DP IB Environmental Systems & Societies (ESS): SL

Your notes

Systems & Models

Contents

The Systems Approach

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Systems

- A systems approach is the term used to describe a method of simplifying and understanding a complicated set of **interactions**
  - **Systems**, and the interactions they contain, may be **environmental** or **ecological** (e.g. the water cycle or predator-prey relationships), **social** (e.g. how we live and work) or **economic** (e.g. financial transactions or business deals)
- The interactions within a system, when looked at as a whole, produce the **emergent properties** of the system
  - For example, in an ecosystem, all the different ecological interactions occurring within it shape how that ecosystem looks and behaves - if the interactions **change** for some reason (e.g. a new predator is introduced), then the emergent properties of the ecosystem will change too
- There are two main ways of studying systems:
  - A **reductionist approach** involves dividing a system into its **constituent parts** and studying each of these separately - this can be used to study specific interactions in great detail but doesn't give the overall picture of what is occurring within the system as a whole
  - A **holistic approach** involves looking at all processes and interactions occurring within the system together, in order to study the system as a **whole**
- For example, sustainability or sustainable development depends on a highly complex set of interactions between **many different factors**
  - These include environmental, social and economic factors (sometimes referred to as the three pillars of sustainability
  - A systems approach is required in order to understand how these different factors **combine** and **interact** with one another, as well as how they all work **together** as a whole (the holistic approach)

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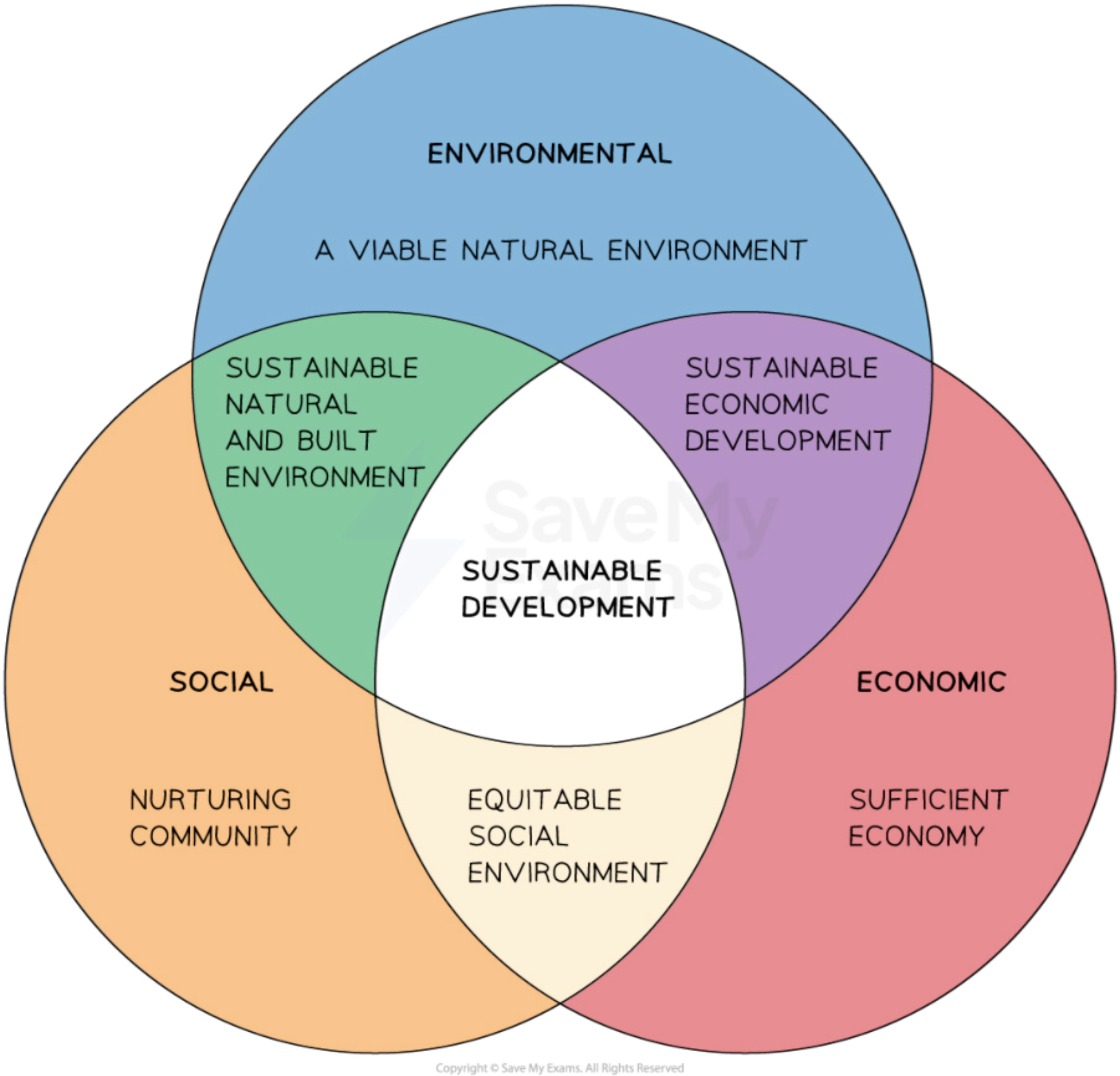

A systems approach is a way of visualising a complex set of interactions, which may be ecological, societal or economic in nature – a holistic systems approach is required when considering sustainable development

The Characteristics of Systems

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Storages & Flows

- A system is comprised of storages and flows
  - The flows provide **inputs** and **outputs** of energy and matter
- The flows are processes that may be either:
  - **Transfers** (a change in location)
  - **Transformations** (a change in the chemical nature, a change in state or a change in energy)

Transfers and Transformations

- These are two fundamental concepts in systems (and systems diagrams) that help to understand how **matter** and **energy** move through a system
- Transfers are the movement of matter or energy from one component of the system to another, **without** any change in form or quality
  - For example, water flowing from a river to a lake is a transfer
- Transformations, on the other hand, involve a **change** in the form or quality of matter or energy as it moves through the system
  - For example, when sunlight is absorbed by plants, it is transformed into chemical energy through the process of photosynthesis
- Transfers and transformations are often represented in systems diagrams by **arrows** that connect the different components of the system
  - Arrows that represent transfers are usually labeled with the quantity of matter or energy being transferred (e.g., kg of carbon, kJ of energy), while arrows that represent transformations may include additional information about the process involved (e.g., photosynthesis, respiration)
- Systems diagrams can help to identify the key transfers and transformations that occur within a system and how they are **interconnected**
- By understanding these processes, it is possible to identify opportunities to improve the **efficiency** or **sustainability** of the system
- Transfers and transformations can occur at **different scales** within a system, from the molecular level to the global level
  - For example, at the molecular level, nutrients are transferred between individual organisms, while at the global level, energy is transferred between different biomes

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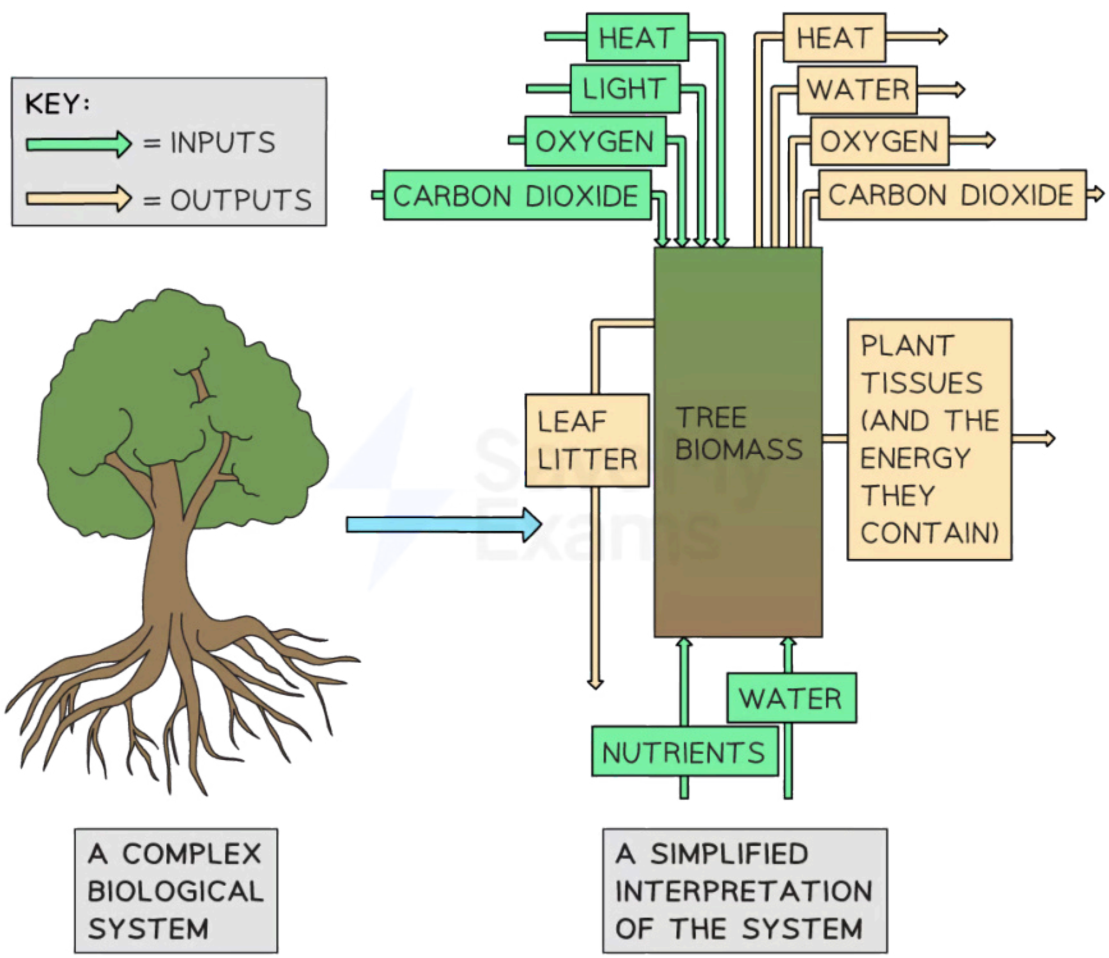
System Diagrams

- Systems are often represented as simplified diagrams made up of storages and flows
  - Storages are commonly drawn as boxes
  - Flows are commonly drawn as arrows
  - These arrows represent the various inputs and outputs occurring within a system



A tree, which can itself be viewed as a whole system, can be represented using a simplified diagram like the one shown above

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Types of System

Types of System

- There are three main types of systems. These are:
  - **Open** systems
  - **Closed** systems
  - **Isolated** systems
- The category that a system falls into depends on how **energy** and **matter** flow between the system and the **surrounding environment**

Open Systems

- Both energy and matter are exchanged between the system and its surroundings
- Open systems are usually **organic** (living) systems that interact with their surroundings (the environment) by taking in energy and new matter (often in the form of biomass), and by also expelling energy and matter (e.g. through waste products or by organisms leaving a system)
- An example of an open system would be a particular **ecosystem** or **habitat**
- Your body is also an example of an open system - energy and matter are exchanged between you and your environment in the form of food, water, movement and waste

Closed Systems

- Energy, but not matter, is exchanged between the system and its surroundings
- Closed systems are usually **inorganic** (non-living), although this is not always the case
  - The International Space Station (ISS) could perhaps be seen as a closed system
  - It is a self-contained environment that must maintain a balance of resources, including air, water, and food, as well as waste management, energy production, and temperature control
  - The ISS cannot exchange matter with its surroundings
- The Earth (and the atmosphere surrounding it) could be viewed as a closed system
  - The main input of energy occurs via **solar radiation**
  - The main output of energy occurs via **heat** (re-radiation of infrared waves from the Earth's surface)
  - Matter is **recycled completely** within the system

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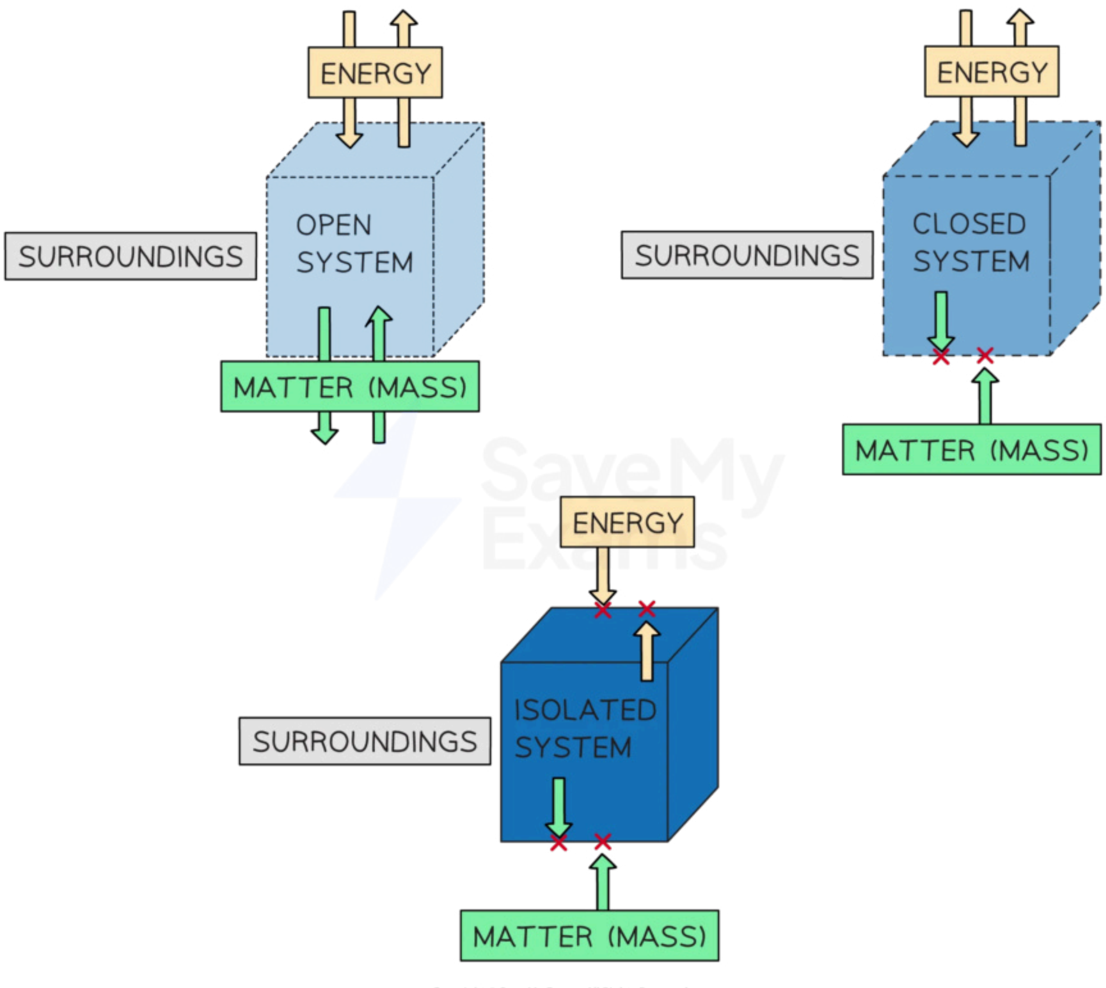
- Although, technically, very small amounts of matter enter and leave the system (in the form of meteorites or spaceships and satellites), these are considered **negligible**
- Artificial and experimental ecological closed systems can also exist - for example, sealed terrariums, containing just the right balance of water and living organisms (such as mosses, ferns, bacteria, fungi or invertebrates) can sometimes survive for many years as totally closed systems, if light and heat energy is allowed to be **exchanged** across the glass boundary

Isolated Systems

- Neither energy nor matter is exchanged between the system and its surroundings
- Isolated systems do not exist naturally - they are more of a **theoretical concept** (although the entire Universe could be considered to be an isolated system)



A system can be categorised based on how energy and matter flow between the system and its surrounding environment

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Models

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Models

- A **model** is a **simplified version of reality**
- A model is often used to represent a system
  - The model can then be **analysed** or **tested** to learn more about how the system works and to **predict** how the system might **respond** to change
  - For example, weather models are used to predict how our weather systems change over time, allowing us to create weather forecasts
- Some models can be very **simple**, such as a child's model car, whilst other models can be **highly complex** and require the power of supercomputers, such as the computer models that are currently being used to predict how our climate will change in the future
  - To some extent, due to their very nature, all models involve some level of **approximation** or **simplification**, and therefore some loss of accuracy (even the very powerful and complex models)
- Models have a variety of strengths and weaknesses

Strengths and Limitations of Models

Strengths	Limitations
Models simplify complex systems	Models can be oversimplified and inaccurate
Models allow predictions to be made about how systems will react in response to change	Results from models depend on the quality of the data inputs going into them
System inputs can be changed to observe effects and outputs, without the need to wait for real-life events to occur	Results from models become more uncertain the further they predict into the future
Models are easier to understand than the real system	Different models can show vastly different outputs even if they are given the same data inputs
Results from models can be shared between scientists, engineers, companies and communicated to the public	Results from models can be interpreted by different people in different ways

Results from models can warn us about future environmental issues and how to avoid them or minimise their impact	Environmental systems are often incredibly complex, with many interacting factors - it is impossible to take all possible variables into account