# Atmosphere and change (1)

## GLOBAL WARMING

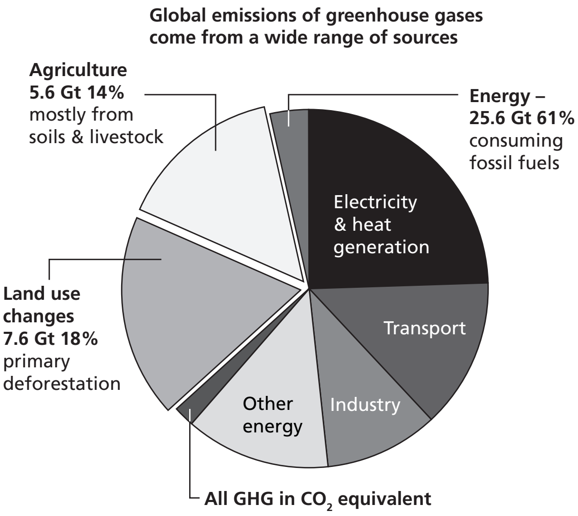
- **Global warming** refers to the increase in temperatures around the world that has been noticed over the last 50 years or so, and in particular since the 1980s.
- The **greenhouse effect** is the process by which certain gases – water vapour, carbon dioxide, methane and chlorofluorocarbons (CFCs) – allow short-wave radiation from the sun to pass through and heat up the earth, but trap an increasing proportion of long-wave radiation from the earth. This radiation leads to a warming of the atmosphere.
- The **enhanced greenhouse effect** is the increasing amount of greenhouse gases in the atmosphere as a result of human activities, and their impact on atmospheric systems, including global warming.

One concern about global warming is the build-up of greenhouse gases (GHGs).

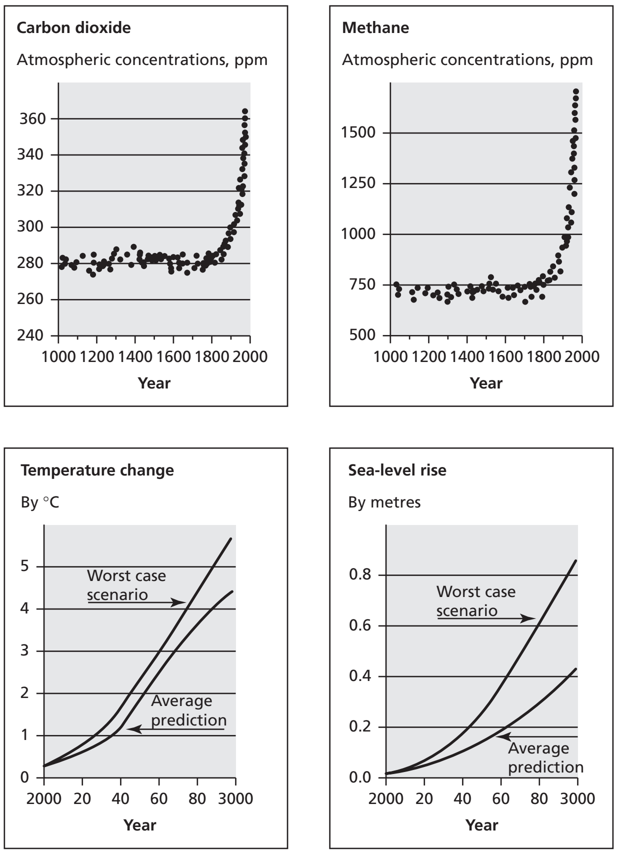
**Carbon dioxide** ($CO_2$) levels have risen from about 315 parts per million (ppm) in 1950 to 355 ppm and are expected to reach 600 ppm by 2050. The increase is due to human activities – burning fossil fuels (coal, oil and natural gas) and deforestation. Deforestation of the tropical rainforest is a double blow – not only does it increase atmospheric $CO_2$ levels, it removes the trees that convert $CO_2$ into oxygen.

**Methane** is the second largest contributor to global warming, and is increasing at a rate of 1% per annum. It is estimated that cattle convert up to 10% of the food they eat into methane, and emit 100 million tonnes of methane into the atmosphere each year. Natural wetland and paddy fields are another important source – paddy fields emit up to 150 million tonnes of methane annually. As global warming increases, bogs trapped in permafrost will melt and release vast quantities of methane.

**Chlorofluorocarbons** (CFCs) are synthetic chemicals that destroy ozone, as well as absorb long-wave radiation. CFCs are increasing at a rate of 6% per annum, and are up to 10,000 times more efficient at trapping heat than $CO_2$.




*Main sources of $CO_2$ emissions*




*Causes and consequences of global warming*

### The effects of global warming

- A rise in sea levels, causing flooding in low-lying areas such as the Netherlands, Egypt and Bangladesh – up to 200 million people could be displaced
- An increase in storm activity (owing to more atmospheric energy)
- Changes in agricultural patterns (e.g. a decline in the USA's grain belt, but an increase in Canada's growing season)
- Reduced rainfall over the USA, southern Europe and the Commonwealth of Independent States (CIS)
- Extinction of up to 40% of species of wildlife

***EXTENSION***

**Pie charts – absolute and relative scale**

Pie charts are a great way of showing *relative* data. They are quite easy to draw and label and show clearly the biggest contributors – in this case energy.

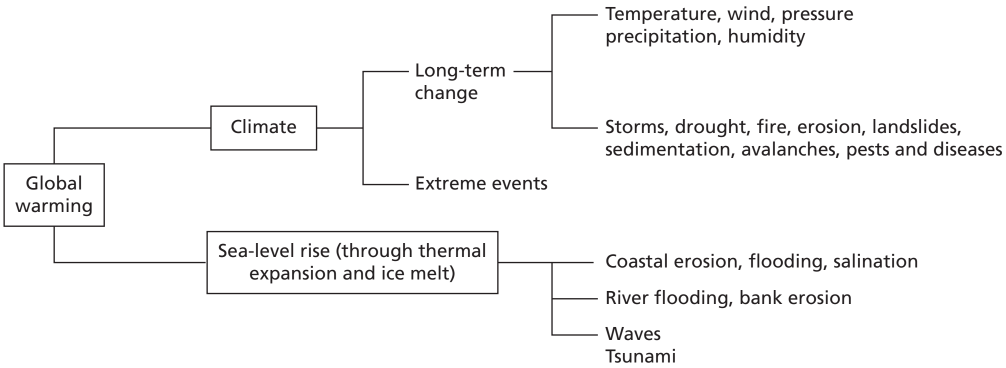
However, pie charts are not very good at representing *absolute* data. Sometimes, as here, it is important to add the absolute size (25.6 Gt for energy) to give some idea of the scale of the data.

Two pie charts may be drawn at the same size but may have very different absolute scales.

# Atmosphere and change (2)

## THE IMPLICATIONS OF CLIMATE CHANGE

The effects of global warming on the natural, social and economic environment are mixed:




*Consequences of the greenhouse effect*

## POLICIES TO COMBAT CLIMATE CHANGE

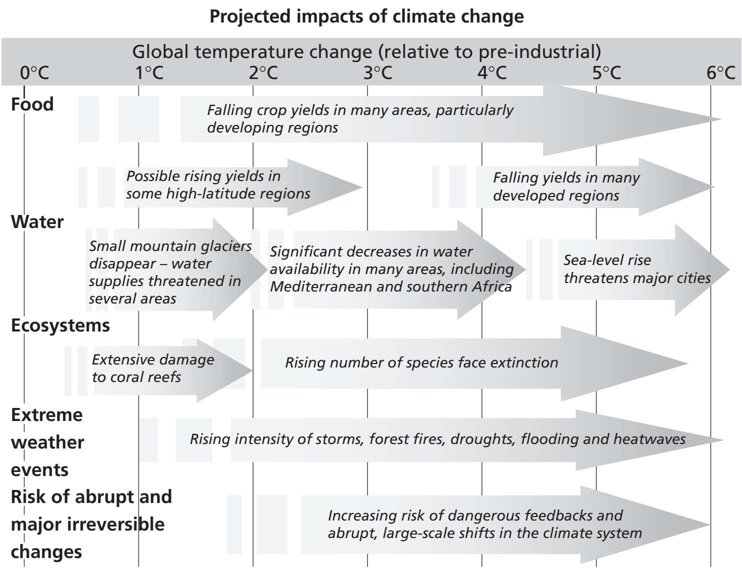
Emissions of the main anthropogenic (man-made) greenhouse gas, $CO_2$, are influenced by:

- the size of the human population
- the amount of energy used per person
- the level of emissions resulting from that use of energy.

A variety of technical options which could reduce emissions, especially from use of energy, are available. Reducing $CO_2$ emissions can be achieved through:

- improved energy efficiency
- fuel switching
- use of renewable energy sources
- nuclear power
- capture and storage of $CO_2$.

These options are most easily applicable to stationary plant. Another class of measure involves increasing the rate at which natural sinks take up $CO_2$ from the atmosphere, for example by increasing the number of forests.




*The effects of temperature rises*

## INTERNATIONAL POLICY TO PROTECT CLIMATE

See page 48 for an account of policy at an international scale.

### *EXTENSION*

**Uncertainty in geography**

There is a great amount of uncertainty in geography. Try to avoid statemements that are too forceful or dogmatic. For example, nobody knows what the impact of climate change will be. There are different scenarios based on possible termerature changes. Some people even suggest that certain areas might get colder, such as the northern UK if the Gulf Stream shuts down. We do not know what will happen – therefore it is wise to be aware that there is uncertainty and there may be very different results in the end.

# Soil degradation (1)

## TYPES OF SOIL DEGRADATION

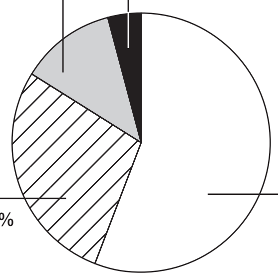
**Soil degradation** is the decline in quantity and quality of soil. It includes:

- 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, salinization and chemical toxicity).

There are many types of water erosion, including surface, gully, rill and tunnel erosion.

Water and wind erosion account for more than 80% of the 20 million km$^2$ of degraded land worldwide.

Acidification is the change in the chemical composition of the soil, which may trigger the circulation of toxic metals.




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.

## THE UNIVERSAL SOIL LOSS EQUATION (USLE)

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.

| 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 on infiltration capacity and the structural stability of soil. Soils with high infiltration capacity and high structural stability, which 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 steeper the slope, the greater the erosivity; the longer the slope, the more water is received on the surface. |
| *Land-use types* | |
| 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; 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. |

*Factors relating to the universal soil loss equation (USLE)*

## CAUSES OF DEGRADATION

Causes of soil or land degradation include:

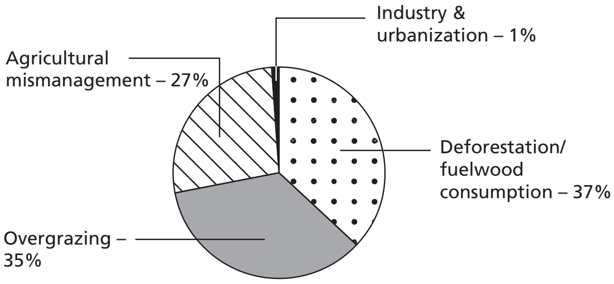
- the reduction of the natural vegetative cover, which renders the topsoil more susceptible to erosion
- unsustainable land-use practices such as excessive irrigation, the inappropriate use of fertilizers and pesticides and overgrazing by livestock
- groundwater overabstraction, which may lead to dry soils, resulting in physical degradation
- atmospheric deposition of heavy metals and persistent organic pollutants, which make soils less suitable to sustain their original land cover and land use.

Climate change will probably intensify the problem. It is likely to affect hydrology and hence land use.

# Soil degradation (2)

## CAUSES OF DEGREDATION (CONTINUED)

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




## THE EFFECTS OF LOSS OF COVER

The removal of vegetation and topsoil has resulted in:

- increased surface runoff and stream discharge
- reduction of water infiltration and groundwater recharge
- development of erosional gullies and sand dunes
- change in the surface microclimate that enhances aridity
- drying up of wells and springs
- reduction of seed germination of native plants.

## 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 policymakers 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, for example physical barriers such as embankments and windbreaks, or they may focus on vegetation cover and soil husbandry. Overland flow can be reduced by increasing infiltration.

### Mechanical methods

Mechanical methods include bunding, terracing and contour ploughing, and shelter belts such as trees or hedgerows. The key is to prevent or slow the movement of rainwater 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 levées) 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, shelter belts 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 the wind's ability to disturb the topsoil and erode particles.

### Cropping techniques

Preventing erosion by different cropping techniques largely focuses on:

- maintaining a crop cover for as long as possible
- keeping in place the stubble and root structure of the crop after harvesting
- planting a grass crop – grass roots bind the soil, minimizing the action of the wind and rain on a bare soil surface.

Increased organic content allows the soil to hold more water, thus preventing aerial erosion and stabilizing 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.

### Managing salt- and chemical-affected soils

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

- flushing the soil and leaching the salt away
- application of chemicals, such as gypsum (calcium sulphate) to replace the sodium ions on the clay and colloids with calcium ones
- 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.

## LAND DEGRADATION IN BARBADOS

The most significant area of land degradation in Barbados is within the Scotland District. Changing land-use practices and the application of inappropriate agricultural techniques (growing sugar cane on very steep slopes, for example) have resulted in significant and visible loss of soils.

### 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. Farmers in the region are taught methods which include keeping the soil covered, incorporating organic matter to assist with percolation and reducing the use of fertilizers.

# Water usage and change (1)

## CHANGING SUPPLY AND DEMAND

During the past century, while world population has tripled, the use of water has increased sixfold. Some rivers that formerly reached the sea no longer do so – all of the water is diverted before it reaches the river's mouth. The Colorado in the USA is a good example. Half the world's wetlands have disappeared in the same period, and today 20% of freshwater species are endangered or extinct. Many important aquifers are being depleted, and water tables in many parts of the world are dropping at an alarming rate. Worse still, world water use is projected to increase by about 50% in the next 30 years.

It is estimated that, by 2025, 4 billion people – half the world's population at that time – will live under conditions of severe water stress, with conditions particularly severe in Africa, the Middle East and south Asia. Many observers predict that disputes over scarce water resources will fuel an increase in armed conflicts. Water that is safe to drink remains as central to survival – and to improving the lives of the poor – as it has always been. Currently, an estimated 1.1 billion people lack access to safe water, 2.6 billion are without adequate sanitation, and more than 4 billion do not have their waste water treated to any degree. These numbers are likely to grow worse in the coming decades.

## WATER SUPPLY

Water supply depends on several factors in the water cycle, including the rates of rainfall, evaporation, the use of water by plants (transpiration), and river and groundwater flows. It is estimated that less than 1% of all fresh water is available for people to use (the remainder is locked up in ice sheets and glaciers). Globally, around 12,500 km$^3$ of water are considered available for human use on an annual basis. This amounts to about 6600 m$^3$ per person per year.

If current trends continue, only 4800 m$^3$ will be available in 2025. This is an optimistic calculation because it is based on estimates of all the water flowing in rivers after evaporation and infiltration into the ground. It does not take into account the minimum required to maintain river ecosystems, for example. Nor does it reflect the difficulty in accessing all of this water or its extremely unequal distribution.

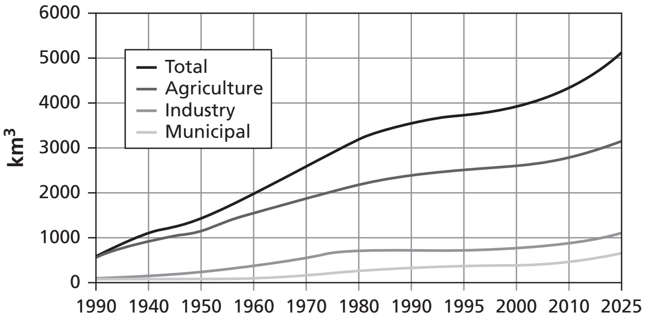
The world's available freshwater supply is not distributed evenly around the globe, either seasonally or from year to year. About three-quarters of annual rainfall occurs in areas containing less than one-third of the world's population, whereas two-thirds of the world's population live in the areas receiving only one-quarter of the world's annual rainfall. For instance, about 20% of the global average runoff each year is accounted for by the Amazon Basin, a vast region with fewer than 10 million people. India gets 90% of its rainfall during the summer monsoon season – at other times rainfall over much of the country is very low.

### Water stress

When per capita water supply is less than 1700 m$^3$ per year, an area suffers from "water stress" and is subject to frequent water shortages. In many of these areas today, water supply is actually less than 1000 m$^3$ per capita, which causes serious problems for food production and economic development. Some 2.3 billion people live in water-stressed areas. If current trends continue, water stress will affect 3.5 billion – or 48% of the world's projected population – in 2025.

## WATER USE

Currently, the quantity of water used for all purposes exceeds 3700 km$^3$ per year. Agriculture is the largest user, consuming almost two-thirds of all water drawn from rivers, lakes and groundwater. Since 1960, water use for crop irrigation has risen by 60–70%. Industry uses about 20% of available water, and the municipal sector uses about 10%. Population growth, urbanization and industrialization have increased the use of water in these sectors. As world population and industrial output have increased, the use of water has accelerated, and this is projected to continue. By 2025 global availability of fresh water may drop to an estimated 5100 m$^3$ per person per year, a decrease of 25% on the 2000 figure.



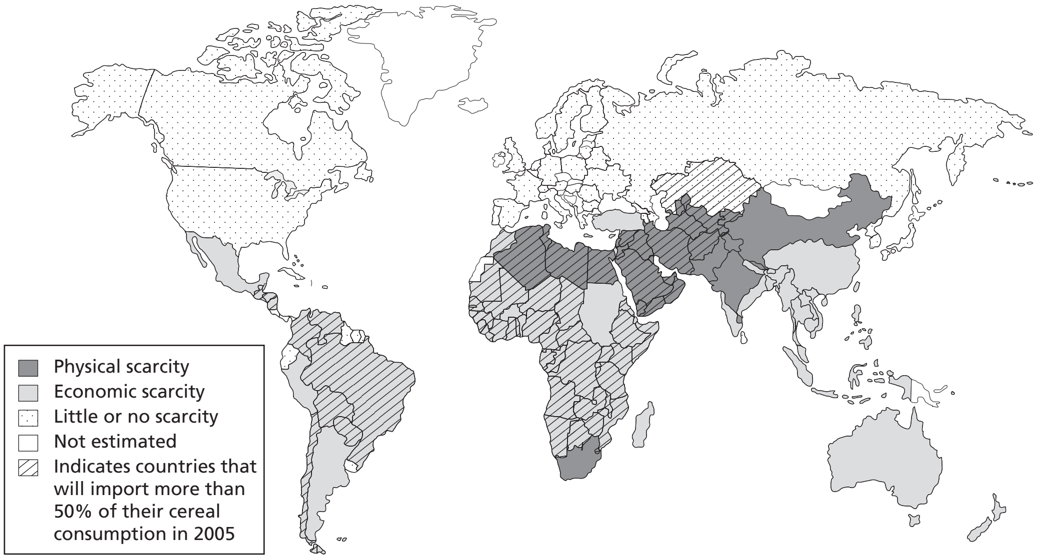
*Trends in water use*

# Water usage and change (2)

## WATER SCARCITY

Where water supplies are inadequate, two types of water scarcity affect LEDCs in particular:

- **Physical water scarcity** occurs where water consumption exceeds 60% of the usable supply. To help meet water needs, some countries such as Saudi Arabia and Kuwait import much of their food and invest in desalinization plants.
- **Economic water scarcity** occurs where a country physically has sufficient water resources to meet its needs, but additional storage and transport facilities are required – this will mean embarking on large and expensive water development projects, as in many in sub-Saharan countries.




*Water scarcity, 2025*

In addition, in LEDCs access to adequate water supplies is most affected by the exhaustion of traditional sources, such as wells and seasonal rivers.

In many poor countries farmers use, on average, twice as much as water per hectare as in industrialized countries, yet their yields can be three times lower – a sixfold difference in the efficiency of irrigation.

## WATER QUALITY

Water also needs to be of an adequate quality for consumption. However, the World Health Organization (WHO) estimates that around 4 million deaths each year can be attributed to water-related disease, particularly cholera, hepatitis, malaria and other parasitic diseases.

The real problem of drinking water and sanitation in developing countries is that too many people lack access to safe and affordable water supplies and sanitation.

## GLOBAL WATER SUPPLY AND SANITATION

Urban areas are better served than rural areas, and countries in Asia, Latin America and the Caribbean are better off than African countries. Many piped water systems, however, do not meet water quality criteria, leading more people to rely on bottled water bought in markets for personal use (as in major cities in Colombia, India, Mexico, Thailand, Venezuela and Yemen).

In some cases, the poor pay more for their water than the rich. For example, in Port-au-Prince, Haiti, surveys have shown that households connected to the water system typically paid around $1.00 per cubic metre, while unconnected customers forced to purchase water from mobile vendors paid from $5.50 to a staggering $16.50 per cubic metre.

### Sanitation and population growth

Fewer people have adequate sanitation than safe water, and the global provision of sanitation is not keeping up with population growth. Between 1990 and 2000 the number of people without adequate sanitation rose from 2.6 billion to 3.3 billion. Least access to sanitation occurs in Asia (48%), especially in rural areas.

There are still pressure points, especially in areas of rapid population growth. With squatter settlements in many of the world's poorest cities expanding rapidly, and local authorities unable to or legally prevented from providing sanitation, the situation is likely to deteriorate rapidly.

# The world's riches: biodiversity and change (1)

## BIODIVERSITY

**Biodiversity** means biological diversity. It is the variety of all forms of life on earth – plants, animals and micro-organisms. It refers to species (species diversity), variations within species (genetic diversity), and interdependence within species (ecosystem diversity) and habitat diversity.

It is estimated that there are up to 30 million species on earth. However, only 1.4 million species have yet been identified. The tropics are the richest area for biodiversity. Tropical forests contain over 50% of the world's species in just 7% of the world's land. They account for 80% of the world's insects and 90% of primates.

## THE VALUE OF TROPICAL RAINFORESTS

| Industrial uses | Ecological uses | Subsistence uses |
|---|---|---|
| Charcoal | Watershed protection | Fuelwood and charcoal |
| Saw logs | Flood and landslide protection | Fodder for agriculture |
| Gums, resins and oils | Soil erosion control | Building poles |
| Pulpwood | Climate regulation e.g. $CO_2$ and $O_2$ levels | Pit-sawing and saw-milling |
| Plywood and veneer | | Weaving materials and dyes |
| Industrial chemicals | | Rearing silkworms and bee-keeping |
| Medicines | | Special woods and ashes |
| Genes for crops | | Fruits and nuts |
| Tourism | | |

## DEFORESTATION OF THE TROPICAL RAINFOREST

Tropical forests are being destroyed at a rate of over 11 million hectares a year (or 21 ha/minute). Increasingly, tropical rainforests are very scattered and fragmented. The Amazon rainforest is the main exception, although it is imploding.

### Causes of deforestation in Brazil

There are five main causes of deforestation in Brazil:

- agricultural colonization by landless migrants and speculative developers along highways and agricultural growth areas
- conversion of the forest to cattle pastures, especially in eastern and south-eastern Para and northern Mato Grosso
- mining, for example the Greater Carajas Project in south-eastern Amazonia, which includes a 900 km railway and extensive deforestation to provide charcoal to smelt the iron ore; another threat from mining comes from the small-scale informal gold mines, *garimpeiros*, causing localized deforestation and contaminated water supplies
- large-scale hydroelectric power schemes such as the Tucurui Dam on the Tocantins River
- forestry taking place in Para, Amazonas and northern Mato Grosso.

Other causes include:

- drought (increases risk)
- climate change (can cause drought)
- timber exploitation (fires are used to overcome laws about clearing timber for sale, or to create a source for damaged and thus cheap timber)
- selective logging (can create artificially dry forests by opening up the canopy)
- lightning (the main natural cause)
- land clearing ("slash-and-burn" agriculture during dry and windy conditions can cause major fires).

### Trends

Deforestation in Brazil shows five main trends:

1. It is a recent phenomenon.
2. It has partly been promoted by government policies.
3. There is a wide range of causes of deforestation.
4. Deforestation includes new areas of deforestation as well as the extension of previously deforested areas.
5. Land speculation and the granting of land titles to those who "occupy" parts of the rainforest is a major cause of deforestation.

# The world's riches: biodiversity and change (2)

## EFFECTS OF DEFORESTATION

There are many effects of deforestation, including:

- disruption to the circulation and storage of nutrients
- surface erosion and compaction of soils
- sandification
- increased flood levels and sediment content of rivers
- climatic change
- loss of biodiversity.

Deforestation disrupts the closed system of nutrient cycling within tropical rainforests. Inorganic elements are released through burning and are quickly flushed out of the system by the high-intensity rains.

Soil erosion is also associated with deforestation. As a result of soil compaction, there is a decrease in infiltration, an increase in overland runoff and surface erosion.

Sandification is a process of selective erosion. Raindrop impact washes away the finer particles of clay and humus, leaving behind the coarser and heavier sand. Evidence of sandification dates back to the 1890s in Santarem, Rondonia.

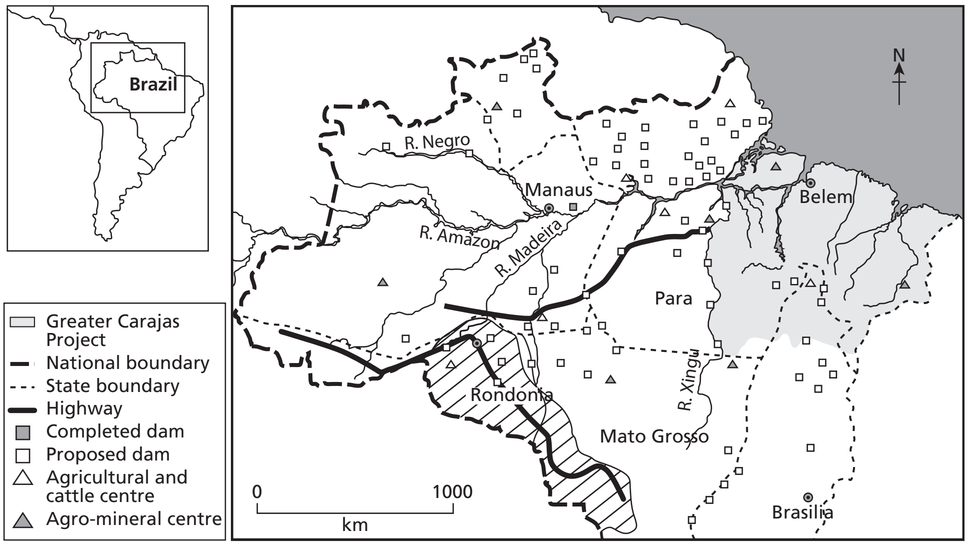
As a result of the intense surface runoff and soil erosion, rivers have a higher flood peak and a shorter time lag. However, in the dry season river levels are lower, the rivers have greater turbidity (murkiness due to more sediment), an increased bed load, and carry more silt and clay in suspension.

Other changes relate to climate. As deforestation progresses, there is a reduction of water that is re-evaporated from the vegetation, hence the recycling of water must diminish. Evapotranspiration (EVT) rates from savanna grasslands are estimated to be only about one-third of those of the tropical rainforest. Thus mean annual rainfall is reduced, and the seasonality of rainfall increases.

## AMAZON'S RESCUE REVERSED

Government satellite images show that at least 1249 square miles (3235 $km^2$) of rainforest were lost between August and December 2007, mainly because of soy planting and cattle ranching. The true figure could be as high as 2700 square miles (almost 7000 $km^2$).

Environmentalists say as much as 20% of the rainforest has already been destroyed, mostly since the 1970s. A further 40% could be lost by 2050 if that trend is not reversed, they estimate.




*Economic development and deforestation in the Brazilian rainforest*

## THE COST OF ENVIRONMENTAL INACTION IN NIGERIA

The conventional constraint on government and private sector action has been concern about the costs of taking new environmental protection measures. This narrow preoccupation has overshadowed the equally important consideration of the mounting economic, social and ecological costs of not acting.

A recent World Bank study provides a stark assessment of the risks and enormous costs if no remedial action is taken. In sum, the long-term losses to Nigeria of not acting on growing environmental problems are estimated to be around $5000 million annually.

| | |
|---|---|
| Soil degradation | 3000 |
| Water contamination | 1000 |
| Deforestation | 750 |
| Coastal erosion | 150 |
| Gully erosion | 100 |
| Fishery losses | 50 |
| Water hyacinth | 50 |
| Wildlife losses | 10 |
| **Total** | **5110** |

*Annual costs of inaction (US$ million/year)*