DP IB Environmental Systems & Societies (ESS): SL

Your notes

Terrestrial Food Production Systems & Food Choices

Contents

Your notes

Sustainability of Terrestrial Food Production Systems

- Sustainability in terrestrial food production systems is a complex challenge influenced by various factors, including scale, industrialisation, fossil fuel use, seed and livestock choices, water management, fertiliser use, pest control, pollinators, antibiotics, government policies, and the balance between commercial and subsistence food production
  - It is crucial to understand the implications of these factors for developing **strategies** that promote **resilient**, **environmentally-friendly**, and **socially equitable** food systems
  - By examining each factor in detail, it is possible to gain insights into the complexities and opportunities involved in creating sustainable terrestrial food production systems

Photo by Kenny Eliason on Unsplash

Organic farming may be more sustainable than industrial farming, but yields can be compromised

Scale

- The scale of food production systems plays a crucial role in their sustainability:
  - Large-scale industrial agriculture tends to rely heavily on **intensive practices** that can have negative environmental impacts, making them unsustainable
  - On the other hand, smaller-scale and localised food production systems often prioritise **sustainable practices** such as **organic farming**, biodiversity conservation, and **reduced resource consumption**


Your notes

Industrialisation and Mechanisation

- The industrialisation and mechanisation of food production have led to **increased efficiency** and **higher yields**
  - However, these practices can also contribute to **environmental degradation**, **soil erosion**, and **habitat destruction**
  - Balancing the benefits of mechanisation with sustainable practices is essential for long-term food system sustainability

Fossil Fuel Use

- The reliance on fossil fuels for **transportation**, **machinery**, and the production of synthetic **fertilisers** has significant implications for the sustainability of food production
  - The combustion of fossil fuels contributes to greenhouse gas emissions and climate change
  - Transitioning to **renewable energy sources** and promoting energy-efficient practices can help **reduce the carbon footprint** of food production

Your notes

Photo by Melissa Askew on Unsplash

Monocultures and genetically uniform crops such as wheat can lead to increased vulnerability to pests, diseases, and crop failure

Seed/Crop/Livestock Choices

- The selection of seeds, crops, and livestock breeds affects the sustainability of food production systems
    - Diversifying crop varieties, promoting seeds of indigenous species, and supporting resilient livestock breeds can enhance the long-term sustainability and resilience of food systems

Water Use

- Efficient water management is critical for sustainable food production
    - Excessive irrigation can **deplete water resources** and **degrade aquatic ecosystems**
    - Implementation of **water-saving technologies**, optimisation of irrigation practices, and promotion **water-conserving crop varieties** can help mitigate water scarcity issues and improve the sustainability of food production systems

Your notes

Fertilisers

- The use of synthetic fertilisers in agriculture can lead to **nutrient runoff**, **water pollution**, and **soil degradation**
    - Sustainable nutrient management practices, such as **organic fertilisers**, cover cropping, and **crop rotation**, can reduce reliance on synthetic fertilisers and promote soil health

Pest Control

- Traditional pest control methods often rely on **chemical pesticides**, which can have adverse effects on ecosystems and, in some cases, human health
    - Integrated Pest Management (IPM) approaches that combine various pest control methods, such as **biological control**, **crop rotation**, and cultural practices, can minimise the use of chemical pesticides and promote ecological balance

Photo by David Clode on Unsplash

Your notes

Pollinators, such as bees and butterflies, play a crucial role in food production

Pollinators

- Ensuring the conservation of pollinators through **habitat preservation**, **reduced pesticide use**, and **diversified agricultural landscapes** is vital for sustainable food systems

Antibiotics

- In livestock production, the overuse of antibiotics can lead to the emergence of **antibiotic-resistant bacteria**, potentially posing risks to human health
    - Implementing **responsible antibiotic use practices**, promoting animal welfare, and exploring **alternative disease management strategies,** can support sustainable livestock production

Government Policy and Legislation

- Government policies and legislation greatly influence the sustainability of food production systems
    - Supportive policies that **incentivise** sustainable practices, **protect** natural resources, **promote** biodiversity, and ensure **fair trade** can contribute to a more sustainable food system

Commercial vs. Subsistence Food Production

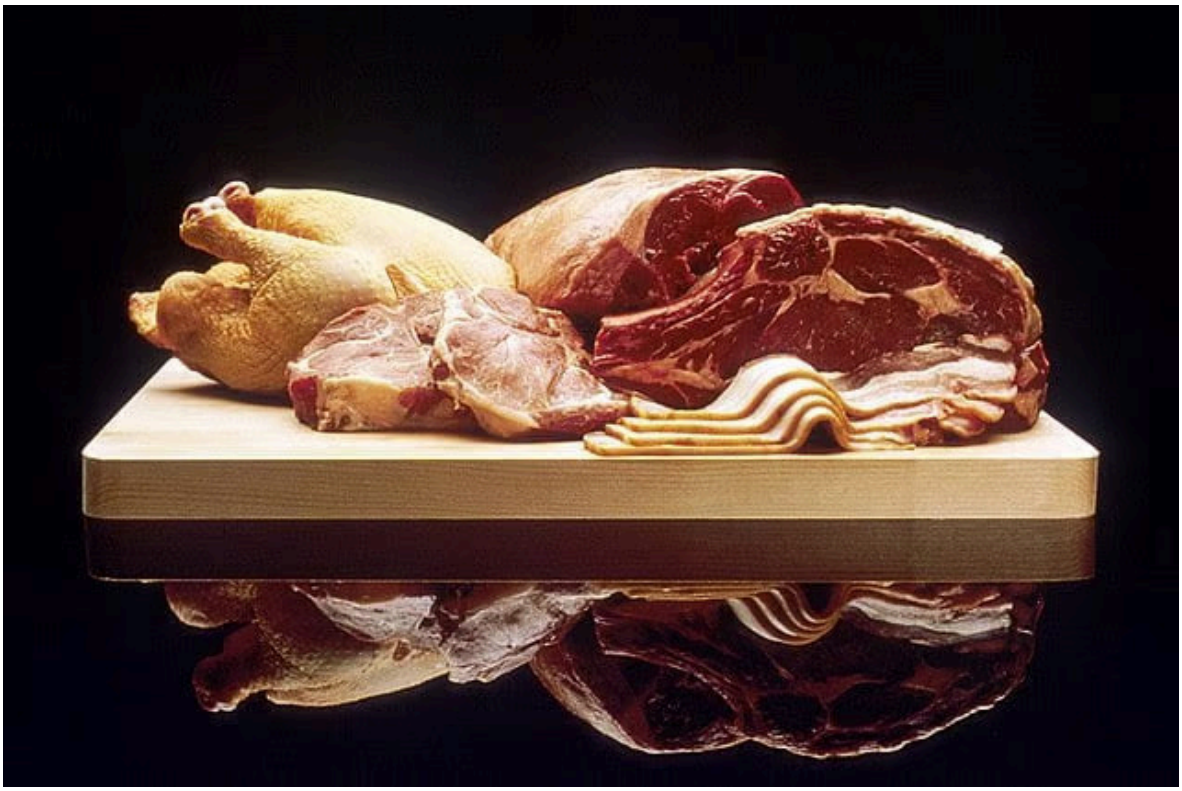
- Balancing commercial food production with subsistence agriculture is essential for food security and sustainability
    - Prioritising **local food systems**, supporting **small-scale farmers**, and reducing dependence on global commodity markets can enhance **food sovereignty**, promote **resilient communities**, and reduce the ecological footprint of food production
- All of the factors outlined above **interact** in complex ways, and addressing them **collectively** is crucial for achieving sustainable terrestrial food production systems that balance environmental stewardship, social equity, and economic viability

Your notes

Inequalities & Food Waste

Inequalities in Food Production and Distribution

- The **growing global population**, which is increasing by over 80 million people each year, puts significant pressure on the global food production system to meet the increasing demand for food



By Unknown photographer, Public Domain, Wikimedia

Meat based diets require more resources and have a higher environmental impact

- In addition, **changes in dietary preferences**, particularly in middle- and high-income countries, contribute to inequalities in food production
  - As people's incomes rise, there is a shift from grain-based diets to meat- and dairy-based diets, which require **more resources** and have a **higher environmental impact**
- Since the early 2000s there has been a steady **increase in world food prices**


Your notes

- While there has also been an increase in food production during this period, the rise in demand for food has outpaced production
- This imbalance has contributed to inequalities in food availability and affordability, particularly for vulnerable populations

- **Fluctuations in oil prices** also have a direct impact on food production and distribution
  - Higher oil prices lead to increased costs in transportation, which can affect the availability and affordability of food, especially in remote or underprivileged regions
- Inequalities also exist in **access to resources and technology** for food production
  - For example, small-scale farmers, particularly in developing countries, often face challenges in accessing good quality seeds, fertilisers, and employing modern agricultural practices
  - This limits their productivity and exacerbates disparities in food production
- Socioeconomic factors, such as **income inequality** and limited **access to education and healthcare**, also contribute to inequalities in food production and distribution
  - Specifically, these factors affect individuals' purchasing power, nutritional status, and overall food security
- **Government policies** and **trade agreements** can either support or hinder equitable food production and distribution
  - Subsidies, tariffs, and regulations can impact the availability and affordability of food, influencing the dynamics of global food systems and exacerbating inequalities
- Finally, **climate change** and **natural disasters** disproportionately affect vulnerable populations and disrupt food production
  - Extreme weather events, water scarcity, and shifting climatic patterns pose challenges for farmers, particularly in developing countries, leading to food insecurity and unequal access to nutritious food
- These various factors all **interact** to create a complex web of inequalities in food production and distribution globally
- Addressing these challenges requires a combined approach that involves sustainable agricultural practices, improved access to resources and technology, equitable policies, and efforts to reduce poverty and inequality on a global scale

Food Waste in LEDCs and MEDCs

Taz, CC BY 2.0, via Wikimedia Commons

Food waste is a global issue that impacts both Less Economically Developed Countries (LEDCs) and More Economically Developed Countries (MEDCs), albeit for different reasons

- Understanding the factors contributing to food waste in these differing regions is crucial for developing effective strategies to address this problem
- By examining the distinct challenges faced by LEDCs and MEDCs, it is possible to identify **targeted solutions** to reduce food waste, promote sustainability, and improve food security on a global scale

LEDCs

- Food waste occurs primarily at the **farm level** due to **inadequate storage and refrigeration** facilities
  - Without proper infrastructure, perishable crops and products are more likely to **spoil** before reaching the market
- Limited access to **efficient transportation** systems and poor road infrastructure contribute to food waste during transportation

Your notes


Your notes

- Inadequate packaging and handling practices contribute to the problem, resulting in **spoilage** and **loss** of produce **during transit**
- Post-harvest losses, such as improper handling, drying, and storage of crops, are common in LEDCs
  - Insufficient knowledge and resources for implementing proper **preservation techniques** contribute to food waste
- Lack of **market access** and limited **value chain integration** in rural areas can lead to **surplus production** that cannot be effectively distributed or sold, resulting in food waste

MEDCs

- Food waste occurs primarily at the **household level** due to consumer behaviour, such as overbuying, improper storage, and discarding edible food
- **Retail-level** food waste is also significant in MEDCs
  - Strict adherence to "sell-by" and "best-before" dates leads to **premature disposal of food** that is still safe to consume
  - Retailers often discard products based on **appearance** rather than actual quality, contributing to unnecessary waste
- Consumer preferences for **aesthetically perfect produce** contribute to waste in the supply chain
  - Retailers often reject imperfect-looking fruits, vegetables, and other products, leading to significant losses at the farm and distribution levels
- Large-scale food operations, such as restaurants, hotels, and catering services, also contribute to food waste due to factors such as portion sizes, buffet systems, and excess food prepared but not consumed

Socioeconomic factors and cultural practices influence food waste

Your notes

Peter van der Sluijs, CC BY-SA 3.0, via Wikimedia Commons

In LEDCs, poverty and limited resources result in a greater emphasis on meeting immediate food needs rather than preventing waste

- Lack of awareness and education about food waste management also play a role in food waste in LEDCs
- In MEDCs, consumer **affluence**, abundance, and a culture of convenience contribute to higher levels of food waste
    - Generous portion sizes, impulse buying, and a disconnect from food production and its value contribute to wasteful behaviours
- Addressing food waste requires targeted strategies that address the specific challenges in LEDCs and MEDCs
    - In LEDCs, this includes improving infrastructure and storage facilities, promoting efficient agricultural practices, enhancing transportation and value chain management, and raising awareness about food waste reduction
    - In MEDCs, this includes promoting initiatives focussing on consumer education, better date labelling practices, improved redistribution of surplus food, and encouraging sustainable consumption habits

Links Between Social Systems & Food Production Systems

Your notes

Factors Influencing Food Production Systems

Factors Influencing Choice of Food Production Systems

- There are many different factors that influence the choice of food production systems
  - These factors interact and vary across **regions** and **countries**, leading to diverse food production systems

Food Display - Wikimedia

Food production reflects a combination of socioeconomic, cultural, ecological, political, and economic influences

Socioeconomic Factors

- **Higher-income** countries tend to have a **higher demand for meat and processed foods** due to increased purchasing power


Your notes

- Urbanisation and the associated lifestyle changes impact the demand for convenience foods and processed products
- **Lower-income** countries may rely more on traditional **subsistence farming** methods due to limited resources and access to technology

Cultural Factors

- Cultural preferences for specific crops or livestock can influence the selection of food production systems
  - For example, in predominantly **vegetarian cultures**, such as India, the choice of food production systems may prioritise plant-based agriculture
  - **Religious** or **ethical beliefs** may influence preferences for organic, vegetarian, or sustainable food production methods

Ecological Factors

- Natural resources, such as land availability, climate conditions, and water availability, determine the suitability of specific food production systems
  - For example, in areas with limited water resources, such as **arid regions**, food production systems may focus on **drought-resistant crops** and **efficient irrigation** techniques
  - Regions with rich biodiversity may prioritise sustainable farming methods to protect ecosystems and **preserve native species**

Political Factors

- Government policies promoting organic farming or providing subsidies for certain crops can influence the choice of food production systems
  - For example, the European Union's Common Agricultural Policy (CAP) includes **financial support** for farmers who adopt organic farming practices
  - This policy encourages farmers to choose organic food production systems by providing **incentives** and **subsidies**
- **Import and export regulations** and trade agreements can affect the availability and affordability of specific food products
  - For example, the United States has **import restrictions** on certain agricultural products to protect domestic farmers
  - Restrictions on imported sugar can affect the availability and affordability of specific food products, influencing the choice of production systems within the country
- **Food security** and **self-sufficiency** goals may drive policies favouring certain production systems
  - For example, in Japan, the government has implemented policies to promote self-sufficiency in rice production

- This includes subsidies and support for rice farmers, as rice is considered a staple food and maintaining domestic production is seen as crucial for food security
- These policies therefore favour rice production systems in Japan

Stephen Morrison/Africa Practice, CC BY 2.0, via Wikimedia Commons

A Malawian woman husks corn in her village on the outskirts of Lilongwe, Malawi. MEDCs use their expertise and experience to help improve food security in African countries

Economic Factors

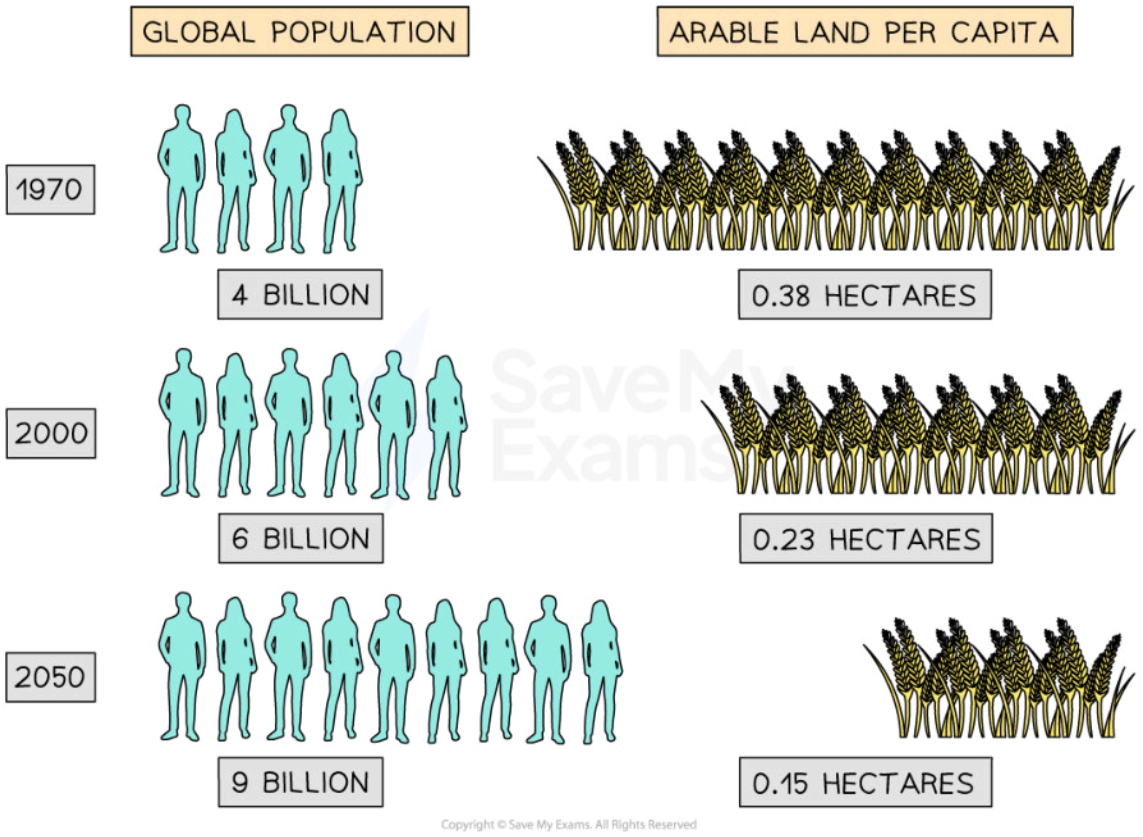
- Cost-effectiveness, profitability, and market demand influence the choice of food production systems
- Global trade dynamics and market forces can shape the competitiveness of different production methods
  - For example, countries with a strong agricultural sector may prioritise **large-scale industrial farming** for **export purposes**
  - On the other hand, small-scale sustainable farming may be more **economically viable** in regions with limited resources

Your notes

Availability of Land

Your notes

- As the human population grows, the demand for food increases, putting **pressure** on available land for food production
- **Urbanisation** leads to the conversion of agricultural land into urban areas, further reducing the availability of land for food production per capita
- **Soil degradation**, caused by factors like erosion, nutrient depletion, and pollution, reduces the fertility and productivity of agricultural land, limiting its capacity to support food production



Historical and predicted arable land per capita

Efficiency of Terrestrial Food Production

- **Increasing** the **yield of food per unit area** is crucial to meet the growing food demand
- Plant-based food production, such as grains, vegetables, and fruits, often yields greater quantities of food per unit area compared to animal-based food production.

- In general, **lower trophic levels**, such as plant-based food production, generally have **higher yields** compared to higher trophic levels like meat production
- Energy efficiency is greater in a plant-based diet compared to a meat-eating diet due to several factors:


Your notes

Trophic Levels

- **Energy** is **lost** at each trophic level moving 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

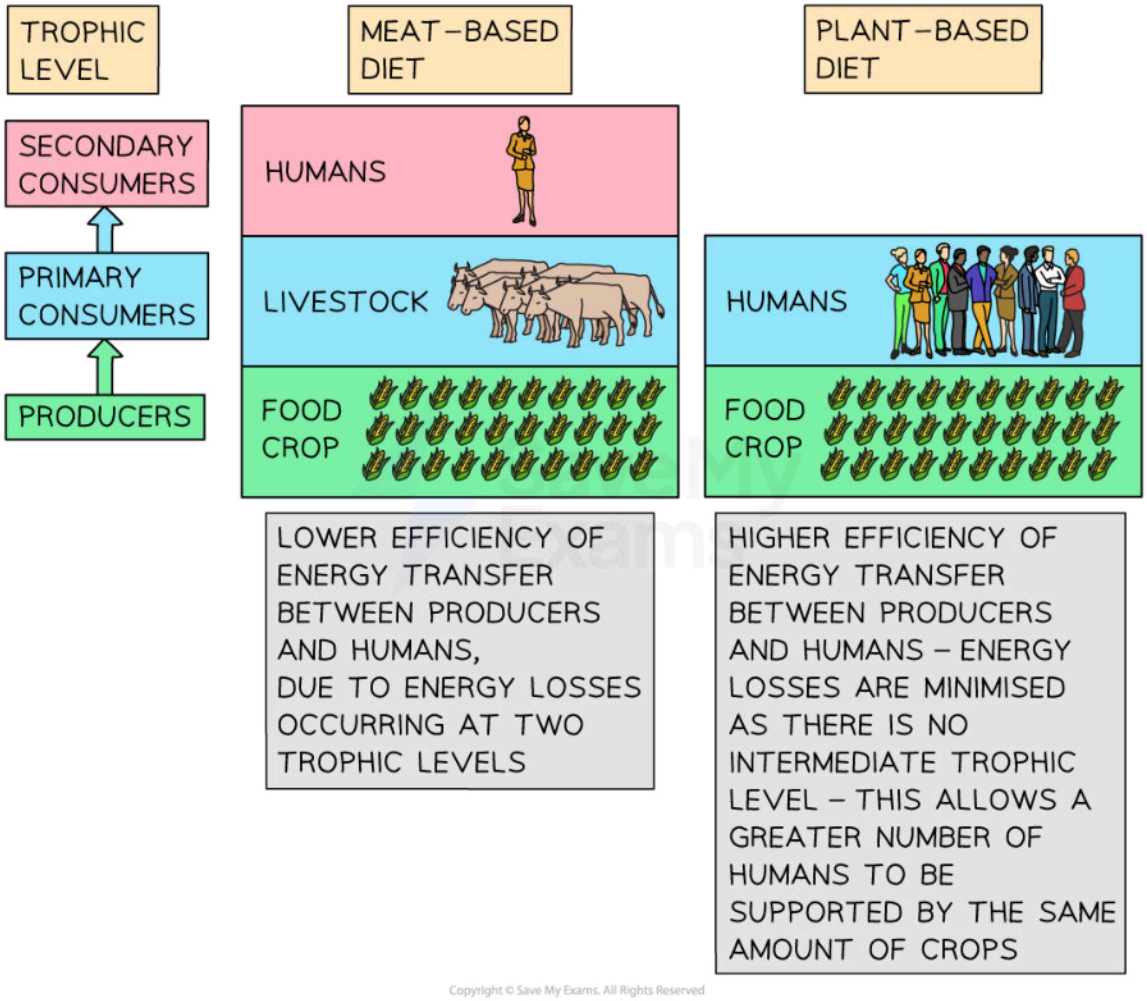
Feed Conversion Efficiency

- 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

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 and sustainable farming practices, it is possible to maximise food production per unit area, at the same time **mitigating the pressure on land resources**

Your notes



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

Your notes

Comparing Terrestrial Food Production Systems

Photo by Johny Goerend on Unsplash

Terrestrial food production systems can be compared and contrasted according to their inputs, outputs, system characteristics, environmental impacts and socioeconomic factors

Inputs

- **Land**: Terrestrial food production systems require varying amounts of land, ranging from extensive grazing systems to highly intensive agricultural practices using relatively smaller areas of land
- **Water:** Different systems have different water requirements, depending on factors such as irrigation methods, crop types, and livestock hydration needs

- **Energy**: The energy inputs in food production systems can vary greatly - industrialised systems tend to rely heavily on fossil fuels for machinery, transportation, and synthetic inputs like fertilisers, while traditional systems may rely more on human labour and organic inputs
- **Inputs of fertilisers and pesticides**: Conventional agricultural systems often rely on synthetic fertilisers and pesticides to enhance crop yields, whereas organic systems prioritise the use of natural fertilisers and pest control methods


Your notes

Outputs

- **Food production**: The quantity and quality of food produced vary among different systems - some systems prioritise high yields, while others focus on specialty or organic products
- **Waste and byproducts**: Different systems generate varying amounts and types of waste, such as crop residues, animal manure, and packaging materials

System Characteristics

- **Scale**: Systems can range from small-scale subsistence farming to large-scale industrialised agriculture
- **Diversity**: Some systems promote crop diversity, while others may focus on **monoculture** practices
- **Livestock**: Systems may involve the raising of livestock for meat, dairy, or manure
- **Technology and mechanisation**: The level of technological advancement and mechanisation varies, with industrialised systems heavily relying on machinery

Environmental Impacts

- **Biodiversity**: Different systems can have varying impacts on biodiversity, with intensive agriculture often associated with habitat destruction and loss of biodiversity
- **Soil degradation**: Intensive agricultural practices can lead to soil erosion, degradation, and loss of fertility, while sustainable practices prioritise soil conservation and improvement
- **Water pollution**: The use of synthetic fertilisers and pesticides in conventional systems can contribute to water pollution through runoff and leaching
- **Greenhouse gas emissions**: The carbon footprint of food production systems can vary significantly, with industrialised systems often associated with higher emissions due to fossil fuel use

Photo by Mark Stebnicki on Pexels

The use of synthetic fertilisers and pesticides in conventional systems can contribute to water pollution through runoff and leaching

Socioeconomic Factors

- **Labor requirements**: Different systems require varying levels of labour, with industrialised systems often characterised by fewer labour-intensive practices
- **Economic viability**: Some systems prioritise high yields and profitability, while others focus on social and economic sustainability, fair trade, and local markets
- **Food accessibility and affordability**: The cost and availability of food vary across systems, with industrialised systems often associated with higher production volumes and lower costs, but potential issues related to food access and distribution
- **Cultural and social values**: Different food production systems align with cultural and social values, such as organic farming, traditional practices, or supporting local communities
- Understanding and comparing these factors can provide insights into the **strengths**, **limitations**, and **impacts** of different terrestrial food production systems
- It allows for **informed decision-making** and the development of more **sustainable** and **resilient** food systems that prioritise environmental conservation, socioeconomic well-being, and food security

Your notes

Your notes

Worked Example

Compare and contrast the inputs, outputs and system characteristics for two food production systems: conventional (non-organic) agriculture and organic agriculture.

Answer

Conventional and organic agriculture are two distinct farming approaches. While conventional agriculture relies on synthetic inputs and intensive methods, organic agriculture generally adopts a more natural, holistic and environmentally conscious approach.

Inputs:

In conventional agriculture, synthetic fertilisers and pesticides are commonly used, whereas in organic agriculture, organic fertilisers, such as compost and manure, are used. Conventional agriculture often relies on greater water inputs via large-scale irrigation systems, while organic agriculture tends to use limited irrigation and focuses on water conservation. Conventional agriculture requires high energy inputs for machinery operation and transportation, whereas organic agriculture generally relies on renewable resources and aims to reduce reliance on external inputs.

Outputs:

Conventional agriculture often achieves greater productivity outputs in terms of high crop yields, while organic agriculture typically has lower crop yields in comparison. Conventional agriculture aims for standardised crops with consistent quality and appearance, whereas organic agriculture emphasises producing high-quality, organic, and environmentally friendly products. The reliance on external inputs such as synthetic fertilisers in conventional agriculture may result in reduced resilience of the soil system, while organic agriculture focuses on building soil health and biodiversity.

System Characteristics:

Conventional agriculture emphasises maximum yield and productivity, often through large-scale monoculture, while organic agriculture promotes sustainable practices, biodiversity, and soil health. In addition, conventional agriculture may have limited crop rotation, whereas organic agriculture encourages crop rotation and diversification.

Worked Example

Evaluate the relative environmental impacts of two given food production systems: intensive monoculture farming and agroforestry.

Answer

Intensive monoculture farming and agroforestry systems differ in their inputs, outputs, and overall environmental implications. By looking at these distinct system characteristics, it is possible to assess their relative sustainability and also their potential for mitigating environmental challenges.

Intensive Monoculture Farming:

Intensive monoculture farming relies heavily on synthetic fertilisers, pesticides, and herbicides to maximise crop yields. These inputs can contribute to water pollution and soil degradation. Additionally, large-scale irrigation systems require huge amounts of water. This farming method often leads to soil erosion, loss of biodiversity, and depletion of soil nutrients. The excessive use of synthetic chemicals can harm beneficial insects, birds, and other wildlife. Intensive monoculture farming also contributes to greenhouse gas emissions, particularly through the use of fossil fuels for machinery, transportation, and the production of fertilisers.

Agroforestry:

Agroforestry systems promote diversity by integrating trees, crops, and sometimes livestock. They require fewer synthetic inputs such as fertilisers and pesticides due to the natural pest control provided by the diverse ecosystem. Water needs are often lower due to better water retention by the tree canopy and tree roots. Agroforestry systems have positive environmental impacts, as the presence of trees helps prevent soil erosion, improves soil health, and enhances biodiversity by providing habitat for various species. Trees also absorb carbon dioxide during photosynthesis, helping to mitigate climate change. The integration of livestock in some agroforestry systems can lead to the recycling of nutrients and reduced waste.

It is clear that intensive monoculture farming can have significant negative effects on soil health, biodiversity, water resources, and contributes to climate change. On the other hand, agroforestry systems promote sustainable practices, including biodiversity conservation, carbon sequestration, and reduced dependency on synthetic inputs. Agroforestry demonstrates more environmentally friendly characteristics, making it a promising alternative for sustainable food production.


Your notes

Photo by PROJETO CAFÉ GATO-MOURISCO on Unsplash

Your notes

An example of coffee agroforestry - these coffee plants are being grown in between the trees that occur naturally as part of this forest ecosystem

Your notes

Your notes

Increasing Sustainability of Terrestrial Food Production

- It is possible to make terrestrial food production systems more sustainable via a number of different methods, including:
  - Changing human behaviours
  - Improving the accuracy of food labels
  - Monitoring and controlling food corporations' standards and practices
  - Planting of buffer zones

Photo by Sara Dubler on Unsplash

Plant-based diets are more sustainable as well as healthier than meat-based diets

Changing Human Behaviours

- Altering human activity to reduce meat consumption and increase consumption of organic, locally produced terrestrial food products:
  - **Promoting plant-based diets**: encouraging individuals to reduce their meat consumption and increase consumption of plant-based foods can significantly reduce the environmental impact associated with intensive livestock production
  - For example, public health campaigns promoting the benefits of vegetarian or vegan diets and providing resources for transitioning to plant-based eating
  - **Supporting organic and local food production**: choosing organic and locally sourced food products reduces the use of synthetic pesticides and fertilisers, supports sustainable farming practices, and reduces the carbon footprint associated with long-distance transportation
  - For example, farmers' markets and community-supported agriculture (CSA) programs that offer organic produce and locally sourced products to consumers

Improving Food Label Accuracy

- Improving the accuracy of food labels to assist customers in making informed food choices:
  - **Clear labelling of environmental impacts**: food labels can provide information on the environmental footprint of food products, including factors like carbon emissions, water usage, and sustainable farming practices
  - For example, labels indicating carbon footprint, water footprint, or eco-certifications (such as Rainforest Alliance or Fair Trade) to inform consumers about the environmental impact of their food choices
  - **Promoting transparency in supply chains**: ensuring that food labels accurately depict the origins of ingredients and production processes helps consumers make choices aligned with their environmental values
  - For example, labels indicating the country of origin, fair trade certifications, or information on sustainable sourcing practices


Your notes

Fair Trade labelling on coffee allows consumers to choose more environmentally sustainable products

Monitoring and Controlling Food Standards and Practices

- Monitoring and control of the standards and practices of multinational and national food corporations by governmental and intergovernmental bodies:
  - **Setting regulations and standards**: governments and intergovernmental bodies can establish regulations and standards for food production practices, waste management, and environmental protection
  - For example, imposing limits on pesticide use, implementing sustainable farming practices, and monitoring compliance through inspections and certifications
  - **Supporting sustainable agriculture programs**: governments can provide financial incentives, subsidies, or grants to farmers adopting sustainable practices, such as organic farming, crop rotation, and agroforestry
  - For example, government-funded programs offering financial assistance to farmers transitioning to sustainable farming methods

Your notes

Planting Buffer Zones

- Planting buffer zones around land suitable for food production to absorb nutrient run-off:
  - **Creating vegetative buffer strips**: planting strips of vegetation or trees along water bodies can capture and filter nutrient run-off from agricultural fields, reducing water pollution
  - For example, establishing buffer zones of grasses, native plants, or trees along rivers, lakes, or streams adjacent to farmland
- These measures, when implemented **together**, can contribute to increased sustainability in terrestrial food production systems by reducing environmental impacts, supporting informed consumer choices, promoting sustainable farming practices, and protecting water bodies from nutrient pollution


Your notes