HL IB Environmental Systems & Societies (ESS)

Your notes

7.3 Solid Waste

Contents

Introduction to Waste


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Sources & Types of Waste

- The use of natural resources generates **waste**
  - This waste can be classified by **source** or **type**

Sources of waste

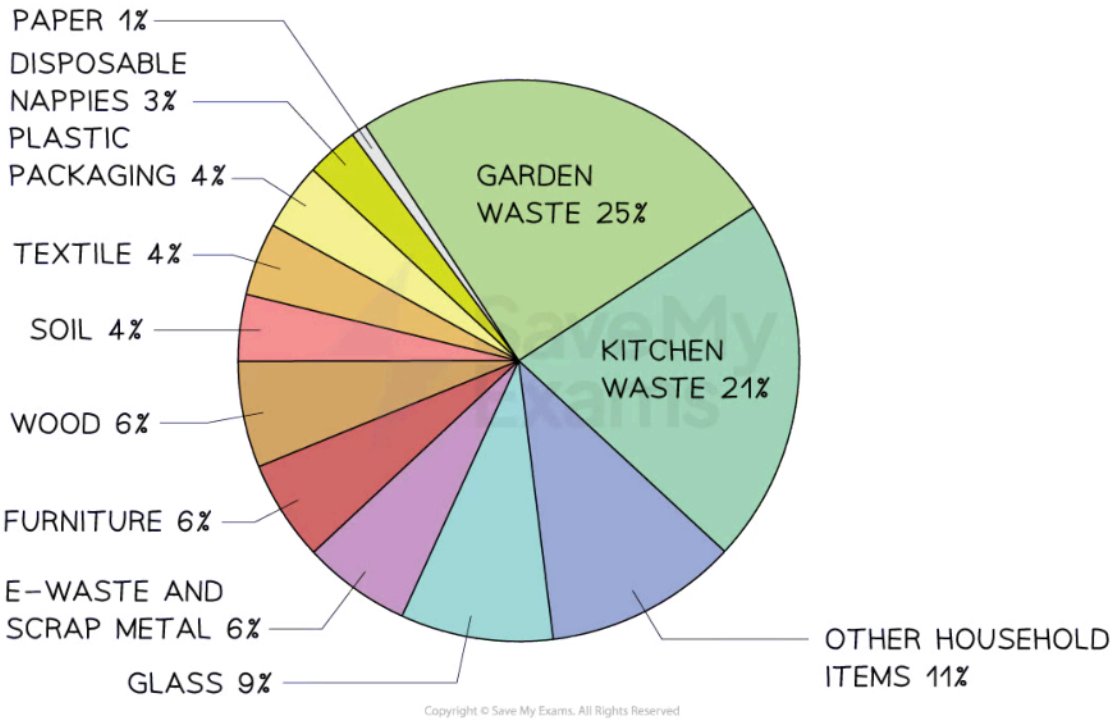
- **Domestic waste**:
  - Waste generated from households, including food scraps, packaging and broken items
- **Industrial waste**:
  - Produced by factories and industries, such as chemicals, metals and manufacturing by-products
- **Agricultural waste**:
  - Created by farming activities, including animal manure, crop residues and empty containers from chemicals like pesticides and herbicides

Types of waste

- **E-waste**:
  - Electronic waste, such as old computers, mobile phones and televisions
  - E-waste contains toxic materials like lead and mercury
- **Food waste**:
  - Edible food that is discarded, often due to over-purchasing or spoilage
- **Biohazardous waste**:
  - Dangerous waste from hospitals or laboratories, such as medical equipment, needles and blood products (e.g. blood or plasma samples)

Solid Domestic Waste

- Solid domestic waste (SDW) refers to the non-liquid waste produced in **homes**
  - SDW typically includes a wide variety of materials, making it a challenge to manage and recycle



Estimate of the proportions of solid domestic waste in the UK in 2020

Common components of solid domestic waste

- **Paper**: newspapers, magazines and packaging materials
- **Cardboard**: packaging boxes and containers
- **Glass**: bottles and jars
- **Metal**: aluminium cans and tin containers
- **Plastics**: bottles, food containers and plastic bags
- **Organic waste**: food scraps, garden clippings and other biodegradable materials
- **Packaging**: items such as plastic wrap, Styrofoam and boxes
- **Construction debris**: waste from home repairs or renovations, such as bricks and wood
- **Clothing**: old or unwanted clothes and textiles

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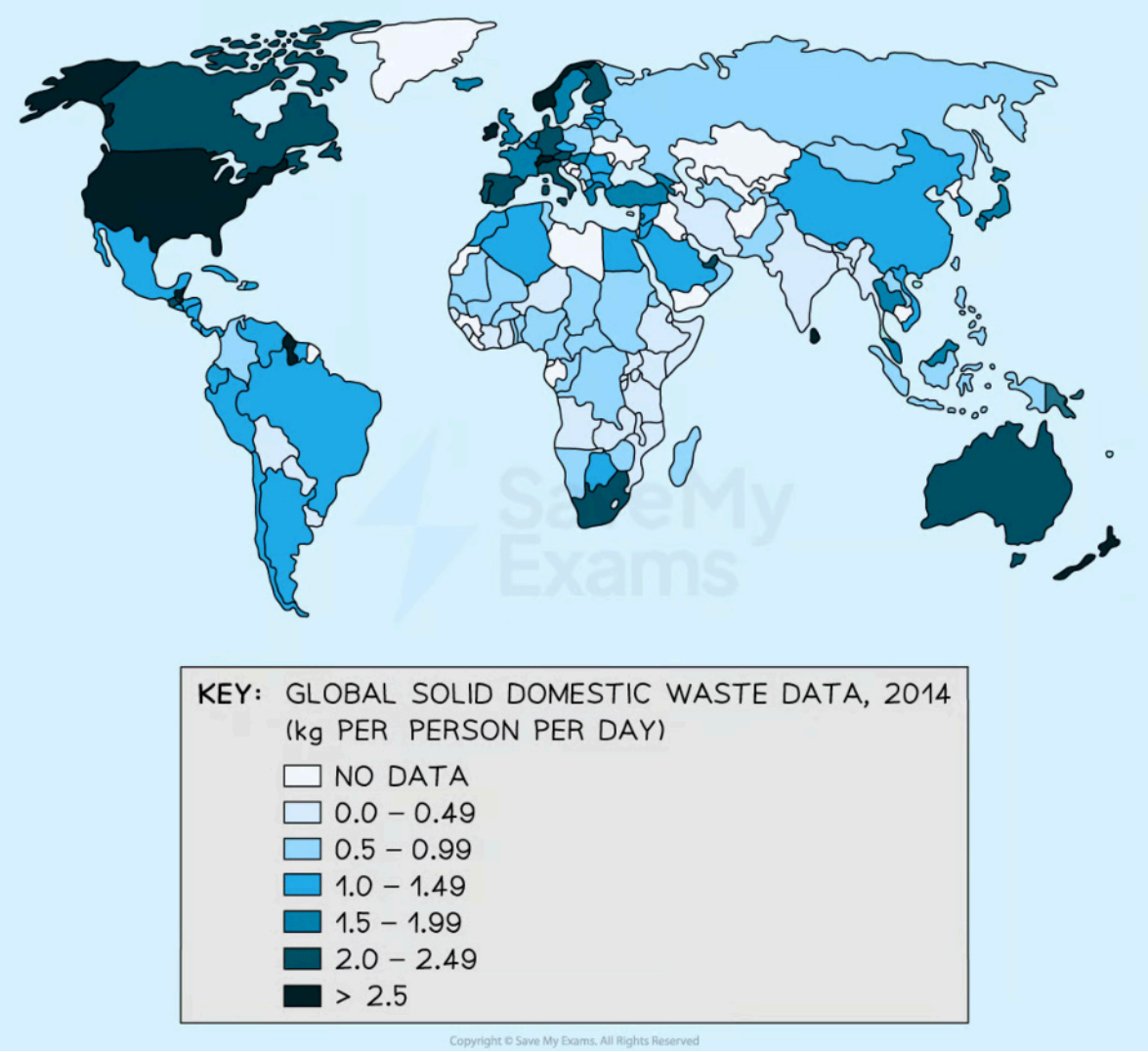

Average daily per capita solid domestic waste generation for different countries in 2014

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EXAM TIP

Don't confuse SDW with other types of waste: solid domestic waste is just one category. Be clear when discussing SDW versus industrial or agricultural waste.

Volume & Composition of Waste

- The **volume** and **composition** of waste vary across time and between societies
  - Numerous factors play a role in this

Factors influencing waste volume and composition


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Socio-economic factors

- Wealthier societies often generate more waste
  - This is due to:
    - Higher consumption levels
    - Single-use products
    - Excessive packaging
    - Culture of convenience
    - Fast fashion
  - For example, high-income countries like the United States generate more waste per person compared to lower-income countries like India
- Lower-income countries may produce less waste
  - However, they often have **less capacity to manage it properly**

Political factors

- Government policies can impact waste production, such as:
  - Recycling laws
  - Waste taxes
  - Bans on certain materials
  - Landfill regulations
- Countries with strong waste management policies tend to have lower levels of unmanaged waste
  - For example, the European Union's ban on single-use plastics has reduced plastic waste in member countries

Environmental Factors

- **Environmental awareness** can lead to reduced waste, such as more recycling or composting programmes
- Geographical location:
  - Popular tourist destinations experience high amounts of waste production during peak seasons

- Large amounts of crop waste follow harvest seasons in the agricultural sector
- Natural disasters can also increase the amount of waste generated
  - For example, after powerful hurricanes, large volumes of construction and debris waste can be generated during rebuilding efforts


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Technological Factors

- Advancements in technology can **reduce** waste, such as:
  - Creating biodegradable plastics
  - More efficient recycling methods
- However, the rapid pace of **technological advancements** causes large amounts of **electronic waste**
  - This is because consumers want to regularly update their devices to newer versions with better features
  - Renewable energy sources can also produce large amounts of electronic waste, e.g. old or damaged solar panels and wind turbine blades
- New products can also increase waste if they are designed for **short-term use** (e.g. disposable electronics such as e-cigarettes or vapes)


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Environmental & Social Impacts of Waste

Environmental impacts of waste

- The **production**, **treatment** and **disposal** of waste can have severe environmental consequences, both locally and globally

Pollution

- **Air pollution**: burning waste, especially in open landfills, can release harmful gases like methane and carbon dioxide
  - These gases contribute to climate change
  - Decomposing organic waste in landfills also produces methane (a potent greenhouse gas)
- **Water pollution**: improper waste disposal can lead to chemicals and hazardous materials leaching into rivers, lakes and oceans
  - This harms aquatic life and contaminates drinking water sources
- **Soil pollution**: hazardous waste, chemicals and heavy metals from landfills or improper waste disposal can seep into the soil
  - These pollutants contaminate soils and harm plant growth, as well as enter food chains through plants and crops

Habitat destruction

- Landfills and waste dumps take up **large areas of land**
  - This often leads to the destruction of natural habitats and loss of biodiversity
  - For example, in Ghana, the Agbogbloshie e-waste dump has not only polluted local water sources but also destroyed large areas of natural land

Social impacts of waste

- Waste management also has important social consequences
  - These particularly affect **low-income communities** and **countries**

Health risks

- Exposure to waste, especially **e-waste** and **biohazardous materials**, can lead to serious health issues

- This can include respiratory diseases, skin infections and cancers
- Low-income countries that receive waste from high-income nations often **lack proper facilities** to safely **handle** and **treat** waste
  - This can result in dangerous living and working conditions for local people


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Environmental injustice

- **Waste exports**: high-income countries often export their waste to low-income countries, which struggle to manage it safely
  - This leads to environmental injustice
  - This occurs when the negative impacts of waste are disproportionately experienced by poorer countries
- The **Basel Convention** was introduced by the **United Nations Environment Programme (UNEP)** in **1992**
  - It is an international treaty designed to:
    - Regulate the movement of hazardous waste between countries
    - Prevent the export of such waste from high-income to low-income nations
    - Protect human health and the environment from the dangers of improper waste disposal
  - However, illegal waste exporting and dumping still occurs

Impact on local communities

- The presence of landfills or waste processing plants near communities can decrease the quality of life for local people due to:
  - Bad smells
  - Noise
  - Potential contamination of local water and soil
- Communities near waste sites often suffer from:
  - Lower property values
  - Reduced economic opportunities
  - Poor health outcomes

EXAM TIP

Remember that waste can be (and is often) transported across borders, causing impacts far from where it was generated.

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Ecosystems & Pollution

- Pollution occurs when harmful substances are added to the environment at a rate **faster** than ecosystems can **process** or **transform** them into **harmless substances**
  - Ecosystems naturally have the ability to absorb and manage a certain amount of waste and pollution
  - They achieve this through processes like photosynthesis and nutrient cycling
  - However, when the amount of waste exceeds their capacity, pollution builds up
  - At this point, it causes harm to the environment

Ability of ecosystems to absorb waste

- **Ecosystems as natural filters**: many ecosystems can absorb and transform pollutants into less harmful substances
- Some examples include:
  - **Forests**: trees absorb **carbon dioxide** during **photosynthesis**
    - They convert it into oxygen, reducing the amount of CO_2 in the atmosphere
  - **Wetlands**: ecosystems like **salt marshes** and **mangroves** can absorb **nitrogen**, **phosphorus** and other pollutants from water
    - They act as natural filters, trapping these substances and using them for plant growth
  - **Grasslands** and **farmlands**: plants can take up nitrogen and phosphorus from the soil as nutrients for their growth
    - This can help reduce the impact of agricultural runoff
- **Ecosystem services**: ecosystems provide services that help manage pollution, such as:
  - **Carbon sequestration**: plants absorb CO_2 from the atmosphere and store it in their tissues, reducing greenhouse gases
  - **Water filtration**: wetlands and forests filter pollutants from water before they enter rivers, lakes, or oceans, improving water quality
    - For example, salt marshes along coastlines can absorb pollutants like heavy metals and excess nutrients
    - This reduces the flow of these substances into the ocean, protecting marine ecosystems

Limits to ecosystem absorption


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- **Overloading ecosystems**: when pollutants are added at a faster rate than ecosystems can process them, pollution occurs
- For example:
  - **Excess CO2**: while forests can absorb CO2, human activities like deforestation reduce the number of trees
    - This limits their ability to manage rising CO2 levels
  - **Eutrophication**: wetlands can absorb nutrients, but when agricultural runoff contains too much nitrogen and phosphorus, these ecosystems become overloaded
    - This leads to water pollution and eutrophication

Biodegradability and half-lives

- The term **biodegradability** refers to how quickly natural processes can break down a substance into harmless components
  - **Biodegradable materials**: substances like paper and food waste decompose quickly
    - This is because bacteria and other organisms break them down into harmless materials
  - **Non-biodegradable materials**: substances like plastic, glass or synthetic chemicals do not break down easily
    - They can remain in the environment for hundreds or thousands of years
- **Half-lives**: this concept refers to the time it takes for half of a substance to decay or break down
- Some pollutants, especially chemicals or radioactive materials, have long half-lives, meaning they remain dangerous in the environment for extended periods
  - **Long half-lives**: pollutants like **pesticides** (e.g. DDT) or **radioactive waste** have long half-lives
    - They persist in ecosystems for years or decades
    - For example, DDT has a half-life of around 15 years, meaning it can stay in the soil and water for decades, affecting wildlife, food chains and whole ecosystems
  - **Short half-lives**: substances like organic waste decompose quickly
    - This reduces their environmental impact

Waste Disposal

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Waste Disposal Methods

- Waste disposal is critical in **managing** and **minimising** the environmental impact of waste
- Various methods are available
  - Each has advantages and disadvantages that should be taken into account when considering their impact on societies and ecosystems

1. Landfill sites

- Landfills involve burying waste in designated areas in large holes dug into the ground

Advantages

- **Centralised waste management:** provide a single location for managing large volumes of waste
- **Flexible:** handle a wide range of materials, including non-recyclable materials
- **Lower operational costs:** relatively inexpensive compared to other waste disposal methods
- **Reduced environmental impact:** can be engineered with liners and **leachate** collection systems to minimise environmental impact
- **Gas capture potential:** some capture methane gas, which can be used as an energy source

Disadvantages

- **Methane generation:** produces methane, a potent greenhouse gas
- **Land requirements:** needs significant land, which can be difficult to find
- **Risk of contamination:** potential for groundwater and soil pollution from leachate
- **Long-term monitoring:** requires management long after closure
- **Environmental injustice:** often causes noise and smell pollution in less affluent urban outskirts
  - This disproportionately impacts the health and quality of life of residents in these areas

2. Incineration

- Incineration involves burning waste materials at high temperatures to reduce their volume

Advantages

- **Reduces waste volume:** drastically cuts down the physical size of waste

- **Less reliance on landfills:** reduces amount of waste sent to landfill sites
- **Handles hazardous waste:** can process hazardous materials safely


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Disadvantages

- **Air pollution:** emits harmful gases and pollutants, including greenhouse gases
- **High operational costs:** requires expensive technology and maintenance.
- **Ash disposal:** produces toxic ash that requires careful disposal
- **Public concern:** communities often oppose incinerators due to health and environmental concerns

3. Waste-to-energy (WtE)

- Waste-to-energy (WtE) or energy-from-waste (EfW) plants burn waste to generate electricity or heat

Advantages

- **Energy recovery:** converts waste into usable energy, reducing reliance on fossil fuels
- **Reduces landfill use:** decreases the amount of waste sent to landfills
- **Waste volume reduction:** significantly reduces the amount of waste

Disadvantages

- **Pollution risks:** can release harmful emissions and greenhouse gases unless controlled properly
- **High capital investment:** expensive to build, operate and maintain WtE plants
- **Limited by waste composition:** not all types of waste can be efficiently converted to energy
- **Not a perfect solution:** still encourages waste generation instead of focusing on reduction and recycling.

4. Exporting Waste

- Exporting waste involves sending waste materials to other countries for treatment, recycling or disposal

Advantages

- **Offloads waste responsibility:** countries with waste management challenges can send waste to others
- **Reduces domestic pressure:** eases the burden on local waste management systems
- **Access to advanced facilities:** may provide waste producers with access to specialised waste treatment options

- **Economic benefit**: may be cheaper for some countries to export waste than to process it locally

Disadvantages

- **Environmental injustice:** exporting to low-income countries may cause environmental and social harm there, raising ethical concerns
- **Environmental impact of transport:** shipping waste long distances increases carbon emissions
- **Legal risks:** can lead to legal issues between exporting and importing nations
- **Long-term effects**: does not help solve the root cause of excessive waste generation

5. Recycling

- Recycling involves converting waste materials into new, usable products

Advantages

- **Resource conservation:** saves raw materials and reduces the need for new resource extraction, which can be environmentally damaging and polluting
- **Energy savings:** recycling typically uses less energy than producing new materials
- **Economic cost:** may be cheaper than other waste disposal options
- **Reduces landfill and incineration:** keeps recyclable materials out of waste disposal facilities

Disadvantages

- **Energy use in processing:** sorting, collecting and processing recyclables can be energy-intensive
- **Limited recycling facilities:** availability and access to recycling facilities can vary between countries and regions
- **Contamination:** contaminated recyclables can reduce the efficiency of the recycling process
- **Limited market:** not all materials are recyclable and there can be limited demand for recycled products

6. Composting

- Composting is the process of breaking down organic waste into nutrient-rich soil

Advantages

- **Environmentally friendly:** composting produces natural fertilisers, reducing the need for chemical alternatives
- **Reduces landfill waste:** organic matter is kept out of landfills, lowering methane emissions


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- **Enriches soil:** compost improves soil health and can enhance crop growth
- **Low cost:** can be done on a small scale at home or in local communities

Disadvantages

- **Limited to organic waste:** can only handle biodegradable materials
- **Space and time requirements:** requires space for compost piles and can take time to break down waste
- **Potential for odour:** if not properly managed, composting can create unpleasant smells

EXAM TIP

Be prepared to explain how each method affects the **environment**, especially in terms of pollution, resource use and sustainability. You should also be able to discuss how waste management affects **communities**.


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Waste Management Strategies

- Waste management strategies aim to minimise the impact of waste on the environment and human health
- They can be divided into **preventative** and **restorative** strategies

Preventative strategies

- Preventative strategies focus on **reducing waste generation** and controlling pollution **before it happens**
  - These strategies are generally **more sustainable** than restorative approaches
- **Changing human behaviour**: encouraging people to reduce consumption and recycle more effectively can prevent waste from accumulating.
  - E.g. **reduced consumption** through campaigns encouraging people to buy only what they need or use reusable products like bags and bottles
  - E.g. **composting food waste** at home reduces organic waste sent to landfills and returns nutrients to the soil
- **Controlling the release of pollutants**: limiting the amount of pollution and waste released into the environment can help prevent damage
  - E.g. **waste disposal legislation** sets strict rules about how and where waste can be disposed of to minimise environmental harm
  - E.g. **recycling and reuse programmes** help conserve natural resources and reduce the need for landfills and incinerators
- The most effective preventative strategy is to consume fewer products, leading to **less waste**

Restorative strategies

- Restorative strategies focus on:
  - **Cleaning up waste**
  - **Repairing environmental damage** caused by waste mismanagement
- **Oceanic garbage patch clean-up**: efforts to remove plastic waste from the Great Pacific Garbage Patch are an example of a restorative strategy
  - Though challenging and expensive, it helps to reduce harm to marine life

- **Landfill reclamation**: some landfills are being reclaimed by **removing waste** and turning the land into parks or other usable spaces
  - This process restores the land but is costly and time-consuming
- **Restoration of contaminated sites**: some areas heavily polluted by industrial waste or hazardous materials undergo clean-up efforts to make the land safe again
  - This often involves removing soil or water contamination


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Sustainability of preventative vs. restorative strategies

- Preventative strategies are more sustainable because they stop the problem **before it happens**
  - They require less energy and resources compared to cleaning up waste after the damage has been done
- Restorative strategies are important but less sustainable
  - They usually require large amounts of money, time and effort
  - Often the damage cannot be fully undone

Hierarchy of waste management strategies

- Different waste management strategies can also be viewed as being part of a hierarchy
  - The hierarchy of waste management strategies ranks options from the most to least sustainable
  - It prioritises reducing waste at the source, followed by reusing, recycling, recovering energy, and finally, disposing of waste in landfills or through incineration

Awaiting image: Waste hierarchy

Image caption: Hierarchy of waste management strategies

Sustainable Waste Management

- Sustainable waste management focuses on:
  - Minimising the environmental and social impacts of waste
  - Promoting more efficient use of resources
- It encourages reducing, reusing and recycling waste rather than relying on disposal methods like landfills and incineration

Strategies for promoting sustainable waste management

- Societies can adopt various strategies to promote more sustainable management of solid domestic waste (SDW):


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- **Taxes**:
  - Governments can impose taxes on activities or products that generate excessive waste
  - E.g. plastic bag taxes in the UK have reduced single-use plastic consumption by over 90% since 2015
- **Incentives**:
  - Financial rewards can encourage sustainable behaviour, such as recycling or composting
  - E.g. deposit-return schemes for bottles and cans provide consumers with a financial incentive to recycle
- **Social policies**:
  - Social policies can regulate the way waste is managed at a societal level
  - E.g. **pay-as-you-throw** (PAYT) waste schemes: in some areas, residents are charged based on the amount of waste they produce
    - This encourages people to recycle more and generate less waste, as they can save money by reducing their waste output
- **Legislation**:
  - Laws can require businesses and individuals to follow sustainable waste management practices
  - E.g. the European Union's **Waste Framework Directive** sets clear guidelines for recycling and waste reduction
- **Education and campaigns**:
  - Educating the public about the importance of sustainable waste management can change behaviours
  - E.g. **school recycling programmes,** where students are taught about waste separation, recycling and environmental conservation
- **Improved access to disposal facilities**:
  - Making it easier for people to dispose of waste sustainably can encourage more responsible behaviour
  - E.g. increasing the number of **recycling points** in **urban areas** can reduce improper waste disposal

The circular economy and sustainable waste management

- A **circular economy** is a sustainable approach to managing resources and waste by:
  - Keeping materials in use for as long as possible

- Minimising waste
- Recovering resources at the end of a product's life

- This system contrasts with the traditional **linear economy**
  - This is where products are made, used and then discarded
- Principles of the circular economy:
  - **Design for longevity**: making products that last longer and can be reused or repaired
  - **Resource efficiency**: minimising the use of raw materials by recycling and reusing
  - **Product recovery**: recovering and reusing materials at the end of a product's life

Awaiting image: Linear and circular economies

Image caption: Linear vs. circular economy

- Example of a **circular economy path** (aluminium cans):
  - **Manufacturing**: aluminium cans are made from recycled aluminium
  - **Use**: consumers purchase and use the cans
  - **Collection**: used cans are collected through recycling bins or deposit-return schemes
  - **Recycling**: the cans are cleaned, melted and reformed into new cans, reducing the need for new raw materials
  - **Reuse**: the recycled cans are used to package new products (e.g. soft drinks) and the cycle begins again
- This example demonstrates how the circular economy reduces waste, conserves resources and reduces the need for raw material extraction

EXAM TIP

Make sure you understand the difference between linear and circular economies; you should be able to explain why the circular economy is more sustainable than the linear model.

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