Geo Factsheet

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SOIL DEGRADATION – A CREEPING CONCERN?

Introduction

Soil degradation is the decline in quantity and quality of soil. It includes:
- Erosion by wind and water
- Biological degradation (the loss of humus and plant/animal life)
- Physical degradation (loss of structure, changes in permeability)
- Chemical degradation (acidification, declining fertility, changes in pH, salinisation and chemical toxicity.

Causes of degradation

The Universal soil loss equation **A = RKLSCP** is an attempt to predict the amount of erosion that will take place in an area on the basis of certain factors which increase susceptibility to erosion *(Fig. 1)*. These are discussed in *Table 1 below*.

Fig. 1 The Universal soil loss equation

A = the predicted soil loss
R = the climatic erosivity or the rainfall erosivity index
K = soil erodibility
L = slope length
S = slope gradient
C = cover and management
P = erosion control practice

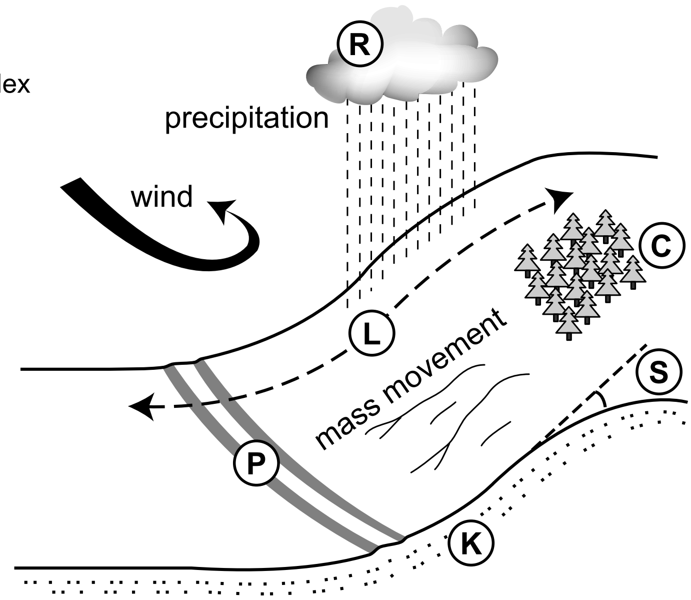


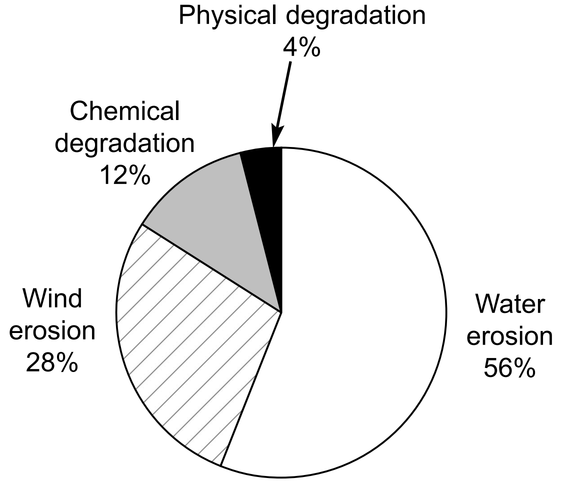
Table 1 Factors relating to the Universal soil loss equation (USLE).

Factor	Description
Ecological conditions	
Erosivity of soil **R**	Rainfall totals, intensity and seasonal distribution. Maximum erosivity occurs when the rainfall occurs as high intensity storms. If such rain is received when the land has just been ploughed or full crop cover is not yet established, erosion will be greater than when falling on a full canopy. Minimal erosion occurs when rains are gentle, and fall onto frozen soil or land with natural vegetation or a full crop cover.
Erodibility **K**	The susceptibility of a soil to erosion. Depends upon infiltration capacity and the structural stability of soil. Soils with high infiltration capacity and high structural stability that allow the soil to resist the impact of rain splash, have lowest erodibility values.
Length-slope factor **LS**	Slope length and steepness influence the movement and speed of water down the slope, and thus its ability to transport particles. The greater the slope, the greater the erosivity; the longer the slope, the more water is received on the surface.
Land use type	
Crop management **C**	Most control can be exerted over the cover and management of the soil, and this factor relates to the type of crop and cultivation practices. Established grass and forest provide the best protection against erosion, and of agricultural crops, those with the greatest foliage and thus greatest ground cover are optimal. Fallow land or crops that expose the soil for long periods after planting or harvesting offer little protection.
Soil conservation **P**	Soil conservation measures, such as contour ploughing, bunding, use of strips and terraces, can reduce erosion and slow runoff water.

Fig. 2 Types and causes of land degradation.

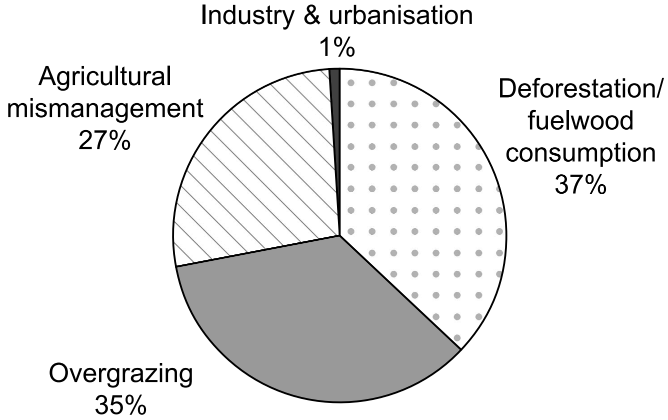
Types of land degradation

Water and wind erosion account for more than 80% of the 20 million km² degraded worldwide.



Causes of land degradation

Overgrazing and agricultural mismanagement affect more than 12 million km² worldwide. 20% of the world's pasture and rangelands have been damaged and the situation is most severe in Africa and Asia. Huge areas of forest are cleared for logging, fuelwood, farming or other human uses.



Soil degradation encompasses several issues at various spatial time scales.

- **Water erosion** accounts for nearly 60% of soil degradation. There are many types of erosion including surface-, gully-, rill- and tunnel-erosion.
- **Wind erosion**
- **Acidification** is the change in the chemical composition of the soil, which may trigger the circulation of toxic metals.
- **Groundwater over-abstraction** may lead to dry soils, leading to physical degradation.
- **Salt affected soils** are typically found in marine-derived sediments, coastal locations and hot arid areas where capillary action brings salts to the upper part of the soil. Soil salinity has been a major problem in Australia following the removal of vegetation in dryland farming.
- **Atmospheric deposition** of heavy metals and persistent organic pollutants may make soils less suitable to sustain the original land cover and land use.
- **Climate change** will probably intensify the problem. Climate change is likely to affect hydrology and hence land use.

Climate change, leading to higher average temperature and changing precipitation patterns, may have three direct impacts on soil conditions:

- The higher temperatures cause higher decomposition rates of organic matter. Soil organic matter is important as a source of nutrients and it improves moisture storage.
- More floods will cause more water erosion.
- More droughts will cause more wind erosion.

Human activities

Human activities have often led to degradation of 15% of the world's land resources *(Table 2)*. These impacts frequently lead to reduction in yields. Land conservation and rehabilitation are essential parts of sustainable agricultural development. While severely degraded soil is found in most regions of the world, the negative economic impact of degraded soil may be most severe in the countries most dependent on agriculture for their incomes.

Table 2 Human activities and their impact on soil erosion.

Action	Effect
Removal of woodland or ploughing established pasture	The vegetation cover is removed, roots binding the soil die and the soil is exposed to wind and water. Particularly susceptible to erosion if on slopes.
Cultivation	Exposure of bare soil surface before planting and after harvesting. Cultivation on slopes can generate large amounts of runoff and create rills and gullies.
Grazing	Overgrazing can severely reduce the vegetation cover and leave surface vulnerable to erosion. Grouping of animals can lead to over-trampling and creation of bare patches. Dry regions are particularly susceptible to wind erosion.
Road or tracks	Collect water due to reduced infiltration that can cause rills and gullies to form, e.g. when the west coast highway was built in St. Lucia, Tropical Storm Debbie led to massive erosion as water was channelled along exposed, bare road.
Mining	Exposure of the bare soil. Degradation from chemical dumping.

Fig. 3 The state of the world's soils.

Case Study 1: Soil degradation in India

Factors responsible:

- *The amount of India's land area dedicated to cropland has grown steadily, from 99.3 million hectares in 1950 to almost 170 million hectares, largely due to the Green Revolution. An additional 12 million hectares fall under the classification of 'meadows and pasture' and are utilised for animal husbandry.*
- *India is the fourth largest fertiliser consumer in the world. India has also increased its consumption of insecticides, herbicides and fungicides from only a little over 24,000 tonnes in 1971 to over 82,000 tonnes.*
- *The area of agricultural land under irrigation has continued its growth, from 32% in 1970 to 43% in 2000. The majority of this increase has come from increases in water extracted from groundwater supplies. This is significant because in many ways, groundwater supplies can be considered a non-renewable resource. Finally, the demand for water irrigation is expected to increase markedly over the next few decades, in line with population growth.*
- *Productivity has increased, e.g. rice paddy production has more than tripled and total grain production has almost doubled since 1960. However, the increased use of chemical fertilisers has become a source of concern since a significant portion of fertiliser and pesticide applied to the soil runs off into surface water or leaches into groundwater.*
- *Land affected by water erosion represents nearly half of total Indian land area, and 80% of degraded land. Most of this damage is in the form of loss of topsoil. Among the remaining categories, salinisation, waterlogging and loss of top soil from wind erosion (the former two resulting from over-irrigation) are the most common problems. Water erosion and wind erosion damage can be attributed to inadequate land cover, whether it be from deforestation, monocropping, overgrazing or from farming on marginal and land areas.*

Table 3 Classification of Indian soil degradation

Classification of Indian soil degradation	Area (Millions Ha)	%
Water erosion		
Loss of top soil	132.5	*40.3*
Terrain deformation	16.4	*5.0*
Wind erosion		
Loss of topsoil	6.2	*4.1*
Terrain deformation/overblowing	4.6	*1.9*
Chemical deterioration		
Loss of nutrients	3.7	*1.1*
Salinisation	10.1	*3.1*
Physical deterioration		
Waterlogging	11.6	*3.5*
Land not fit for agriculture	18.2	*5.5*
Soils with little or no degradation	90.5	*27.5*
Soils under natural condition	32.2	*9.8*
Total	**328.7**	***100.0***

Chemical degradation in the form of loss and leaching is the result of shortened fallow periods. Only 37% of Indian land area can be said to be largely free from degradation of any kind, and degraded land will continue its growth in years to come.

Exam Hint: *Using the case study as an example of one country try to simplify and make sense of the data. Firstly, summarise the factors which have led to soil degradation in India. Secondly, annotate the table to explain the main causes of soil degradation in India.*

Case Study 2: Land degradation in Barbados

The most significant area of land degradation in Barbados is within the Scotland District (Fig. 4) which falls within the parishes of St. Andrew, St. Joseph and St. John. This area represents 14% of the island's topography and is geologically unique, since it is the only area on the island where the limestone cap has been removed. Changing land use practices and the application of inappropriate agricultural techniques (growing sugar cane on very steep slopes, for example) have also resulted in significant and visible loss of soils in the limestone areas of the island. The Scotland District is particularly prone to landslides and slippage because of its elevation and soil structure. The soil in this area comprises clays and shales.

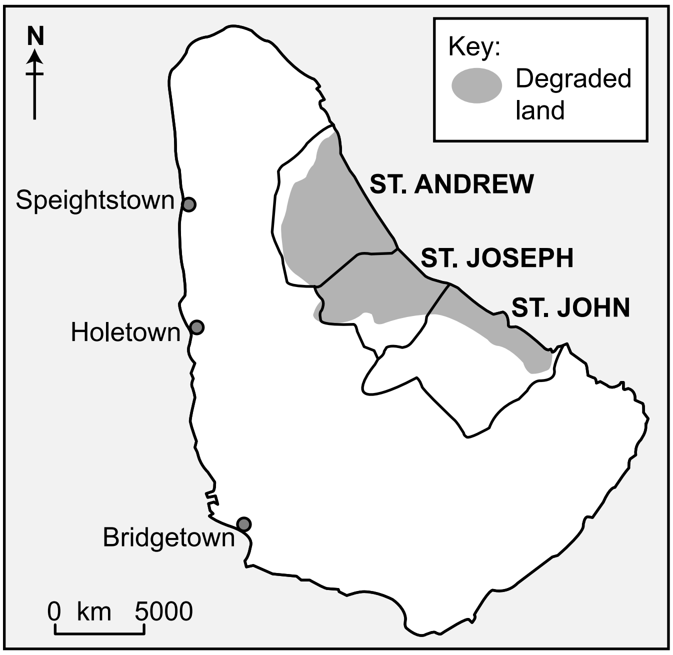
Causes of land degradation

- *The reduction of the natural vegetative cover which renders the topsoil more susceptible to erosion.*
- *Unsustainable land use practices such as excessive irrigation, the inappropriate use of fertilisers and pesticides and overgrazing by livestock.*

The removal of vegetation and topsoil has resulted in:

- *Increased surface runoff and stream discharge*
- *Reduction of water infiltration and groundwater recharge*
- *Development of erosionial gullies and sand dunes*
- *Change in the surface microclimate that enhances aridity*
- *Drying up of wells and springs, and*
- *Reduction of seed germination of native plants*

Fig. 4 The Scotland District



Controlling land degradation

One of the most effective ways in which land degradation can be controlled is through increasing the vegetative cover within the affected area. The Soil Conservation Unit located within the Scotland District is involved in educating farmers about sustainable farming practices. The farmers are taught methods which include keeping the soil covered, incorporating organic matter to assist with percolation and reducing the use of fertilisers.

Managing soil degradation

Abatement strategies, such as afforestation, for combating accelerated soil erosion are lacking in many areas. To reduce the risk of soil erosion, farmers are encouraged towards more extensive management practices such as organic farming, afforestation, pasture extension and benign crop production. Nevertheless, there is a need for policy makers and the public to intensify efforts to combat the pressures and risks to the soil resource.

Methods to reduce or prevent erosion can be mechanical, e.g. physical barriers such as embankments and wind breaks, or they may focus on vegetation cover and soil husbandry. Overland flow can be reduced by increasing infiltration.

Mechanical methods include bunding, terracing and contour ploughing, and shelterbelts such as trees or hedgerows. The key is to prevent or slow the movement of rain water downslope. Contour ploughing takes advantage of the ridges formed at right angles to the slope to act to prevent or slow the downward accretion of soil and water. On steep slopes and in areas with heavy rainfall, such as the monsoon in South-East Asia, contour ploughing is insufficient and terracing is undertaken.

The slope is broken up into a series of flat steps, with bunds (raised levees) at the edge. The use of terracing allows areas to be cultivated that would not otherwise be suitable. In areas where wind erosion is a problem shelterbelts of trees or hedgerows are used. The trees act as a barrier to the wind and disturb its flow. Wind speeds are reduced which therefore reduce its ability to disturb the topsoil and erode particles.

Preventing erosion by different cropping techniques largely focuses on:

- Maintaining a crop cover for as long a possible
- Keeping in place the stubble and root structure of the crop after harvesting
- Planting a grass crop. Grass roots bind the soil, minimising the action of the wind and rain on a bare soil surface. Increased organic content allows the soil to hold more water, this preventing aerial erosion and stabilising the soil structure. In addition, care is taken over the use of heavy machinery on wet soils and ploughing on soil sensitive to erosion, to prevent damage to the soil structure.

There are three main approaches in the management of salt affected soils:

1. Flushing the soil and leaching the salt away
2. Application of chemicals, e.g. gypsum (calcium sulphate) to replace the sodium ions on the clay and colloids with calcium ones.
3. A reduction in evaporation losses to reduce the upward movement of water in the soil.

Equally specialist methods are needed to decontaminate land made toxic by chemical degradation.

Fig. 5 Controlling soil erosion - identify the methods marked 1 - 6.

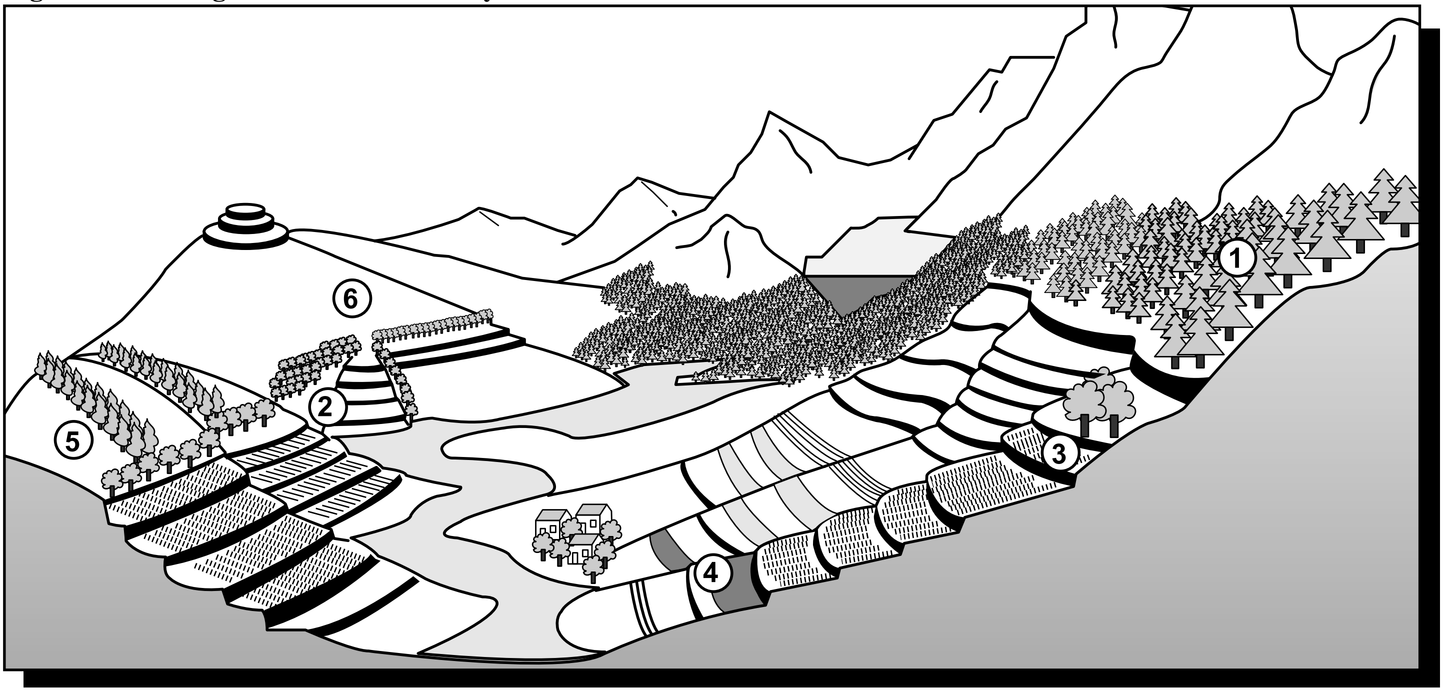


Table 4 Human-induced land degradation.

	Land area 000s km^2	Total affected by severe/very severe land degradation 000s km^2	Amount of severe/very severe land degradation due to agricultural activities 000s km^2
Sub-Saharan Africa	23,772	5,931	1,996
North Africa and Near East	12,379	4,260	759
North Asia, east of Urals	21,033	4,421	1,180
Asia and Pacific	28,989	8,407	3,506
South and Central America	20,498	5,552	1,795
North America	19,237	3,158	2,427
Europe	6,843	3,274	727
World	134,907	35,003	12,390

Conclusion

Soil degradation is a complex issue. It is caused by the interaction of physical forces and human activities. Its impact is increasing and is having a negative effect on food production. Some areas are more badly affected than others but in a globalised world the impacts are felt worldwide. The method of dealing with soil degradation depends on the cause of the problem, but also the resources available to the host country. Degradation is likely to increase over the next decades as a result of: climate change; population growth; the use of increasingly marginal areas for living and food supply.

References

- *Technical Report on Soil Degradation*. van den Born, G.J. et al, EEA (2000)
- *Europe's Environment*, European Environment Agency (1998)
- *Physical geography: a human perspective*. Huggett, R. et al. Arnold (2004)
- A useful website is www.unepo.org

Exam question

Study *Table 4*. Describe and suggest reasons for the variations shown between continents in the amount of severely graded land.

Answer guidelines

Work on the statistics to calculate the percentage of severely affected land by area and by cause. Note the very high % of eroded land in Europe. Also note that in Europe only 25% of land from agricultural activities. Look for factors such as chemical contamination, urbanisation and industrialisation or impact of deforestation (e.g. Tennessee Valley or the Dustbowl in the Great Plains) as a result of over-cultivation, overgrazing and farming very marginal lands.

Use this Factsheet to interpret the differences between amount and causes, always supplying precise % when interpreting the statistics.

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