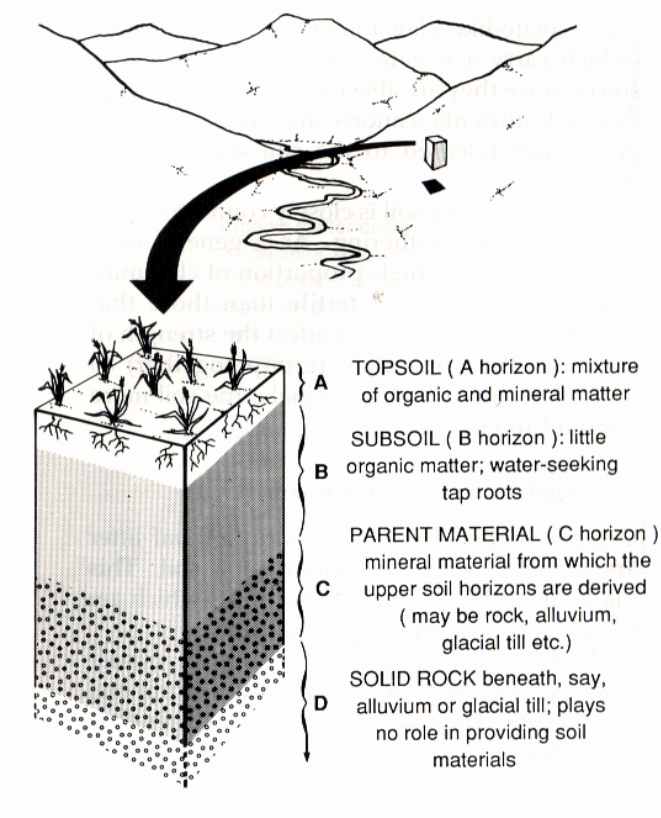
A2 Geography 4.3 Ecosystems Student Notes

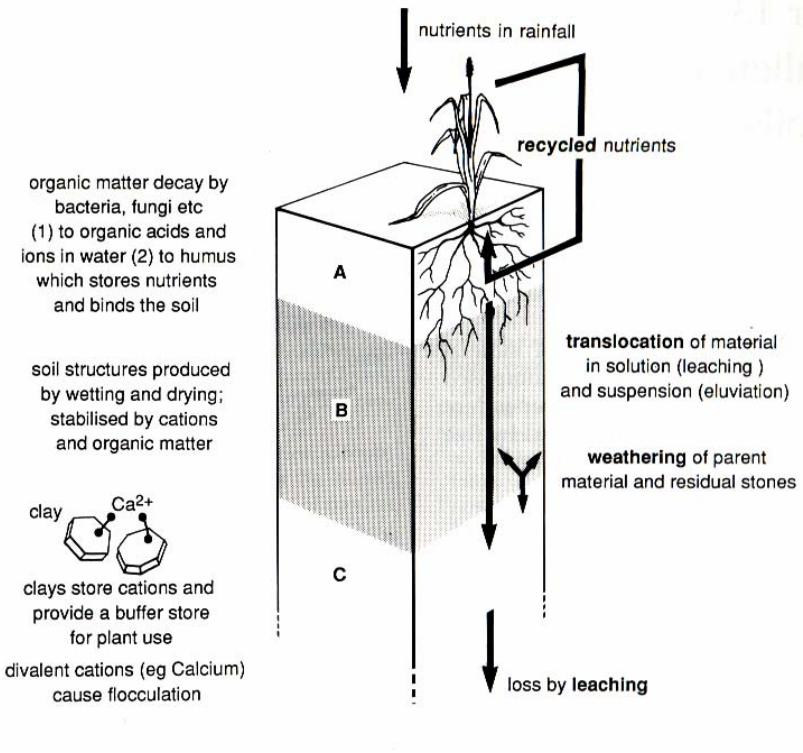
The causes and management of Soil Erosion.

You need to know the physical and human causes of soil erosion and how soil resources can be managed in order to minimise soil erosion in at least one area. The management techniques will include farming practices.

Background Information:



The Characteristics of a Soil Profile



The main soil forming processes

What is soil erosion?

Soil erosion takes place naturally in many environments. Normally, soils are in a sate of **dynamic equilibrium** in that the rate of soil erosion is balanced with the rate of soil formation. This natural balance can be disturbed by human activity.

As more soil is removed, so **yields** (short term output) and **productivity** (long term capability for production) fall.

An estimated 7% of surface soils are lost each year in soil erosion. Around 80% of Africa's topsoil is at risk and India loses some 12 billion tonnes of soil every year. In the American prairies in the 1980's, soil losses are almost as fast as they were in the 1930's Dust Bowl.

In England and Wales, around 44% of soils are at risk according to the Soil Survey in around 2 million hectares of land. Erosion is particularly bad in the South Downs, Norfolk, West Sussex and Shropshire. Soil erosion is caused by the removal of surface vegetation and the breakdown of the structure of the soil, which is removed either by wind or by surface runoff. The consequences are not just for farmland but also for watercourses, which can silt up and suffer eutrophication.

Soil Erosion and Vegetation Cover

Land Use	Erosion mm/vr
Forest	0.08
Pasture	0.03
Scrub forest	0.1
Crops (contour ploughing)	10.6
Crops (downslope ploughing)	29.8

Soil erosion Rates (tonnes/ha/yr)

UK		World	
South Downs	250	China (loess)	250
Norfolk	160	Nepal	70
West Sussex	150	Ethiopia	42
Shropshire	120	Burkina Faso	35

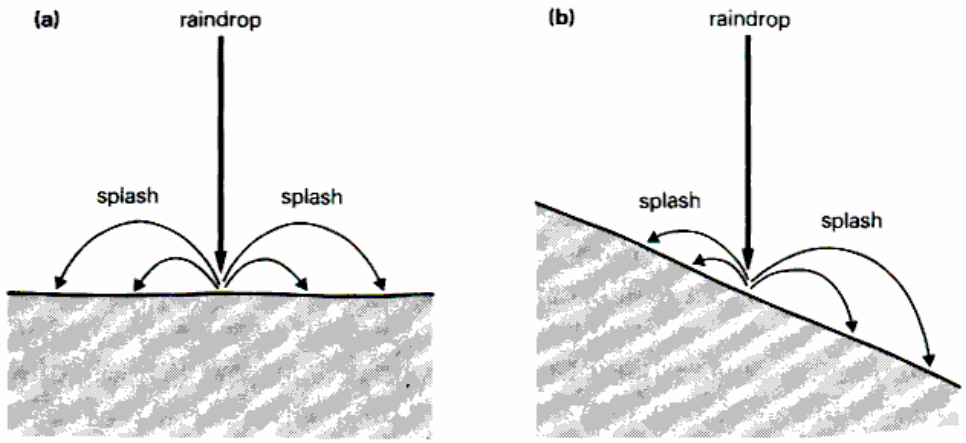
What causes soil erosion?

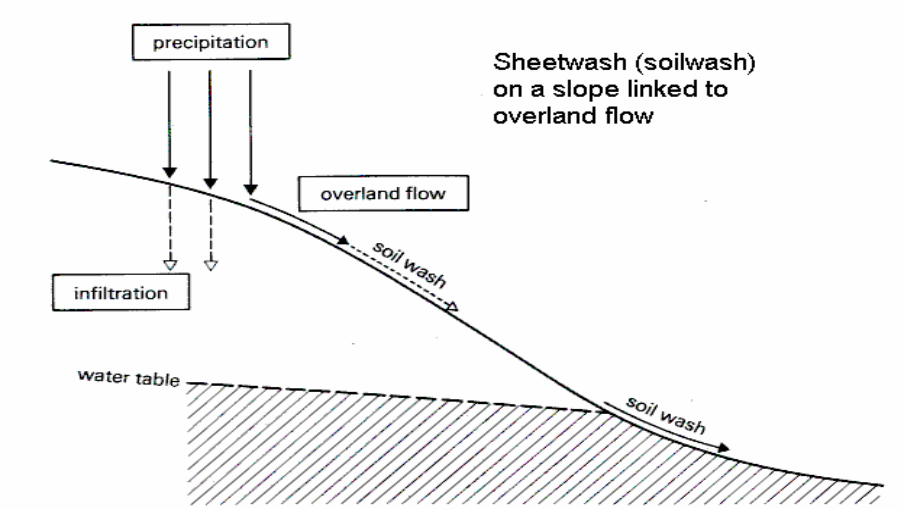
Soil erosion can be caused by a variety of factors, but the common theme is **human mismanagement** of ecosystems and the soil.

The most common cause of erosion is the removal of the natural vegetation. Large-scale deforestation in many countries, such as Ethiopia relates to population growth and the growing demand for farmland and fuelwood. The monsoon nature of the climate accentuates the effect as soils can desiccate and turn powdery and dusty in the dry season, only to be washed away by the seasonal rainfall.

The lack of interception leads to **rainsplash** (the direct impact of rainfall). This loosens the soil particles from each other and removes some particles downslope. It also prepares the soil for **sheetwash** in surface runoff (overland flow). Without interception, water arrives at the surface more directly and at a higher rate so infiltration rates are exceeded. Where there is no, or little vegetation, there will be few plant roots or organic matter to bind the soil particles, so runnels or rills may form. These may develop into large gullies leaving the land uses for agriculture.

The impact of rainsplash on (a) flat land and (b) on a slope.



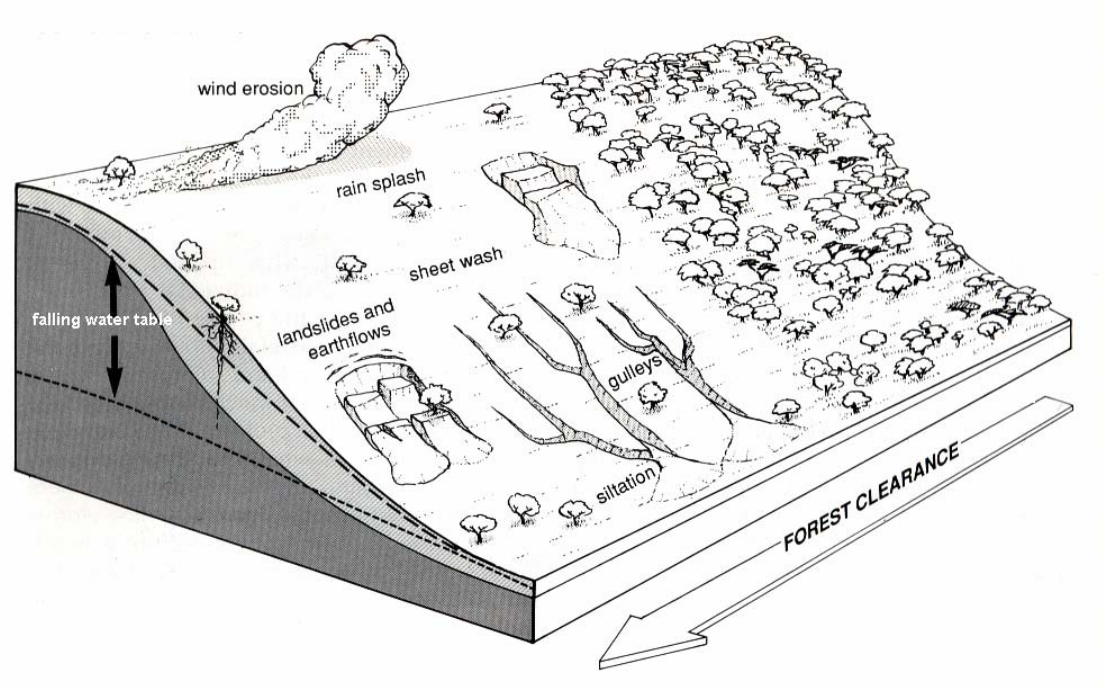


Even where soil erosion does not take place, the heavy rainfall can lead to the leaching of nutrients, humus and even clay particles. This can lead to a breakdown in the soil structure from large aggregates (or **peds**) to fine powder. Vegetation may deteriorate leading to a greater risk of soil erosion at a later time.

Wind Erosion

In dryer climates, or climates with distinct dry seasons, the fine, structureless soil can be removed by wind erosion. This occurred in the US Dust Bowl in the 1930's and is a common problem in the Sahel belt in sub-Saharan Africa today. Even parts of Norfolk have experienced wind erosion, particularly where hedges have been removed to enlarge fields to make room for modern machinery.
A variety of farming practices can have adverse effects of soil erosion. These include ploughing, soil compaction with machinery, overgrazing, monoculture, dung burning, salinisation of soils, lowering of the water table through over-abstraction and inappropriate use of man-made chemicals.

Some of the possible consequences on soil erosion of the removal of the natural vegetation cover.



Land-use Practices that Accelerate Soil Erosion

Ploughing – Deep ploughing can destroy the soil structure by breaking up the **peds** and burying organic matter too deep for plant roots. It also loosens the topsoil for wind and water erosion. Ploughing up and down slopes can create plough furrows, which can encourage rill and gully formation.

Soil compaction with machinery – Heavy farm machinery can compact the soil. Or produce **platy peds.** Both of these reduce infiltration rates and inhibit soil aeration.

Overgrazing – In the prairie grasslands of the mid-west or the Sahel belt of Africa, overgrazing reduces the vegetation cover leaving the soil exposed to wind erosion or sheetwash. Overgrazing may be an indirect consequence of population growth. Areas previously considered marginal may be grazed or not allowed a sufficient fallow period to allow the vegetation to recover.

Monoculture – When the same crop is repeatedly cultivated in the same soil it can deplete the soil of the nutrients that it most requires. This leads to a breakdown in the ped structure of the soil leading to wind or water erosion

Dung burning – In parts of the world where fuelwood has become scarce, such as in Ethiopia, dung is collected, dried and burned as fuel. This deprives the soil of organic matter, reducing both its fertility and its moisture holding potential, leading to deterioration in the soil's structure.

Salinisation of soils – Irrigation in dry climates, such as the Imperial Valley in southern California, can lead to salinisation, with dissolved salts being drawn to the surface by capillary action. This can lead to salt crusts forming and a loss of vegetation, leading to the risk of soil erosion during periods of rainfall.

Lowering of the water table through over-abstraction – The sinking of wells in sub-Saharan African countries, such as Senegal, has lowered the water table, making it harder for the surface vegetation to find moisture. The wells themselves act as a magnet for migrants and their cattle, which can lead to overgrazing and tree removal for fuelwood. Soil erosion is an inevitable consequence.

Chemical Fertilisers and Pesticides – Over reliance on chemical fertiliser that do not replenish organic matter and the use of pesticides that kill vital soil organisms can also lead to soil deterioration

Sustainable Management of Soils

1. **Afforestation** – The planting of trees to increase interception and reduce surface runoff. The tree roots help to bind the soil. Leaf litter will improve the organic content of the soil leading to the formation of larger peds.

2. **Ground Cover Crops** – On agricultural land, ground cover crops can reduce rainsplash and sheetwash and can protect newly ploughed land from strong winds and heavy rainfall.

3. **Planting Wind Breaks** – Wind beaks or shelterbelts can reduce the impact of wind by as much as 50%. Trees and hedges cause less turbulence than fences and provide an important habitat for wildlife.

4. **Crop rotation** – This helps to prevent mineral deficiencies in the soil as different crops use different nutrients in different qualities. Rotation also reduces the effectiveness of soul-borne diseases. Some crops, such as clover, are leguminous and can help to improve the nitrogen levels in the soil. Grasses improve the sol structure

5. **Fallow Periods** – many tropical soils need periods of 5-15 years without cultivation to allow the soil to recover.

6. **Contour Ploughing** – In areas with slopes of 12º or more, ploughing along the contours is an effective way of reducing rill and gully formation. Water is trapped and can infiltrate the soil.

7. **Terracing** – Terracing helps to prevent downslope runoff giving water more time to infiltrate. It is often done in conjunction with irrigation.

8. **Strip Cultivation and Buffer Strips** - Strip cropping can involve either planting crops in strips along the contours or intercropping different crops. On slopes in Kenya, strips of bananas, sugar cane and maize or beans are grown. The crops are harvested at different times so he soil is never left completely exposed. Buffer strips of pasture may be left along stream channels to the effectiveness of rainsplash or sheetwash. Strip cultivation is common practice in the southern United States.

9. **Dry farming** – Where evapotranspiration exceeds precipitation, the soil ma be farmed at a low intensity and a mulch of straw or another organic mulch that reduces water loss. Frequent weeding may be carried out.

10. **Soil Conditioning and Mulching** – The addition of organic matter can help to improve the structure and moisture holding ability of the soil. Adding lime and also improve texture. Animal dung and straw, left after a cereal harvest can be lightly ploughed in to improve soil structure and fertility.

11. **Green Manures** – Legumes that provide nitrogen, such as clover, can be planted as a ground cover crop and ploughed in as a green manure before the main crop is planted.

12. **Improving Drainage** – Field drains can improve drainage and reduce the infiltration rates. This reduces the risk of sheetwash.

13. **Stone Lines** – In Burkina Faso, stone lines are placed across fields to trap moisture and to collect organic matter (See case study)

14. **Agro-forestry** – In tropical forests, land can be partially cleared of trees and food crops are inter-planted. In Nigeria*, Leucaeno* trees are planted alongside crops, as they are leguminous. The trees provide both nitrogen and leaf litter.

15. **Check dams** – These are used to reduce soil loss in gullies by trapping it, but allowing water to drain through.

16. **Organic Farming** – Organic farming systems encourage a wide range of soil conservation and soil improvement measures. Organic farming encourages sustainable soil management. Organic soils usually have a greater macrobiotic content, higher levels of organic matter, thicker topsoil and a higher germination rate. In Britain, the Soil Association (the governing body for organic farming) also encourages hedge and tree planting, low density livestock farming, the use of animal and green manures and a range of other measures which help to maintain or improve soil quality, wildlife habitats and the quality of food products.

Case Study: Issues of Soil management in northern Shaanxi (China)

In the Loess Plateau of northern China there is rapids soil erosion. Over 200m of loess was deposited by Arctic winds in the late stages of the Pleistocene. Under Mao, the natural tree and grass cover was removed to make way for cereal farming. Heavy monsoon rains were able to remove the loess at an average rate of 1cm year. Landslides were common and over 1.6 billion tonnes of soil entered the Huang He (Yellow River) every year. The river became severely silted and in places it flows 10m above its flood plain. Flooding is a major hazard, should the rivers flood banks be breached (1 million drowned in floods in 1939 and crops were ruined).

Serious desertification occurred in Shaanxi, creating shifting dunes, which have buried farms and villages. Droughts, floods, dust storms were frequent linked to the lack of protective vegetation.
Since 1980, the Central Government has supported a comprehensive programme for erosion control on the loess plateau with the aim of stabilising the soil in the loess plateau and to transform the soil throughout Shaanxi.

The techniques used were:

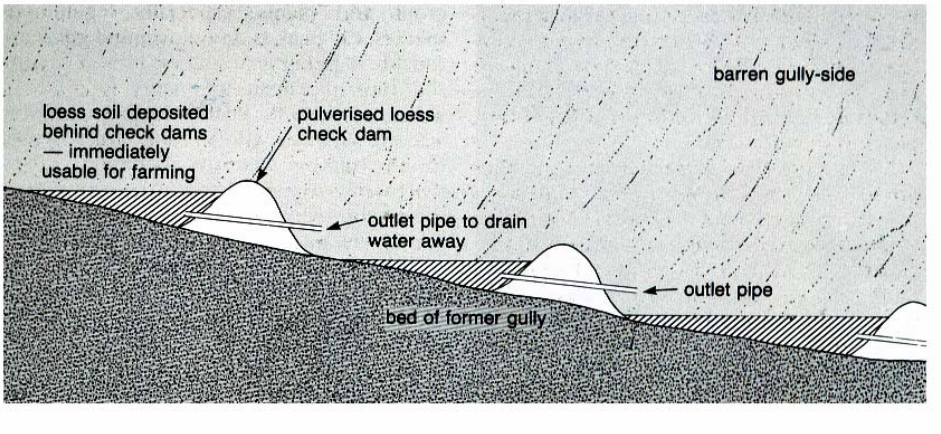
- **Terracing hillsides** to reduce downslope movement.

- Planting trees as a **shelter-forest** network to reduce the effect of wind on the shifting loess.

- Constructing **check dams** using compressed loess to a height of 6m. These dams across gullies trap silt in stream runoff and allow the water to be drained through pipes.

- **Irrigating projects** that allow controlled use of water to farmland, often in conjunction with terraces.

By late 1990's, over 50% of the eroded land had been converted back to agriculture. Yields have increased leading to a grain surplus and fruit, vegetables and tobacco are produced as cash crops. Incomes for farmers have trebled and migrants are being attracted back to Shaanxi. The shelter-forests have stabilised the dunes. Less soil is washed into the Huang He and biodiversity in the river has improved.



Constructing **check dams** using compressed loess to a height of 6m across gullies. These dams trap silt in stream runoff and allow the water to be drained through pipes.

Case Study: Burkina Faso

The growing herds of cattle and goats have overgrazed the scrublands on the Saharan fringes. As they migrate south, the nomadic herdsmen compete with sedentary farmers who are already struggling to produce enough food for their needs.

The size of cattle herds has grown with the growing population. Farmers move their cattle south into moister environments in search of pasture.

Competition for land in the south leads to the carrying capacity being exceeded. Vegetation is overgrazed, soils are not left fallow for long enough, the soil loses its protection and its structure and wind erosion sets in.

Fuelwood is also in short supply leading to the removal of trees and the burning of dung that cold be used to improve the soil.

Oxfam's Burkina Faso-Special Programme for Soil and Water Conservation and Agroforestry in the Central Plateau

The project started in 1979 was aimed to introduce water harvesting so that trees could be planted to reduce soil erosion and to increase agricultural productivity. The project met some resistance from local farmers whose prime concern was food production.

Attention was diverted to modifying a traditional technique of producing stone lines or **diguettes** across slopes **to** reduce runoff. This proved difficult on gentle slopes where local farmers could not determine the contours. The problem was solved with a £3 calibrated transparent hose, 15m long, filled with water that could be used to detect changes in slope.

The lines of stone take and 2% of the crop land but increase yields by over 50%. They also replenish falling water tables and they can regenerate soil because organic matter and seeds collect on the upslope side of the diguettes.