable
- This is because plant-based diets decrease the demand for resource-intensive livestock farming
- **Energy efficiency** is greater in a plant-based diet compared to a meat-eating diet due to several factors:

1. **Trophic levels:**
   - **Energy** is **lost** at each trophic level as it moves up the food chain

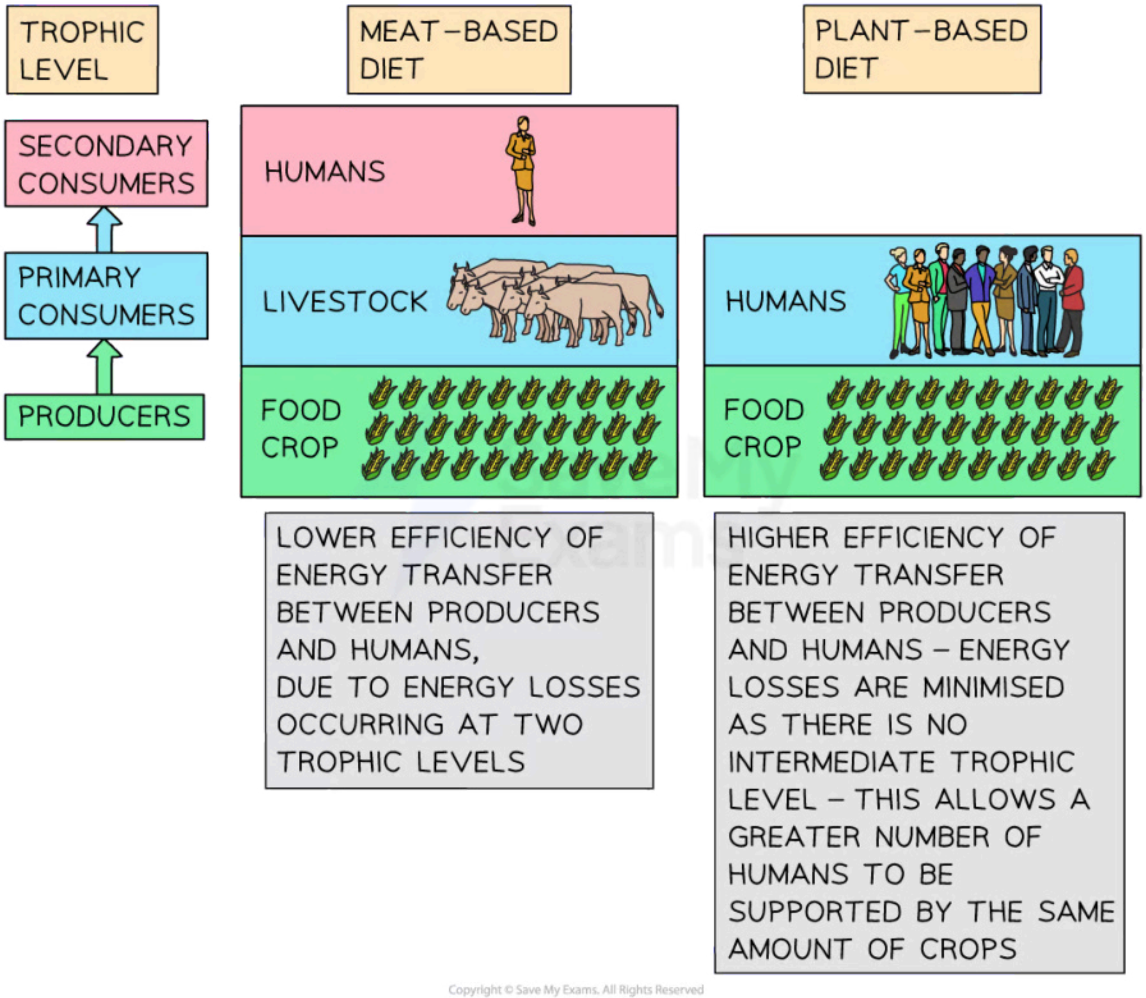
- When we consume plant-based foods directly, we bypass the energy loss associated with raising animals for meat
- By consuming plants (the primary producers) directly, we utilise energy more efficiently

2. **Feed conversion efficiency:**
    - Animals raised for meat require significant amounts of **feed** to grow and develop
    - However, a large portion of the energy from the feed is used for the animals' own **bodily functions** and **metabolic processes**, rather than being converted into **edible biomass**
    - This inefficiency in feed conversion results in higher energy losses when obtaining nutrition from meat
3. **Land use efficiency:**
    - Producing meat requires **vast amounts of land** for grazing or growing animal **feed crops**
    - This land could otherwise be used more efficiently to cultivate plant-based foods directly for human consumption
    - By consuming plant-based foods, we **optimise land use** and reduce the energy required for livestock farming

- By focusing on lower-trophic-level food production, such as promoting plant-based diets, it is possible to:
    - **Maximise food production per unit area**
    - At the same time, mitigating the pressure on land resources

Your notes

Your notes



Efficiency of meat-based vs plant-based terrestrial food production systems

Global food production and distribution

- **Current production:**
  - Global agriculture currently produces enough food to feed approximately eight billion people (the global population currently stands at 8.1 billion in 2024)
- Despite this, food is **not distributed equitably** around the world
  - Some regions experience surpluses, while others face severe shortages
- **Food waste:**
  - It is estimated that at least one-third of all food produced is wasted

- This can be during:
  - Post-harvest
  - Storage
  - Transport and distribution
- **SDG goal:**
  - The United Nations' Sustainable Development Goal 12 aims to:
    - ***"...ensure sustainable consumption and production patterns."***
  - Target 12.3 within this goal focuses on:
    - Reducing global food waste by **50% per capita** at the retail and consumer levels (i.e. halving global food waste) by 2030
    - By minimising food losses throughout production and supply chains (including post-harvest losses)

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Strategies for sustainable food supply

1. **Reducing demand and food waste:**
   - **Encouraging plant-based diets:** shifting towards plant-based diets can reduce the demand for resource-intensive animal products
   - **Improving food distribution systems:** increasing the efficiency of food distribution can help ensure that food reaches those in need and reduce waste. For example:
     - Using refrigerated transport to keep food fresh longer
     - Optimising delivery routes to reduce transport time
     - Collecting and redistributing surplus food to those in need
   - **Educating consumers:** raising awareness about the importance of reducing food waste at the consumer level can have a significant impact
2. **Reducing greenhouse gas emissions:**
   - **Plant-based meat substitutes:** developing and promoting plant-based alternatives to meat can reduce greenhouse gas emissions associated with livestock
     - These products mimic the taste and texture of meat but are made from plants
   - **Low methane rice cultivation:** using rice cultivation practices that produce less methane can help reduce agricultural emissions. For example:
     - Periodically draining and re-flooding rice fields

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- Applying additives that reduce methane emissions
- **Reducing methane release by ruminants:** adjusting livestock diets and using dietary additives like seaweed can lower methane emissions from ruminants

3. **Increasing productivity without expanding agricultural land use:**
    - **Extending shelf life:** improving preservation methods to extend the shelf life of food can help reduce waste. For example:
        - Improved packaging
        - Improved refrigeration
    - **Genetic modification:** using genetic modification to create crops with increased productivity. For example:
        - Crops that produce higher yields with the same inputs
        - Crops that are more resistant to pests and diseases
    - **In-field solar-powered fertiliser production:** using solar energy to produce fertilisers on-site
        - Reduces the need for synthetic fertilisers
        - Reduces reliance on fossil fuels (required for production of synthetic fertilisers)
        - Reduces production and transport costs

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Food Security

Food Security

- Food security can be defined as:

When all individuals, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life

Key components of food security

1. **Availability:** ensuring that enough food is **produced** and **supplied** to meet the population's needs
2. **Access:** ensuring that individuals have the resources (economic means) to obtain the food they need (i.e. food is **affordable**)
3. **Use:** ensuring food is used properly alongside a healthy diet, clean water, sanitation and healthcare to achieve **good nutritional health**
4. **Stability:** ensuring consistent and reliable access to food at all times, **without disruptions** from economic or climate-related issues

Regional food security

- **Developed regions:**
    - Generally **high levels** of food security
    - Good infrastructure, economic stability and social safety nets ensure food availability and access
    - Examples: North America, Western Europe
- **Developing regions:**
    - Varying levels of food security, often **lower** than in developed regions
    - Issues include poverty, poor infrastructure and political instability
    - Examples: Sub-Saharan Africa, parts of South Asia, Latin America

Factors affecting food security

- **Economic factors:**
    - Income levels, food prices and employment opportunities impact individuals' ability to purchase food
- **Environmental factors:**

- Climate change, natural disasters and resource depletion impact food production and availability
- **Social and political factors:**
  - Government policies, conflict and social inequality impact food distribution and access

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Factors Affecting Agricultural Choices (HL)

Your notes

Factors Affecting Agricultural Choices

- The types of agriculture practiced in different regions are largely influenced by **environmental factors**—mainly:
  - **Soil type**
  - **Climate**
- The agricultural methods that are most **productive** and **sustainable** in a particular region depend on:
  - **Soil properties** like fertility, structure, and water-holding capacity
  - **Local temperature** and **rainfall patterns**
- As a result, farmers adopt specific agricultural practices to suit the soil and climate conditions of **each biome**
  - This can lead to **contrasting choices** in farming methods

Steppe and prairie biome: cereal farming vs ranching

- **Soil type: mollisols**
  - Found in grasslands, e.g:
    - North American prairies
    - Eurasian steppes
    - South American pampas
  - Highly fertile and rich in organic matter
  - Deep, dark soils that are capable of holding moisture and supporting plant growth
  - Ideal for agriculture
- **Cereal farming**
  - Common in regions of steppe and prairie that receive sufficient rainfall to support crop growth
  - Mollisols support high-yield cereal crops such as wheat, maize, and barley
    - These crops thrive in these nutrient-rich soils
- **Ranching**

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  - More common in drier areas of the steppe where water is less available for crop irrigation
  - Grasses thrive in mollisols
    - This provides grazing land for cattle and sheep

Tropical forest biome: soya beans vs cattle ranching

- **Soil type: oxisols**
  - Found in tropical rainforest regions, e.g:
    - Amazon Basin
    - Parts of Africa, e.g. Congo Basin, Central and West Africa
    - Southeast Asia
  - These soils are:
    - Heavily weathered
    - Acidic
    - Low in natural nutrients due to high rainfall and temperatures, which cause rapid decomposition and leaching
- **Soya bean farming**
  - Grown in tropical areas where soil can be fertilised and lime is added to adjust pH
  - Soya beans are valuable in global markets for:
    - Human food source
    - Oil production
    - Livestock feed
- **Cattle ranching**
  - Often chosen for areas where soil quality does not support crops
  - Overuse can lead to soil degradation

Desert biome: irrigated crops vs ranching

- **Soil type: aridisols**
  - Found in arid regions, such as deserts in e.g:
    - North Africa

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        - Middle East
        - American Southwest
    - Dry, sandy soils
    - Low in organic matter and nutrients
    - They are challenging to cultivate without irrigation or soil amendments
- **Irrigated crops**
    - Found in areas with access to water resources for irrigation, e.g. Nile Delta or regions of California
    - With irrigation, crops like alfalfa, cotton, and various fruits can be grown, but this requires **careful water management**
    - Irrigation in arid areas can lead to salinisation if not managed properly
- **Ranching**
    - Common in areas with:
        - Limited water availability
        - Desert vegetation that provides sparse but resilient grazing for livestock
    - Often low-intensity (fewer animals per hectare) to match the limited feed resources available

Temperate forest biome: mixed arable and pasture farming

- **Soil type: brown earths**
    - Found in temperate forest regions, e.g:
        - Parts of Europe
        - Parts of North America
    - These soils are fertile with a balanced pH, good drainage, and moderate organic content
        - This makes them **versatile** for agriculture
        - They can support a range of agricultural activities, from crop production to grazing livestock
- **Mixed arable farming**
    - Involves growing crops like wheat, oats, and vegetables
        - Often grown in rotation to maintain soil health and fertility
    - Mixed arable farming is ideal for brown earth soils, as they retain nutrients well and support a wide range of crops
- **Pasture farming**

- Common in areas where grass grows well, providing fodder for livestock like cattle and sheep
- Rotating fields between arable crops and pasture helps **prevent soil degradation**

Your notes

Examiner Tips and Tricks

You don't need to memorise all four pairs of contrasting agricultural choices outlined above, but it's a good idea to familiarise yourself with one or two of these. Practicing with one or two examples will help you explain how local conditions can lead to different agricultural choices within a similar biome—a key skill for exam success!

Alternative Farming Approaches (HL)

Your notes

Alternative Farming Approaches

- Alternative farming approaches aim to address **environmental**, **economic**, and **sustainability issues** in agriculture
- These methods focus on **conserving resources**, **improving soil health**, and creating **sustainable food systems**
- Key alternative approaches include:
  - Soil regeneration
  - Rewilding
  - Permaculture
  - Non-commercial cropping
  - Zero tillage

Soil regeneration

- Soil regeneration improves soil health by restoring structure, nutrients, and biodiversity
  - Techniques include:
    - Cover cropping
    - Crop rotation
    - Mulching (adding compost)
    - Adding organic matter like manure
    - Reducing soil disturbance due to ploughing
    - Nutrient management
- Regenerative farming typically **reduces or eliminates synthetic fertilisers**
  - This promotes sustainable nutrient cycles
- Soil regeneration also helps **increase soil carbon storage**
  - This helps reduce greenhouse gases and mitigate climate change

Rewilding

Your notes

- Rewilding involves allowing land to return to a **natural state**, supporting biodiversity and ecosystem health
  - This often includes **reducing human activity** and allowing native plants and animals to flourish
- Benefits of rewilding include:
  - Enhancing wildlife habitats
  - Supporting pollinators
  - Restoring natural soil nutrient cycling
- Rewilding also contributes to **carbon storage** as natural vegetation regrows and stores carbon in plants and soil

Permaculture

- The word 'permaculture' is a contraction of **permanent agriculture**
- Permaculture is a farming design that **mimics natural ecosystems** to create **self-sustaining systems**
  - The aim is that these systems can be **continuously used** for agriculture
- Key practices include:
  - Conserving water
  - Promoting plant diversity
  - Using natural pest control
  - Minimising artificial inputs like synthetic fertilisers or pesticides
- Crop diversity and crop rotation are used to **maintain soil fertility** and reduce pests and diseases

Non-commercial cropping

- Non-commercial cropping is growing crops for **local consumption** rather than to be sold commercially
  - It focuses on community food security and supporting local economies
  - For example, **urban allotments** can be used for non-commercial cropping
- Reduces the need for long-distance transport
  - This lowers the carbon footprint of food production

Zero tillage (no-till farming)

- Ploughing breaks up the surface of the soil

Your notes

  - This leads to **increased erosion**, **loss of organic matter**, **loss of moisture** and **soil organisms**, and **soil compaction**
- Zero tillage (or no-till farming) involves planting seeds directly into **unploughed soil**
  - This helps prevent soil erosion, conserve moisture, and maintain soil structure
- This approach also reduces the need for heavy machinery and fuel, lowering environmental impact

Examiner Tips and Tricks

Each of these methods aims to address specific ecological goals like **soil health** or **biodiversity**, with most of them addressing multiple issues. In your exam, you may also need to relate these methods to **larger issues** like **climate change** or **food security** for stronger answers.

Regenerative Farming Systems (HL)

Your notes

Regenerative Farming Systems

- Regenerative farming systems aim to restore:
  - Soil health
  - Biodiversity
  - Productivity
- These systems focus on creating **long-term sustainable farms** through natural processes
- They often use **mixed farming techniques**
  - This involves combining plants and animals to work together for better farm productivity and environmental health
- Regenerative farming systems are commonly associated with **permaculture**
  - Permaculture is a farming approach focused on mimicking natural ecosystems

Key techniques in regenerative farming

Use of animals in regenerative farming

- **Animals as natural tools**:
  - Animals like pigs and chickens help **clear vegetation** and **aerate the soil**
    - This reduces the need for heavy machinery
  - Animal movement disturbs the soil just enough to help with seed growth and reduce soil compaction
  - Animals also **introduce manure to the soil**
    - This acts as a natural fertiliser that boosts soil nutrient levels and organic matter
- **Advantages**:
  - Reduces reliance on synthetic fertilisers
  - Increases natural fertility of soil
  - Promotes organic matter in the soil, which improves soil structure and nutrient content
  - Creates a self-sustaining ecosystem by recycling nutrients within the farm

- **Disadvantages**:
  - Requires careful management to prevent issues like **overgrazing** or **soil erosion** by animals
  - Can be labour-intensive on large farms, needing regular monitoring
  - Animal welfare and ethical practices need to be prioritised

Mob grazing

- **Mob grazing**:
  - Mob grazing involves moving animals in concentrated groups into specific areas for short periods
    - It is sometimes called "tall grass grazing" because the grass can grow very tall in between grazing periods
  - In contrast to **continuous grazing**, mob grazing is more controlled and **mimics natural herding patterns** of large herbivores
  - This method allows the plants to **recover** between grazings
    - This maintains their root systems and enhances soil structure
- **Advantages**:
  - Boosts soil fertility through natural fertilisation from animal manure
  - Provides a recovery or "rest" period for grasses and soils
  - Encourages biodiversity in the plant life and microorganisms in the soil
- **Disadvantages**:
  - Must be managed well to avoid overgrazing
  - Can lead to soil compaction if not carefully managed
  - Time, labour and monitoring are required to move animals regularly
  - Not all farms have sufficient land or resources to effectively use mob grazing

Plant-based diets and regenerative systems

- **Diverse cropping**:
  - Plant-based diets can be supported through regenerative practices by growing a **variety of crops**
  - Requires techniques that use multiple different crops, like crop rotation, cover cropping, and intercropping

Your notes

  - These methods keep soil healthy by adding organic matter, reducing soil erosion, retaining soil moisture, and reducing pest issues naturally
- Diverse cropping systems in regenerative farming help meet food demands while building a **resilient soil structure**

Examiner Tips and Tricks

If this topic comes up in your exams, always try to think about how regenerative farming **mimics natural ecosystems** (and why this is beneficial), especially when linking to biodiversity and sustainability.

Technological Innovations in Agriculture (HL)

Your notes

Technological Innovations in Agriculture

- Modern agriculture uses advanced greenhouse and vertical farming techniques
- These techniques:
  - Increase productivity
  - Meet the growing food demands of urban areas

High-tech greenhouses

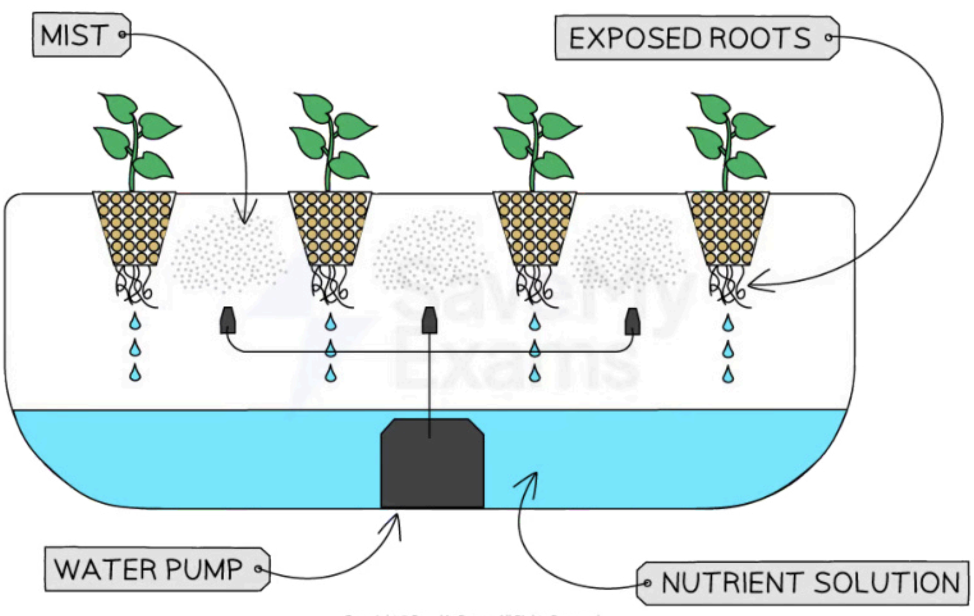
- **Controlled environment**:
  - High-tech greenhouses are designed to maintain ideal growing conditions
    - Factors controlling these greenhouses include temperature, humidity, light, and CO_2 levels
  - Year-round crop growth is possible, ensuring consistent yields
- **Hydroponic systems**:
  - Many greenhouses use hydroponic systems for plant growth
    - Plants are grown in a nutrient-rich water solution instead of soil
  - Hydroponics can reduce water usage by up to 90% compared to traditional farming
    - This is because the water is recycled within the system
  - This method accelerates plant growth and increases yields
- **Energy and climate considerations**:
  - High-tech greenhouses can be energy-intensive
    - Heating, cooling, and lighting require significant energy
  - Some greenhouses are adopting renewable energy sources, such as solar and geothermal, to reduce environmental impact

Vertical farms

- **Efficient use of space**:
  - Vertical farms grow crops in stacked layers within indoor facilities
    - This maximises use of space

Your notes

      - This is an advantage in densely populated urban areas
- **Urban food production**:
  - Vertical farms have the potential to enhance food security in urban environments
  - They can provide fresh produce to residents and reduce reliance on imports
  - Proximity to consumers reduces transportation costs and emissions
- **Artificial lighting and climate control**:
  - Vertical farms use LED lights for optimal photosynthesis
  - Artificial lighting ensures consistent growth conditions
  - Use systems to minimise water use and deliver nutrients precisely
    - Examples include:
      - **Hydroponics**: growing plants without soil, using mineral- and nutrient-rich water instead
      - **Aeroponics**: crops hang in the air with their roots exposed and a nutrient-rich mist waters the plants



An aeroponic system

Advantages and Disadvantages of Vertical Farms

<table>
<tr><th>Advantages</th><th>Disadvantages</th></tr>
<tr><td>
Doesn't require soil, which is ideal for places with poor soils

Can be grown in all sorts of places, from highly urbanised cities to the underground

Much more sustainable, using

Less land
Fewer pesticides and fertilisers (and therefore less pollution)
Less water
Recycled water
Less polluting machinery
Less transport (reducing food miles)

Saves land for other resources

Supporting food security and climate change, as there is less risk of crop damage from flooding or droughts. It is more reliable

Aeroponics reduces the amount of labour needed to grow produce
</td><td>
Needs regular monitoring and knowledge to operate successfully

Low labour inputs may result in fewer jobs and the loss of traditional farming jobs

Heavily technology dependent

If there is a fault in the system, crop loss will be catastrophic

Land in urban areas is expensive, resulting in higher costs

The systems use a lot of energy
</td></tr>
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Sustainability challenges

- High-tech greenhouses and vertical farms face sustainability challenges
    - They rely on artificial climate control and lighting, leading to high energy consumption
    - Much of this energy still comes from burning fossil fuels
- Researchers are exploring ways to improve efficiency
    - Solutions include integrating renewable energy sources and smarter technologies for managing resources such as heat, water and nutrients

Your notes

Your notes

Sustainability of Different Diets (HL)

Sustainability of Different Diets

- Factors that affect a diet's sustainability include:
  - Food production methods
  - Transport of food
  - Farming techniques
  - Societal eating habits

Supply chain efficiency

- **Length of the supply chain**:
  - A longer supply chain usually **increases environmental impact**
  - Food sourced locally has fewer 'food miles' (distance from farm to plate)
    - This reduces **fuel use** and **carbon emissions**
  - Shorter supply chains reduce waste by minimising handling and storage time
- **Environmental impact of imports**:
  - Foods imported from distant countries require transportation
    - This is often by plane, ship, or truck
  - This transportation emits greenhouse gases, contributing to climate change

Year-round food supply and food miles

- **Year-found availability of food**:
  - Many consumers expect continuous availability of foods, e.g. fresh fruits, in **all seasons**
  - This requires importing goods from countries where they are in season, increasing food miles
    - E.g. out-of-season strawberries shipped from across the world have a **higher carbon footprint** than local, in-season produce
    - Tropical fruits such as bananas, pineapples, and avocados are often sourced from distant locations

Meat consumption and cultural shifts

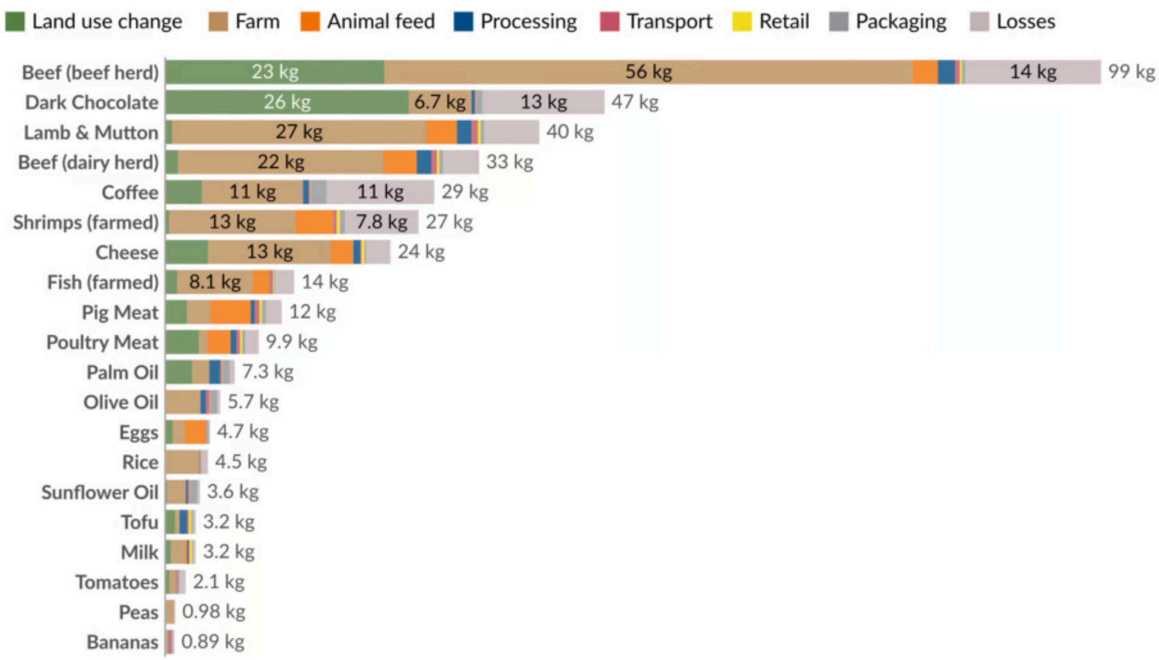
Your notes

- **Environmental cost of meat**:
  - Meat production has a high environmental impact due to **land, water, and energy needs**
    - E.g. compared to plant-based foods, producing 1 kg of beef can require 15 times more water
    - Cattle also release **methane**, a potent greenhouse gas, during digestion
- **Shifts in meat consumption**:
  - In some societies, there is a growing trend to reduce meat consumption
    - This is for **environmental** and **health** reasons
  - Many people are adopting 'flexitarian' diets or 'meatless' days
    - This is often to reduce their personal environmental impact from meat production

Rise of veganism and plant-based diets

- **Growing popularity of plant-based diets**:
  - Plant-based diets are seen as a more sustainable alternative, as they rely less on animal agriculture
  - Focusing on vegetables, grains, and legumes:
    - Reduces land and water use
    - Lowers greenhouse gas emissions
    - Conserves biodiversity
- **Nutritional balance**:
  - A well-balanced plant-based diet can **still meet nutritional needs** whilst also being **more sustainable**

Your notes



Greenhouse gas emissions across the supply chain for different foods. Greenhouse gas emissions are measured in kilograms of carbon dioxide-equivalents (CO_2eq) per kilogram of food. (Joseph Poore and Thomas Nemecek, 2018).

Planetary Health Diet (PHD)

- **Definition and goals of the PHD**:
  - The Eat-Lancet Commission was responsible for developing the Planetary Health Diet (PHD).
    - It is a guide for sustainable and healthy eating
  - This diet **balances human health** with the need to **conserve natural resources** and **reduce environmental damage**
  - It emphasises vegetables, fruits, whole grains, nuts, and a limited amount of animal products
    - E.g. limited amounts of red meat and dairy
- **Benefits of the PHD**:
  - Aims to reduce greenhouse gas emissions by shifting dietary habits
  - **Supports biodiversity** and **soil health** by reducing the need for monoculture farming, which can degrade land
  - Aligns dietary needs with planetary limits

- Aims to provide the global human population with enough nutrients without exceeding planetary boundaries

Awaiting image: Planetary health diet

Image caption: A 'planetary health plate' helps to visualise the different components of the Planetary Health Diet

Examiner Tips and Tricks

Remember that sustainability depends not only on what we eat but also on how food is produced, transported, and managed.

Your notes

Sustainability of Harvesting Wild Species (HL)

Your notes

Sustainability of Harvesting Wild Species

- Harvesting wild species can be a sustainable alternative to converting land for agriculture
- Sustainable harvesting relies on using **traditional** or **low-impact methods** that do not deplete resources
  - This approach can **maintain ecosystem balance** and **biodiversity**

Benefits of traditional harvesting

- Traditional methods are often sustainable because they use **knowledge passed down through generations**
  - This knowledge includes when, where, and how much to harvest without over-extracting resources

Examples of wild species harvesting

- **Brazil nuts:**
  - Harvested from mature Amazon forests without cutting down trees
  - Brazil nut trees rely on the surrounding ecosystem to reproduce
    - Specific bee species pollinate Brazil nut flowers
    - Agoutis (small rodents) spread the seeds
  - Keeping forests intact for nut harvesting supports local economies
  - Local communities benefit financially
    - This encourages rainforest preservation by local communities
  - E.g. in Brazil, Peru, and Bolivia , Brazil nut harvesting supports communities and protects large areas of the Amazon
- **Truffles:**
  - A type of underground fungus harvested in forests in Europe and North America
  - Truffle harvesting uses trained dogs or pigs to locate them
    - This minimises disturbance to the forest ecosystem
  - Preserving forests benefits truffle production, as truffles decline when forests are cut down

Your notes

    - E.g. France and Italy value truffles as delicacies, supporting forest preservation
- **Bamboo:**
    - Bamboo grows very quickly, allowing for sustainable harvesting
    - Harvesting mature bamboo shoots does not harm the plant
    - Bamboo provides materials for construction (e.g. flooring and roofing), furniture, cloth, paper and fuel
    - Young shoots can be harvested for food
    - E.g. in China and Southeast Asia, bamboo shoots provide income and reduce pressure on slower-growing trees
- **Honey:**
    - Bees collect nectar from forest plants, aiding plant pollination
    - Forest-based honey production needs undisturbed habitats for bees
        - This promotes forest conservation
    - E.g. in Ethiopia and India, forest honey production supports biodiversity whilst also providing income for rural communities
- **Insects:**
    - Edible insects, such as grasshoppers and beetles, are sustainable protein sources
    - Insects need minimal land and water
        - They also produce few greenhouse gases
    - Harvesting insects can reduce the demand on traditional livestock

Controversial and endangered species

- **Pangolins:**
    - Pangolins are hunted for scales (used in traditional medicine) and meat
    - Overharvesting and habitat loss threaten pangolin populations
    - Conservation efforts focus on habitat protection and reducing demand
        - E.g. Southeast Asian countries regulate pangolin trade, but poaching remains an issue
- **Bears (for bile and other parts):**
    - Bear bile is traditionally used in some Asian medicines
        - It is often obtained through inhumane farming methods or illegal poaching

Your notes

- This demand has caused declines in some bear populations, e.g. sun bears, Asian black bears, sloth bears
- Synthetic and herbal alternatives are being developed to reduce demand
- **Bushmeat:**
  - Hunting wild animals for food is common in tropical regions, especially Africa and Asia
  - Overhunting disrupts ecosystems and endangers species
  - Alternative food sources, education, and enforcement of wildlife protection laws can help reduce reliance on bushmeat
    - E.g. some conservation groups in Africa are working to provide alternative livelihoods to hunters, such as farming and eco-tourism, to reduce bushmeat demand

Considerations for sustainable harvesting

- Harvesting wild species sustainably can actually help to **preserve biodiversity in some contexts** (e.g. harvesting of brazil nuts and forest honey)
  - These sustainable practices can **support ecosystems**
  - However, overharvesting of wild species can harm food webs and habitat stability
- **Role of legal regulations:**
  - Regulations are essential to ensure sustainable practices and protect endangered species
  - Many countries have laws to protect wildlife but need **effective enforcement** and **community involvement**

Examiner Tips and Tricks

You don't need to learn all these different examples for your exams but you should familiarise yourself with a few well-understood cases, such as Brazil nuts or forest honey, to illustrate how harvesting practices involving wild species can be achieved in a sustainable way.

Sustainability of Lower Productivity Food Systems (HL)

Your notes

Sustainability of Lower Productivity Food Systems

- Lower productivity food systems focus on **small-scale**, **traditional**, or **alternative** farming practices
  - These systems often prioritise:
    - Sustainability
    - Local food security
    - Environmental health
- Examples include:
  - **Indigenous farming** methods
    - These methods often respect natural cycles and ecosystems
  - **Traditional subsistence agriculture**
    - Farmers grow food mainly for their family or local community
  - **Alternative systems** like permaculture
    - Use sustainable methods to grow diverse crops with minimal environmental impact
- These systems generally have **lower yields compared to high-intensity commercial agriculture**

Claims of sustainability

- Advocates argue that low-productivity systems can support global sustainability by:
  - **Reducing the environmental impact**
    - E.g. by reducing greenhouse gas emissions and biodiversity loss
  - **Preserving local ecosystems and biodiversity**
    - E.g. through more natural farming methods
  - Focusing on:
    - Soil health
    - Water conservation
    - Minimising chemical inputs

Your notes

- These systems also often **enhance resilience to climate change**
  - This is because diverse crops and traditional practices may be more adaptable to changing conditions

Challenges for feeding a growing population

- Despite sustainability benefits, low-productivity systems face limitations:
  - **Lower food yields**:
    - These systems may not produce enough food to meet the needs of a large, global population
  - **Economic constraints**:
    - They often rely on local resources and are not designed for **large-scale food distribution**
  - **Lack of commercial viability**:
    - Many low-productivity systems have **limited market reach**, reducing their impact on global food supply chains
- **Balancing sustainability** with the need for **higher food output** is a significant challenge for these systems

Evaluating sustainability vs. productivity needs

- **Pros of low-productivity systems**:
  - Environmentally friendly, with fewer pollutants and minimal resource extraction
  - Promote local food security, particularly for indigenous and rural communities
  - Maintain cultural and agricultural heritage by preserving traditional knowledge
- **Cons of low-productivity systems**:
  - Limited ability to feed large populations at a global scale
  - May struggle to keep up with demand as populations grow, especially in urban areas
  - Often lack the infrastructure to support large-scale distribution, reducing accessibility for wider populations

Real-world examples

- **Rice terraces in Southeast Asia**:
  - Traditional rice terraces **reduce soil erosion** and **promote water conservation**, but the yield may not compete with industrial rice production
- **Amazon rainforest farming (indigenous agroforestry)**:

Your notes

  - Indigenous groups in the Amazon use agroforestry techniques that integrate crops (e.g. cassava) with native trees and plants
  - This method **supports biodiversity** and **preserves soil health** using low-impact techniques
  - It provides food for local communities without large-scale deforestation or high resource inputs
  - But produces lower quantities of food compared to intensive farming
- **Peruvian Andean potato farming**:
  - Andean farmers cultivate diverse potato varieties adapted to high-altitude climates
  - The system relies on local knowledge and traditional farming methods, sustaining soil fertility
  - While it supports food security for local communities, it is not highly productive on a commercial scale

Examiner Tips and Tricks

Make sure you are clear about how these low-productivity systems benefit local communities and the environment, but also why they may **not** solve global food demands.

Your notes

Food Distribution, Quality & Malnutrition (HL)

Food Distribution, Quality & Malnutrition

Food distribution patterns

- Food distribution involves moving food from **production areas** to **consumers**
  - This is influenced by factors like:
    - Economic policies
    - Trade systems
    - Infrastructure quality (e.g. transportation systems)
  - Many countries import a significant portion of their food, relying on global trade networks
- Uneven distribution often results in **food surpluses** in some regions and **food scarcity** in others
  - Wealthier countries typically have diverse, high-quality food supplies
  - Lower-income countries may face food shortages
  - Rural or isolated areas can have limited infrastructure
    - This can make food access difficult, even near production areas

Food quality and nutrition

- Food quality varies widely, impacting nutrition and health
  - Quality food is rich in essential nutrients (vitamins, minerals and protein)
  - Processed foods often have lower nutritional value and may be high in sugar, salt and fats
- Quality of food does not always correlate with food quantity or appearance
  - High biomass (e.g. large volume of staple grains) does not always mean high nutritional value
  - Calorie-rich, nutrient-poor foods can lead to 'hidden hunger'
    - This is where malnutrition and nutrient deficiencies occur despite adequate calories
  - Populations relying on low-quality diets may face health issues even with enough food (e.g. if diets lack essential nutrients)

Types of malnutrition

Your notes

- **Malnutrition** refers to health issues arising from inadequate or unbalanced nutrition
- There are two main types:
  - Undernourishment
  - Overnourishment

Undernourishment and undernutrition

- **Undernourishment** is when there is insufficient calorie intake to meet basic energy needs
- **Undernutrition** is a lack of essential nutrients, even if calories are sufficient
- **Causes**:
  - Food scarcity, poverty, and food distribution problems
  - Common in low-income areas where diets lack variety and essential nutrients
- **Health impacts**:
  - Weight loss
  - Weakened immunity
  - Extreme fatigue
  - Stunted growth
  - Developmental issues

Overnourishment and overnutrition

- **Overnourishment** is the excessive intake of calories
- **Overnutrition** is the excessive intake of non-essential nutrients (e.g. fats, sugars, and salts) without sufficient vitamins and minerals
- **Causes**:
  - Linked to high food consumption and low physical activity
  - Common in wealthier populations with high access to calorie-rich, processed foods
- **Health impacts**:
  - Chronic diseases, e.g. obesity, heart disease, and type 2 diabetes

Causes of food insecurity and malnutrition

- **Natural disasters**: droughts, floods, and crop pests reduce food availability

Your notes

- **Economic inequality**: low-income populations may struggle to afford nutritious food
- **Conflict and political instability**: wars disrupt agricultural production and food distribution networks
- **Cultural and dietary practices**: cultural habits and food preferences impact food choices (e.g. overconsumption in some cultures)

Real-world examples

Irish potato famine (1845–49)

- Caused by potato **blight**, a fungal disease that destroyed potato crops
  - Potato was a staple food for many Irish people at the time
- **Heavy reliance** on a **single crop** left the population **vulnerable to food shortages**
- Poor government response and **weak food distribution systems** worsened the famine
- Led to one million deaths and mass emigration from Ireland

East African famines

- Frequent famines in East Africa, notably in Ethiopia and Somalia
  - Caused by **drought** and **regional conflict**
- Limited infrastructure and political instability **prevent food distribution** in these regions
- Many people are suffering from **undernutrition** due to restricted access to varied, nutrient-rich foods
- Dependence on **international aid** highlights the challenges of local food self-sufficiency in developing countries

Examiner Tips and Tricks

Remember that malnutrition includes both **undernutrition** and **overnutrition**. Be able to give examples of each type and their causes.