3.1.2 Section B: The living world

In this section, students are required to study Ecosystems, Tropical rainforests and **one from** hot deserts or Cold environments.

Ecosystems

2.1. Background to Ecosystems

2.2 The distribution and characteristics of large scale natural global ecosystems.

Tropical rainforests

2.3 Tropical rainforest ecosystems have a range of distinctive characteristics.

2.4 Deforestation has economic and environmental impacts.

2.5 Changing rates of deforestation.

2.6 The Amazon - A case study of a tropical rainforest.

2.7 Tropical rainforests need to be managed to be sustainable.

Hot deserts

2.8 Hot desert ecosystems have a range of distinctive characteristics.

2.9 How plants and animals adapt to the physical conditions.

2.10 Opportunities and challenges of hot deserts

2.11 Areas on the fringe of hot deserts are at risk of desertification.

2.12 Strategies used to reduce the risk of desertification

2.1 Background to Ecosystems

An **ecosystem** is a natural system that comprises a **community of plants and animals** that interact with each other and their physical environment. There are often complex relationships that exist in ecosystems, between the **non-living elements** (soils, rocks, water, sunlight etc.) and the **living elements** (plants, animals, bacteria etc.).

We can look at ecosystems at different scales. A back garden could be classified as a local ecosystem, as could a pond. Larger ecosystems could be ranges of sand dunes, your local woodland or forest, or a lake. At a **global scale** we look at ecosystems as **biomes**, and these include tropical rainforests, deserts and tundra environments. Biomes have common characteristics, such as buttress roots in rainforests, but not necessarily exactly the same species of plants and animals within them.

Small scale ecosystems – Freshwater ponds

Consider a local ecosystem. In this case we will consider a **FRESHWATER POND**. You may have a freshwater pond in your back garden or in your school or the local park. They contain a VARIETY of habitats for plants and animals;

- Animals and plants living in deeper water at the bottom of the pond will have less light and Oxygen to cope with and ADAPT to.
- Living things at the edges of a pond (the margins) have more light and Oxygen, but also have to cope with more wind etc.

Key terms

Consumer – Creature that eats herbivores and/or plant matter.

Decomposer – An organism such as a bacterium or fungus, that breaks down dead tissue, which is then recycled to the environment.

Food chain – The connections between different organisms (plants and animals) that rely upon one another as their source of food.

Food web – A complex hierarchy of plants and animals relying on each other for food.

Nutrient cycling – A set of processes whereby organisms extract minerals necessary for growth from soil or water, before passing them on through the food chain – and ultimately back to the soil and water.

Producer – An organism or plant that is able to absorb energy from the sun through photosynthesis.

Figure 1 - A freshwater pond

We can CLASSIFY living organisms in an ecosystem as either PRODUCERS or CONSUMERS. PRODUCERS generally use energy from the environment, such as from the sun, and convert it into sugars (or glucose). Plants do this in abundance, using PHOTOSYNTHESIS to use sunlight to synthesize nutrients from carbon dioxide and water. CONSUMERS then get their energy by eating the producers for their sugars. In our pond example, reeds living at the edge of the pond and water lilies would be our producers, and pond snails are a consumer as they eat the pond plants.

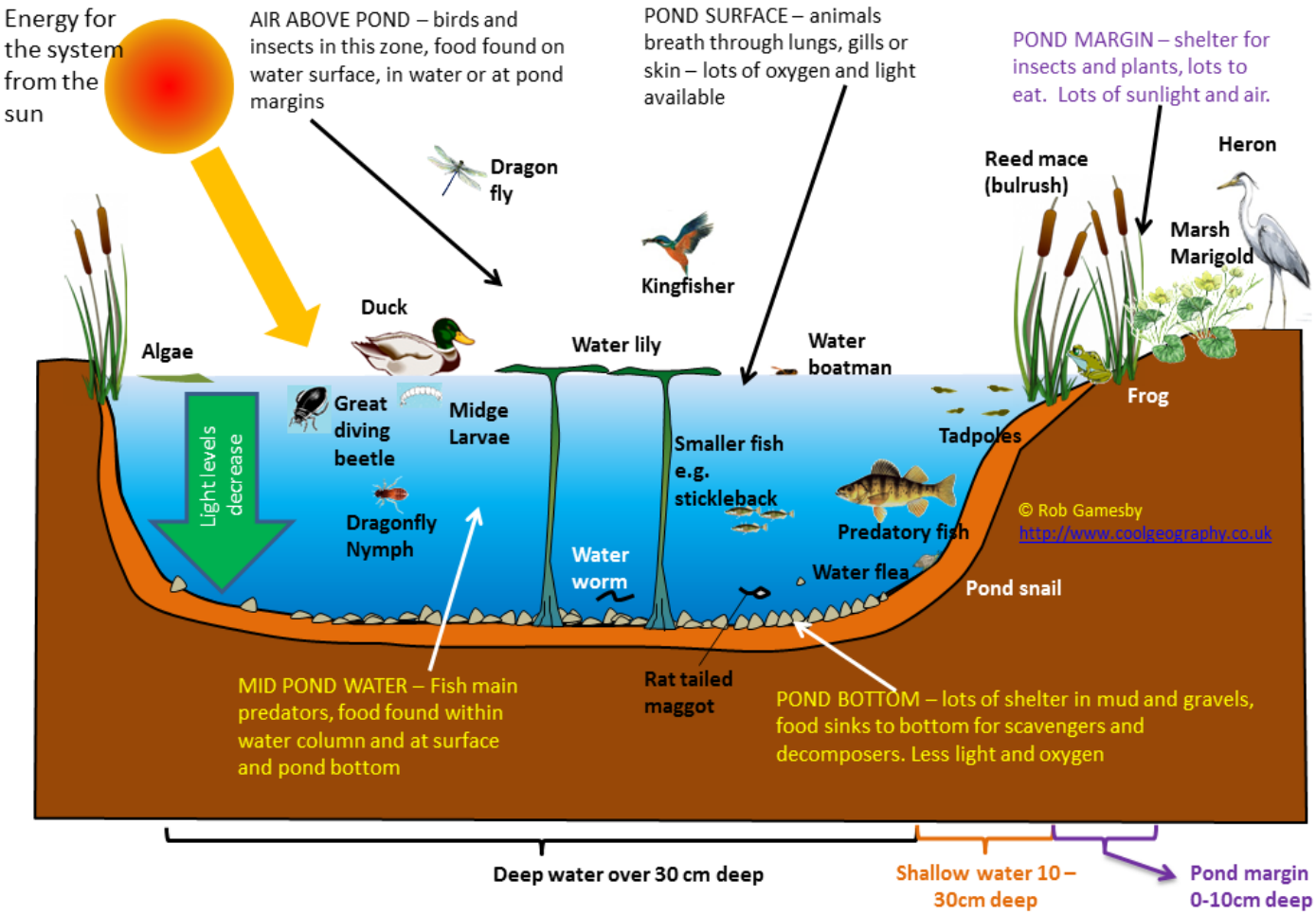

Figure 2 - A freshwater pond ecosystem

Ecosystems therefore have **LINKS** within them as energy flows from one food source to another. There is a clear **TROPHIC PYRAMID** composed of many primary producers, a smaller number of primary consumers, and even smaller number of secondary consumers and a tiny number of tertiary consumers. From this view point the primary producers are very important as the support the whole pyramid.

We can look at the flows in a basic **LINEAR** way along **food chains** – food moves up the line from producer to tertiary consumer.

Figure 3 - Freshwater pond food chain

However, this is too simplistic. Animals might eat many other plants and animals, not have just one source of food. It is better to consider the flows as a **FOOD WEB**; that considers all of the connections between the plants and animals within an ecosystem like a pond.

All ecosystems are also highly reliant upon DECOMPOSERS and SCAVENGERS. These are organisms that break down dead material in an ecosystem and return the nutrients from them into the soil. These nutrients can then be used by other plants for further GROWTH. Decomposers are often bacteria and fungi, but could also be types of insect like dung beetles, worms that we find in compost bins, or the rat tailed maggot found in ponds.

Nutrients then, are the food that plants need for growth, and include Potash, Nitrogen and Potassium. Nutrients can be added from rainwater, weathered out of rocks or recycled by decomposers.

Ecosystems are incredibly VULNERABLE to change. **Invasive species** can out-compete natives, as we have seen with Grey squirrels competing with native British red squirrels.

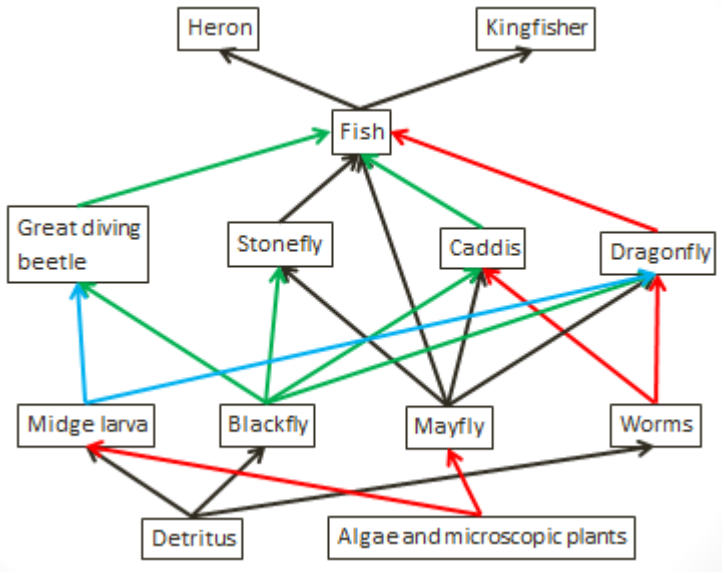

Figure 4 - Freshwater pond food web

Diseases can be introduced and spread which can cause untold damage, as we are seeing with Ash die back in UK ash trees. Within our pond, an increase in the number of water lilies could starve the bottom of the pond of both light and oxygen; this would impact on bottom feeders which would impact upon fish. Similarly, if someone added predatory fish they would eat smaller fish such as Sticklebacks and even small frogs, which would increase the numbers of slugs and flies normally eaten by the frogs.

Pond frog

Frog spawn

Bull rush reeds

Activities 2.1

1. Draw a simple food web for your back garden or a local park.
2. What would happen to the pond ecosystem if insects like rat tailed maggot and great diving Beatles were wiped out?
3. Make a food web out of what you had for dinner last night
4. Should we protect native British species against invasive species? Justify your view.

2.2 The distribution and characteristics of large scale natural global ecosystems.

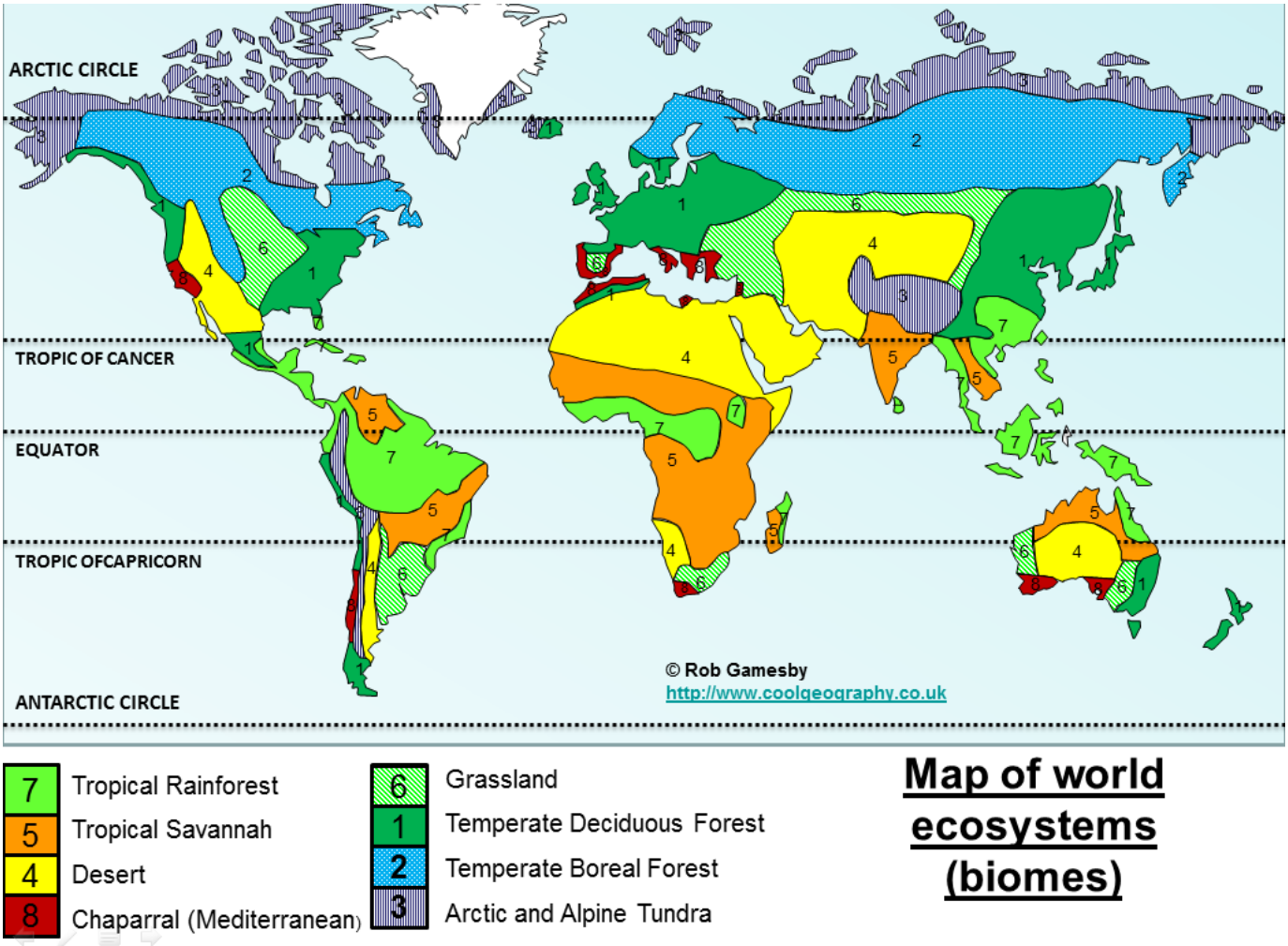

Figure 5 - Map of global biomes

So far we have considered only small scale ecosystems using an example of a pond. However, we must also consider ecosystems at a global scale. These ecosystems are known as **BIOMES**. A biome is a large naturally occurring community of flora (plants) and fauna (animals) occupying a major habitat. The biome is suited to the climate and locality it is placed. Biomes can be spread across continents and although they share similar characteristics, there will be differences in the species of plants and animals that live in those locations. Tropical rainforest in Africa will not be identical to tropical rainforests in Asia for example.

Temperate Deciduous forests

The biome for the UK is a temperate deciduous forest. The word temperate implies that the climate is reasonably stable with not great variation throughout the year. Deciduous forests are those that have trees with broadleaves (e.g. Oak) that are shed in the autumn months. Farming has cleared much of the forest in the UK. Deciduous forests are found in the mid-latitudes which have reasonably evenly spread rainfall throughout the year and winters that are cool but not cold. They are found in Eastern North America, Western Europe and some parts of eastern Asia. They tend to disappear in the interiors of continents as temperatures become more extreme and precipitation levels fall.

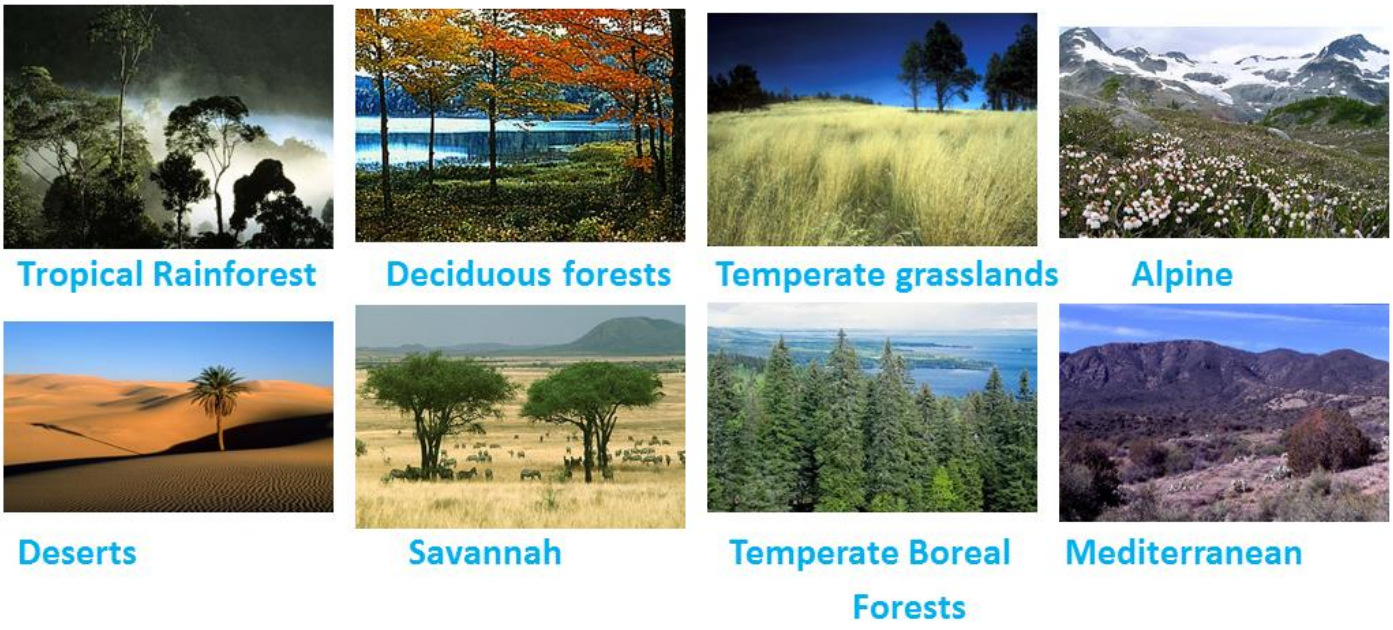

Figure 6 - Types of ecosystem

The major ecosystems can be seen above, and an overview of their major characteristics is outlined below;

- **Tropical Rainforest** – This is a very hot and wet biome located on or around the Equator. These forests are well known for their **Biodiversity** (the **variety** of plant and animal life in the world or in a particular habitat)
- **Tropical Savannah** - A dry and hot area composed of **mainly grassland and scattered shrubs** and isolated trees, which can be found between a tropical rainforest and desert biome in Africa, Arabia and even Australia.
- **Desert** - This biome is **very hot** and also very, very **dry**. Found around 30°N and S of the Equator and includes famous examples such as the Sahara, the Namib and Thar deserts.
- **Chaparral** (Mediterranean – evergreen trees and shrubs in Atlas) – found around the **Mediterranean Sea** and consists of vegetation that can survive drought conditions within the summer months. Includes aromatic shrubs and citrus fruits.
- **Grassland** - rolling terrain of grasses, flowers and herbs. Found mainly in the interior of Europe/Asia and North America. They have been adapted to grow grains such as wheat.
- **Temperate Deciduous Forest** - few extremes of climate and can be found in the eastern half of North America, and the west of Europe. It can also be found in Asia. **The forest has four distinct seasons**.
- **Temperate Boreal Forest** - Also known as the **taiga**, this biome is a northern coniferous (evergreen) forest. Found north of temperate deciduous forests in Canada, Europe, Asia, and the United States
- **Arctic and Alpine Tundra** - covers one-fifth of the land on earth. It is below freezing at night year round and the meaning of its name comes from Lappish language (Lapland) which means “land with no trees”.

Activities 2.2

1. Which ecosystem would you most like to visit and why?
2. Describe the distribution of temperate deciduous forests using the map on the previous page.
3. Explain why temperate deciduous forests are found where they are.

3.3 Tropical rainforests

Tropical rainforests are renowned for their **biodiversity** and are found in a broad belt across the **Equatorial regions** of the Earth. This is shown on figure 7 opposite. They are found in a belt across central and South America, Western parts of central Africa (it is too dry in the east), in parts of Southeast Asia such as Indonesia and even in Northern Australia.

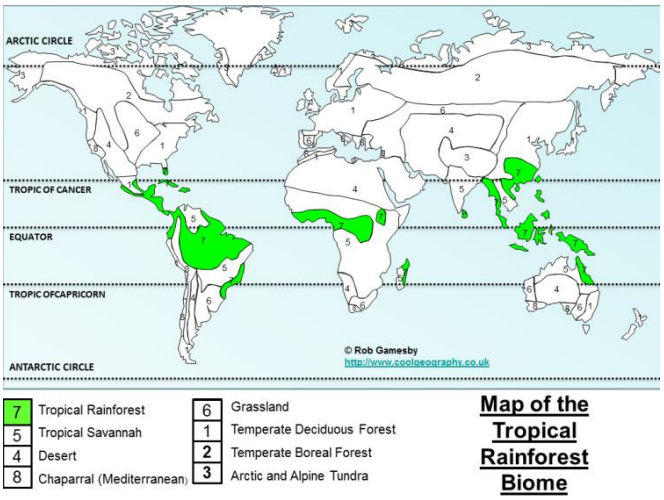

Figure 7 - Map of tropical rainforests

Tropical rainforest ecosystems have a range of distinctive characteristics, mainly physical, that promote their biodiversity. Within four square miles of tropical rainforest, you will find 1500 flowering plant species and 750 types of trees (source).

Factor 1 – Climate

This biome is typified by plentiful rainfall, as its name suggests. Typical tropical rainforests receive over 2000mm of rainfall per year, but the rainfall might not be EVENLY SPREAD. There will be rainfall in each month, but some months are wetter than others as shown on the climate graph for Manaus below.

Temperatures are very even, with most tropical forests averaging 27°C every day with very little variation. These 2 conditions allow for incredible plant growth, allowing a very lush amount of vegetation and of course consumers that feed on the vegetation or primary producers.

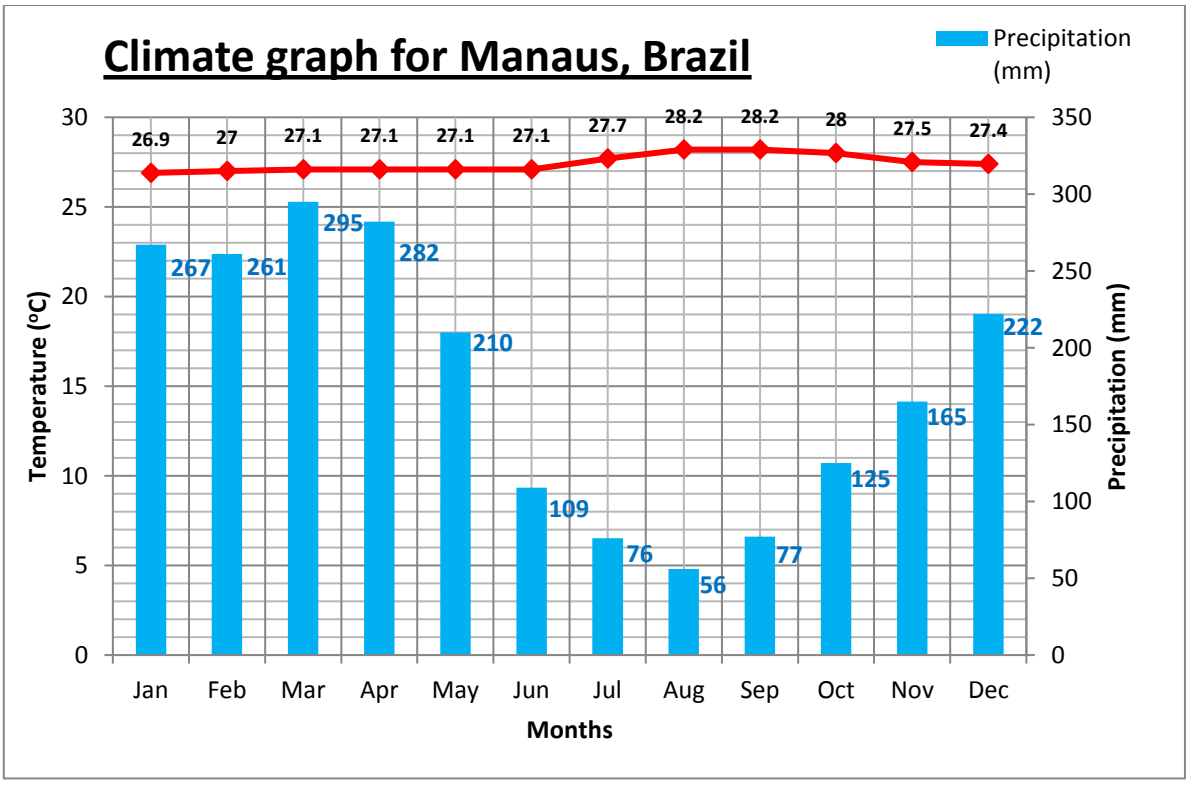

Figure 8 - typical rainforest climate

Factor 2 – soils and nutrients

Figure 9 - Latosol soil

Tropical soils are **very deep**, some of the deepest in the world. This includes the **Latosol**, a typical tropical forest soil. The soils have been underneath tropical rain forests for millions of years and the high rainfall **weathering the rock below** and masses of vegetation allow deep soils to form. Tropical soils can be several metres thick BUT are often **very nutrient poor** as you go down through the soils. This is because the rainwater washes out or **LEACHES the nutrients** and minerals out of the soil. Soils are often red in colour as they are rich in iron.

This leaching means that the lower layers of the soils lack the nutrients and minerals needed by the lush vegetation. It is a huge system of **NUTRIENT CYCLING** that allows the vegetation to grow. This is a good example of the **INTERDEPENDENT** (**where things rely upon each other**) nature of the forest. As vegetation dies it is quickly decomposed by insects, bacteria and fungi. This releases nutrients into the surface of the soil which is taken up quickly by the plants.

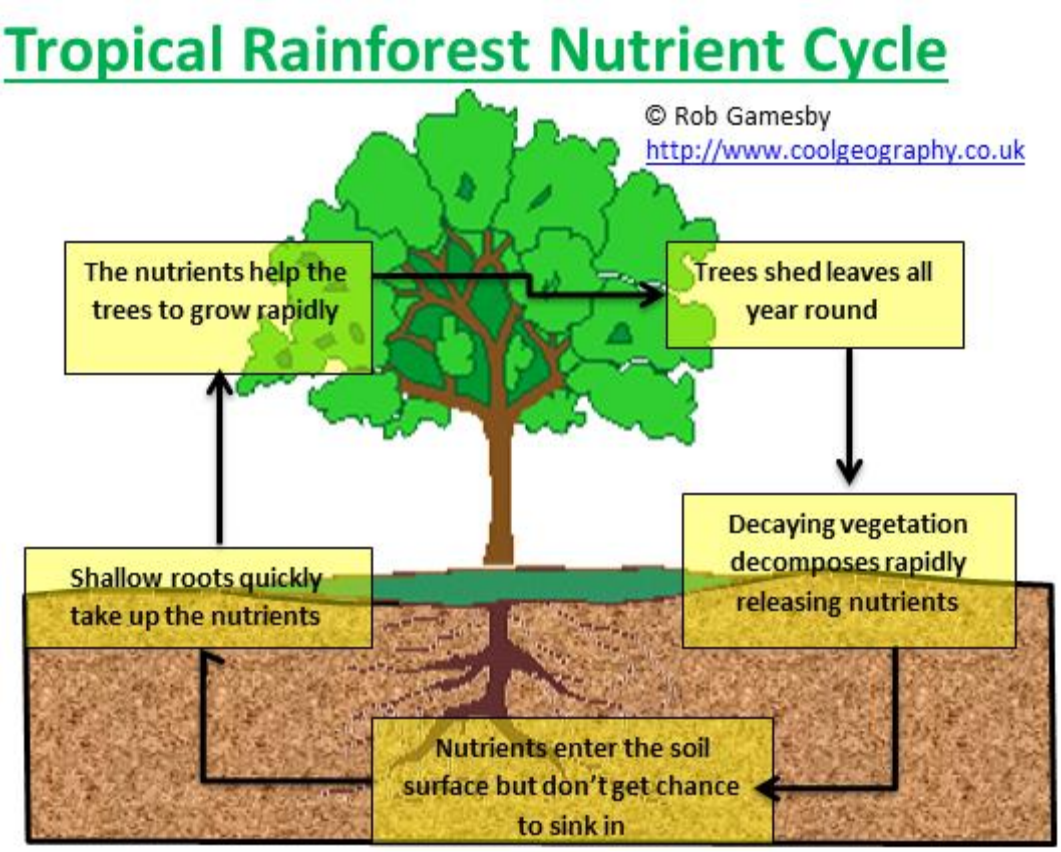

Figure 10 - Tropical rainforest nutrient cycling

Factor 3 – water recycling

Water is also recycled within tropical forests. The roots of plants take up water from the ground and the rain is intercepted (caught and trapped) as it falls – the vast majority of it in the canopy. As the rainforest heats up during the day, the water evaporates into the atmosphere and forms clouds to make the next day's rain. This is convectional rainfall. The forests also protect the soil from being washed away or eroded by the heavy tropical rains.

Factor 4– Stratification (layers) of the forest and adaptations of plants and animals

The tropical rainforests are the most abundant and biologically diverse biomes on Planet Earth. The abundance of sunlight and rainfall allow huge amounts of plant growth via producers such as trees and forest ferns, which in turn allow an abundance of consumers.

Figure 11 - View from an emergent tree in the Peruvian Amazon

The forest is packed full of plants and it is a genuine **competition** between plants for light and space. The rainforest is **layered or stratified**, as plants try to take advantage of what space and light there is. The tallest layer contains **emergent trees**, such as the Capoc tree, which grow tall to maximise the amount of sunlight that they can receive.

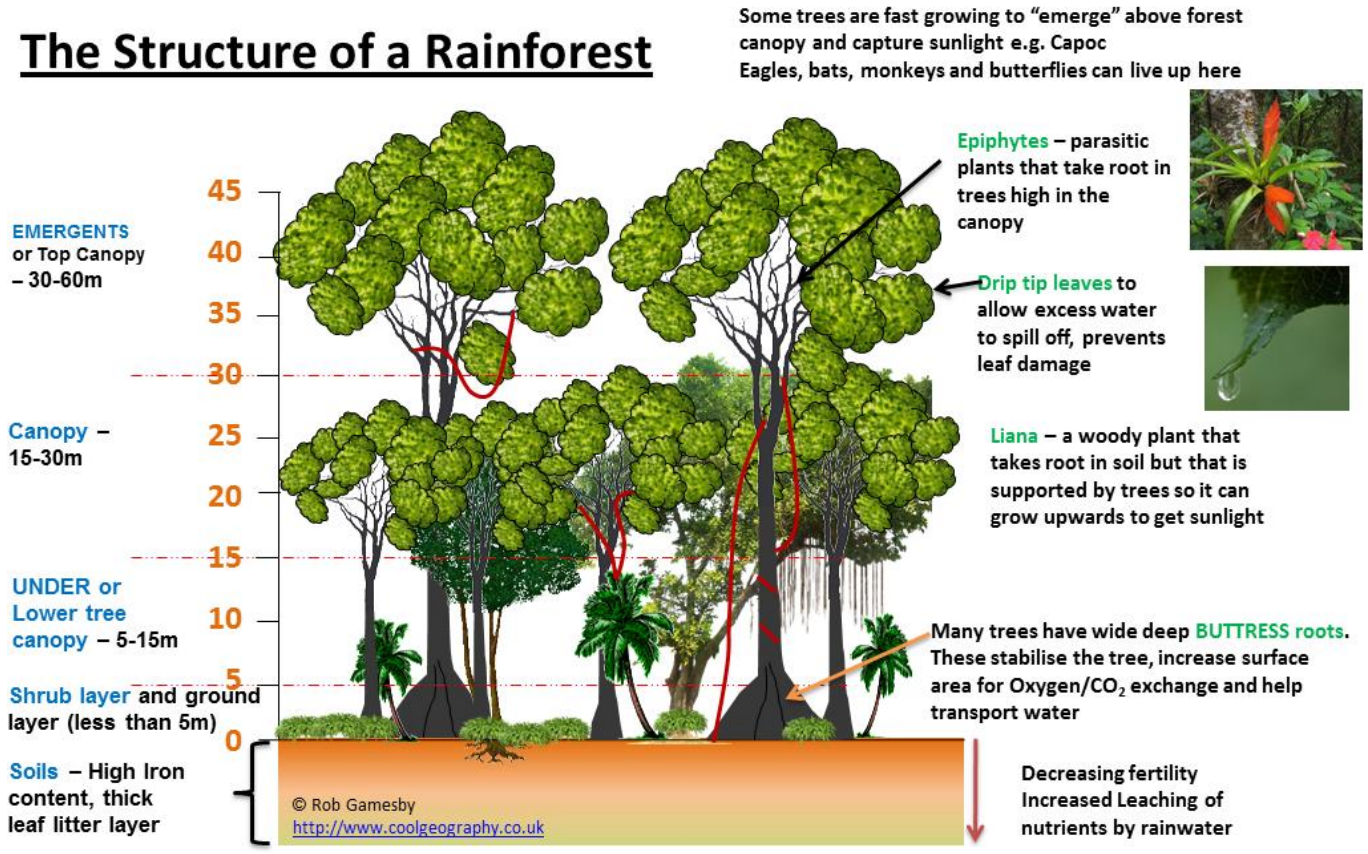

Figure 12 - the structure of a Tropical Rainforest

Just below this layer is a near continuous layer of **Canopy trees**. Again these trees have grown very tall to enable them to access sunlight for photosynthesis. Most animals are found in the canopy where there is maximum light (monkeys are well adapted to living in trees) and where they can access food in the form of fruits and nuts, and be safer from predators on the forest floor. There are still predators in the forest canopy however such as pythons and eagles. Many of the trees have leaves with flexible bases that turn to face the sun. They also have huge **Buttress**

Figure 13 - a buttress root

roots to anchor these tall trees into the soil and prevent falling during high winds. Bark can often be smooth too, to allow water to flow easily down the tree. Some leaves have a tapered point, a drip tip, which stops water accumulating on the leave and damaging it.

Beneath this layer is the **under canopy** of smaller trees just waiting for an opportunity (such as a canopy tree dying) to grow up and occupy a place in the canopy. The lowest layer is the **shrub and ground layer**. Here the plants have to cope with low levels of sunlight as much is absorbed in the canopy above. Ferns grow here and have large leaf sizes to maximise the energy they can capture from the sunlight. Animals such as tapir and deer live on the forest floor eating seeds and berries. There are anteaters here too, plus an abundance of decomposers and insects.

Figure 14 - fungi and leaf litter on the forest floor

Within the layers there are also **epiphytes**, which live on the branches and joints of trees and obtain their nutrients from the water and air rather than soil. These plants are therefore parasites. There are also **lianas**, these are wooden plants that take root in the ground and creep up trees to the canopy where they have their leaves and flowers. Rattan, a liana, is well known for its use in furniture and ropes. Rattan also produces large, edible fruits—a favourite of primates.

Factor 5 – competition and interdependence

Just like our pond ecosystem tropical rainforests have competition for resources and sunlight. Many of the animals and plants are in competition with one another and in many cases they are also reliant upon one another. Changes in one part of the ecosystem, either the living or non-living, could be very damaging for this ecosystem. The loss of some tree cover to deforestation or fire would affect both the water and nutrient cycles for example, and cause soil erosion, increased loss of nutrients from the soils via leaching and extra flooding.

Figure 15 - Tropical rainforest food web

Similarly, if one of the elements of the tropical forest food web, shown opposite, were to change, there would be knock on impacts throughout that food web.

Factor 6 - people.

Some indigenous groups of people such as the Kayapo in Brazil have lived for generations in harmony with the forests. These groups are using the forests to meet their needs for food, water and shelter. However, increasing pressures and damage is being done to the forest because of human activity. Activities such as subsistence and commercial farming, logging, road building, mineral extraction, energy development, settlement, and population growth are all having a major impact as you will see in our case study of a tropical rainforest – the Amazon.

Activities 2.3

1. Make a mind map of all 6 of the factors that affect tropical forests
2. What would happen to the nutrient cycle if tropical trees are cut down?
3. Rank the six factors that affect tropical forests in an order of importance from 1 to 6. Justify your ranking.

2.4 Deforestation has economic and environmental impacts.

Key words

- **Biodiversity** – The variety of life in the world or a particular habitat.
- **Deforestation** – The chopping down and removal of trees to clear an area of forest.
- **Logging** – The business of cutting down trees and transporting the logs to sawmills.

The **clearing of trees** in tropical rainforest areas has huge environmental impacts. Scientists are very concerned about the **loss of biodiversity** from such clearances. Even though topical forests cover only twelve percent of the land area of the Earth, they are home to between 50 and 90 percent of the world's species. It is thought that **we lose one species a day** because of deforestation. This is bad, because we are losing a **genetic resource** and **potential medicines** and technologies. Rainforests are a vital source of medicines. It is thought that roughly a quarter of all modern medicines came originally from rainforests, many originally used by indigenous people. An example includes **Reserpine**, a drug which can be used to treat people with high blood pressure.

There are many **economic positives** of developing rainforests. **Improving transportation** through the forest means easier access to raw materials like minerals and timber. Forest resources can then be transported away and sold, especially when roads are paved. This has happened in Brazil through the Trans Amazonian Highway. Deforestation of tropical hardwoods such as ebony and mahogany can be sold for a good price abroad. This logging of hardwoods also paves the way for **agriculture**. These large scale farms bring money into the country and provide food and jobs for the country's growing population. However, the profits from such large-scale farming and selling resources often go to large companies who set up in the rainforest. Small scale farmers can also lose out. Finally, tropical rainforests often have **Mineral Deposits** including bauxite, iron ore, manganese, gold, silver and diamonds. These can be exploited and sold. The money from exploiting resources can then be used to improve hospitals and education.

Figure 16 - slash and burn agriculture in the Peruvian Amazon

However, deforestation affects the **environment**. All of the land clearances mentioned above remove forest cover. If the forest is allowed to recover, which it rarely is, the forest is rarely as it was before. Hardwood trees take many years to grow so can be difficult to replace for example. **Soils are damaged** as the nutrient cycle is destroyed, whilst soils are also exposed to rainfall so get eroded and that clogs up rivers with sediment. The loss of forest cover also **affects the water cycle** in terms of evaporation, flooding and precipitation. Animal habitat is also lost when trees are cut down. If **indigenous people** are viewed as part of the environment they are also affected. Their numbers have declined and today the Brazilian census reveals that there are 817,000 indigenous peoples.

Activities 2.4

1. List as many environmental and economic impacts of tropical rainforest clearance as possible
2. Describe the damage done by slash and burn agriculture as shown in the photograph opposite

2.5 Changing rates of deforestation.

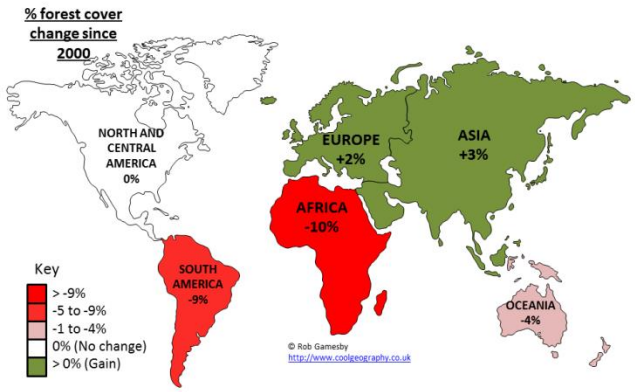

Figure 17 - Changing rates of deforestation

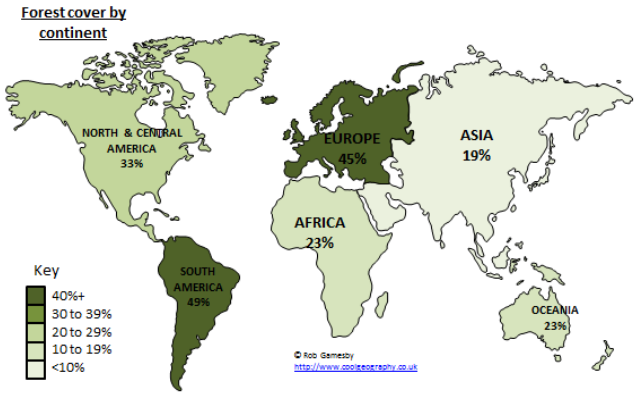

Figure 18 - % of forest cover around the globe

As can be seen above the main continents where tropical forests can be found are those that are experiencing the loss of tropical rainforest cover. Forests are being lost across South America, Africa and Oceania. Locations with temperate forests like the UK, having experienced centuries of deforestation, are now afforesting and expanding their forest cover.

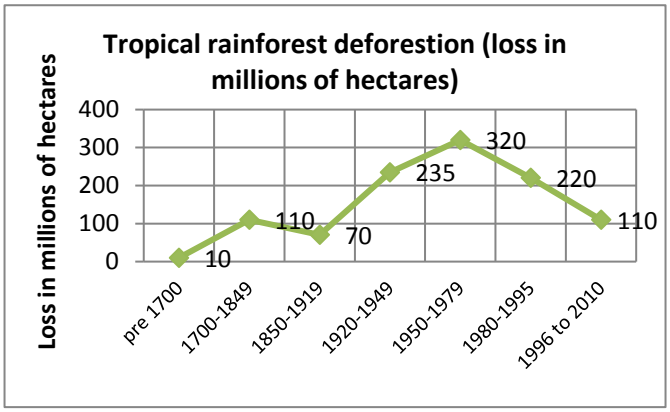

Figure 19 - Tropical rainforest deforestation over time

Over the past 3 centuries rates of tropical rainforest deforestation have been variable. As can be seen on figure 19 **deforestation increased from 1700 to 1979** in tropical areas, and although deforestation is still occurring, the AMOUNT of deforestation is in decline.

In addition, in many countries there is less deforestation happening as shown on figure 20. However, **in some tropical countries the rate of deforestation is increasing rapidly** as those countries use their forest resources. Indonesia has seen the greatest increase, as they replace forests with palm oil plantations. This has threatened the Orang-utan.

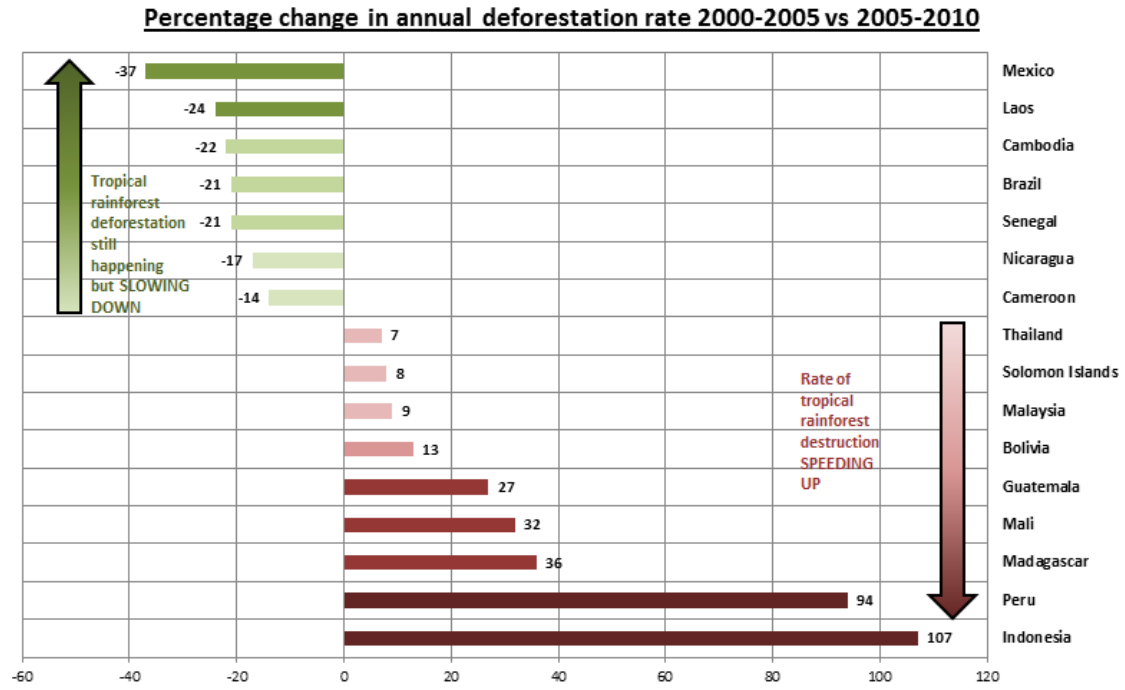

Figure 20 - change in deforestation rates for selected tropical countries

2.6 The Amazon - A case study of a tropical rainforest.

The Amazon is the largest tropical rainforest on Earth. It sits within the Amazon River basin, covers some 40% of the South American continent and as you can see on the map (figure 21) includes parts of eight South American countries: Brazil, Bolivia, Peru, Ecuador, Colombia, Venezuela, Guyana, and Suriname. The actual word "Amazon" comes from river.

Amazing Amazon facts;

- It is home to 1000 species of bird and 60,000 species of plants
- 10 million species of insects live in the Amazon
- It is home to 20 million people, who use the wood, cut down trees for farms and for cattle.
- It covers 2.1 million square miles of land

- The Amazon is home to almost 20% of species on Earth
- The **UK and Ireland** would fit into the Amazon **17 times**!

Figure 21 - the Amazon rainforest within the Amazon River basin

The Amazon caught the public's attention in the 1980s when a series of shocking news reports said that an area of rainforest the size of Belgium was being cut down and subsequently burnt every year. This deforestation has continued to the present day according to the Sao Paulo Space Research Centre. In 2005 they had lost 17% of Amazon rainforest or 650000 square kilometres. Their satellite data is also showing increased deforestation in parts of the Amazon.

The process of deforestation

The Amazon helps a Newly Emerging Economy (NEE), Brazil, to make money. They build roads into the forest, logging firms then go in and take out valuable hard woods such as mahogany and cedar, worth thousands of pounds in richer economies like Europe. Then farmers, often cattle ranchers from big companies, burn the rest to make way for cattle pasture. 75% of cleared areas are used in this way. This is clearly shown on the map on figure 22 in red. Many of the deforested areas follow roads and branch off from there. Deforestation is also worse in the South and South East of the Amazon basin, closer to major centres of population in Brazil.

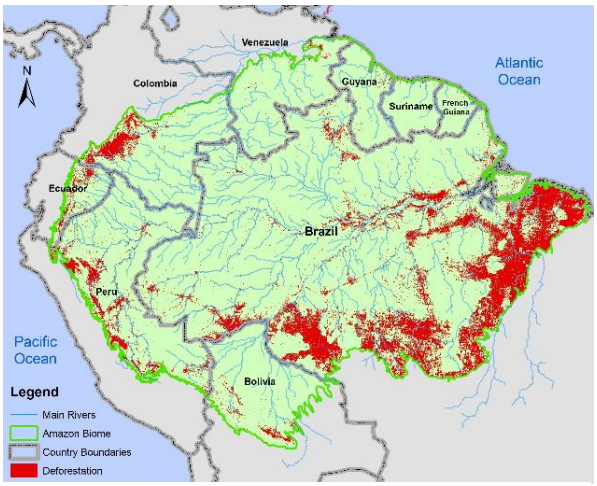

Figure 22 - Map of deforestation in the Amazon © WWF http://wwf.panda.org/wwf_news/?208511/Keeping-an-eye-on-deforestation

The causes of deforestation

1. **Subsistence and commercial farming** – subsistence farming is where poor farmers occupy plots of the forest to grow food to feed themselves and their families. They clear forest and then burn it, hence the name **slash and burn**. They grow crops until the soil is exhausted and then move on. This contributes to deforestation but not as much as commercial farming (Farming to sell produce for a profit to retailers or food processing companies). The Brazilian region of Mato Grosso was affected by deforestation in the 1980s and 1990s. 43% of rainforest losses were in this region, and area almost ½ the size of France. It has been replaced by fields

for grain and cattle. This has allowed Brazil to overtake Australia as the largest exporter of beef in the world. The land is also flat and easy to farm. It also has high temperatures and lots of rainfall.

2. **Logging** – This involves cutting down trees for sale as timber or pulp. The timber is used to build homes, furniture, etc. and the pulp is used to make paper and paper products. Logging can be either selective or clear cutting. **Selective logging** is selective because loggers choose only wood that is highly valued, such as mahogany. **Clear-cutting** is not selective. Loggers are interested in all types of wood and therefore cut all of the trees down, thus clearing the forest, hence the name- clear-cutting.
3. **Road building** – trees are also cleared for roads. Roads are an essential way for the Brazilian government to allow development of the Amazon rainforest. However, unless they are paved many of the roads are unusable during the wettest periods of the year. The Trans Amazonian Highway has already opened up large parts of the forest and now a new road is going to be paved, the BR163 is a road that runs 1700km from Cuiaba to Santarem. The government planned to tarmac it making it a superhighway. This would make the untouched forest along the route more accessible and under threat from development.

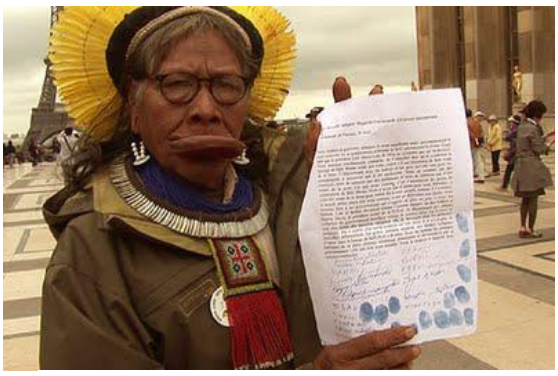

Figure 24 - Chief Raoni in Paris with his petition against Belo Monte Dam.

4. **Mineral extraction** – forests are also cleared to make way for huge mines. The Brazilian part of the Amazon has mines that extract iron, manganese, nickel, tin, bauxite, beryllium, copper, lead, tungsten, zinc and gold!
5. **Energy development** – This has focussed mainly on using Hydro Electric Power, and there are 150 new dams planned for the Amazon alone. The dams create electricity as water is passed through huge pipes within them, where it turns a turbine which helps to generate the electricity. The power in the Amazon is often used for mining. Dams displace many people and the reservoirs they create flood large area of land, which would previously have been forest. They also alter the hydrological cycle and trap huge quantities of sediment behind them. The huge **Belo Monte dam** started operating in April 2016 and will generate over 11,000 Mw of power. A new scheme the 8,000-megawatt **São Luiz do Tapajós** dam has been held up because of the concerns over the impacts on the local **Munduruku people**.

Figure 23 the Belo Monte dam site under construction, copyright http://philclarkehill.co.uk/blog/2014/06/ Used with the kind permission of Phil Clarke-Hill

6. **Settlement & population growth** – populations are growing within the Amazon forest and along with them settlements. Many people are migrating to the forest looking for work associated with the natural wealth of this environment. Settlements like Parauapebas, an iron ore mining town, have grown rapidly, destroying forest and replacing it with a swath of shanty towns. The population has grown from 154,000 in 2010 to

220,000 in 2012. The Brazilian Amazon's population grew by a massive 23% between 2000 and 2010, 11% above the national average.

Impacts of deforestation – economic development, soil erosion, contribution to climate change.

- Every time forest is cleared species are lost – so we lose **BIODIVERSITY**
- **Climate Change** - Burning the forest releases greenhouse gasses like CO_2. This contributes to the warming of our planet via climate change and global warming. In addition, the loss of trees prevents CO_2 being absorbed, making the problem worse. The Amazon also helps to drive the global atmospheric system. There is a lot of rainfall there and changes to the Amazon could disrupt the global system.
- **Economic development** – Brazil has used the forests as a way to develop their country. The forest has many natural riches that can be exploited. In addition, Brazil has huge foreign debt and lots of poor people to feed, so they want to develop the forest. May Brazilians see deforestation as a way to help develop their country and improve people's standard of living.
- **Soil erosion** - the soils of the Amazon forest are not fertile and are quickly exhausted once the forest is cleared. The farmers now artificially fertilise the soil when in the past the nutrient cycle would have done this naturally. In addition, the lack of forest cover means that soils are exposed to the rainfall. This washes huge amounts of soil into rivers in the process of soil erosion.

Activities 2.6

1. Define the term deforestation
2. Make a list of 4 patterns happening in terms of deforestation
3. Rank the 6 causes of deforestation in terms of the amount of damage they do. Justify your ranking
4. Rank the 6 causes of deforestation in terms of the economic importance to Brazil. Justify your ranking
5. Should Brazil develop and deforest parts of the Amazon?

2.7 Tropical rainforests need to be managed to be sustainable.

Sustainable uses of the rainforest are uses that allow **current generations to make a living** from the forest **without damaging** the forest for **future generations** to use. It is clear that many of the current uses of the forest just destroy it, with massive long term impacts. However, the countries and people of rainforests need to make a living, and sustainable uses of forests offer them a way to do just that**.**

Key Words

- **Debt reduction** – Countries are relieved of some of their debt in return for protecting their rainforests.
- **Ecotourism** – Responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and may involve education. It is usually carried out in small groups and has minimal impact on the local ecosystem.
- **Selective logging** – The cutting out of trees that are mature or inferior to encourage the growth of the remaining trees in a forest or wood.
- **Sustainability** – Actions and forms of progress that meet the needs of the present without reducing the ability of future generations to meet their needs.

Selective logging and replanting,

Selective logging is selective because loggers choose only wood that is highly valued, such as mahogany. **Clear-cutting** is not selective. Selective logging is more sustainable than clear-cutting because other trees and plants do survive in the logging process and over time can allow the forest to recover. However, it does have major drawbacks. Although single trees are felled because they are valuable, other trees can be damaged in the process. This is because a felled tree can damage other trees as it falls to the ground once felled. Also, loggers need to access the wood, so have to clear come forest to make way for machinery.

Ecotourism, conservation and education

Conservation is all about the protection, preservation, management, or restoration of tropical forests and the **ecological** communities that inhabit them. In this case **conservation** would seek to manage human use of natural resources in tropical rainforests for sustainable social and economic uses. This includes the Amazon Region Protected Areas Program (ARPA), where the WWF work with the Brazilian government to protect parks covering 150million acres of forest.

Another sustainable use is the development of **ecotourism**. Ecotourism is environmentally friendly tourism where;

- the people involved seek to protect the environment as much as possible
- there is education of the visitor
- some of the profits go back into conserving the rainforest environment
- the tourism is small scale with low visitor densities
- local people are employed and involved

There is an ecotourism lodge (**figures 25 and 26**) where tours of the Amazon forest take place. The tourist stay in wooden huts, there is limited electricity, waste is dealt with on site and the food is sourced locally. All of the tour guides are local.

Figure 25 - an ecotourism lodge close to Puerto Maldonado, in the Peruvian Amazon

Figure 26 - a tour guide in the Amazon rainforest

International agreements about the use of tropical hardwoods

There are also international agreements on the uses of tropical hardwoods and logging. The **International Tropical Timber Agreement** was set up in 2006 to "promote the expansion and diversification of international trade in tropical timber from sustainably managed and legally harvested forests and to promote the sustainable management of tropical timber producing forests".

71 countries have signed up to the agreement sponsored by the United Nations.

Debt reduction.

The rainforests are often found in poorer countries that want to exploit them. Debt reduction or **conservation swaps** offer an alternative to poorer countries to the reckless exploitation of their natural wealth.

These swaps basically see poorer countries have portions of their debts wiped out or paid for by richer nations or charities of richer nations in exchange for promising to protect or **CONSERVE** large parts of their natural environment. This has **large scale global effects**, by protecting the atmosphere and the hydrosphere. In 1984 the World Wildlife Fund came up with the idea of conservation swaps and in 1987 the first was launched in partnership between the Government of Bolivia and Conservation International (CI) for US$ 650000 which protected 3 natural areas. Many countries have since followed, including the Philippines, Sudan, Zambia, Ecuador and Uganda.

Activities 2.7

1. Is current use of tropical forests sustainable?
2. Pick one of the methods to sustainably use the forest. Describe how it works and explain its advantages.
3. Design a plan to help save the tropical rainforest.

2.8 Hot desert ecosystems have a range of distinctive characteristics.

A **hot desert** is a part of the world that has **high average temperatures and very low precipitation**. These areas need to have **less than 250mm of rainfall** per year to be classified as a desert. The stereotypical view of a desert is one totally devoid of life and rolling sand dunes, but deserts do support life and the plants and animals that live in the deserts around the world have adapted to cope with the extreme climate.

As you can see on the map, hot deserts are found on nearly every continent, from the Atacama Desert in South America, the Chihuahuan Desert in North America, the great Sahara in Africa, the Thar Desert in Asia and the Great Sandy Desert in Australia. Although very different they do have common characteristics.

Figure 27 - The Thar Desert in Rajasthan

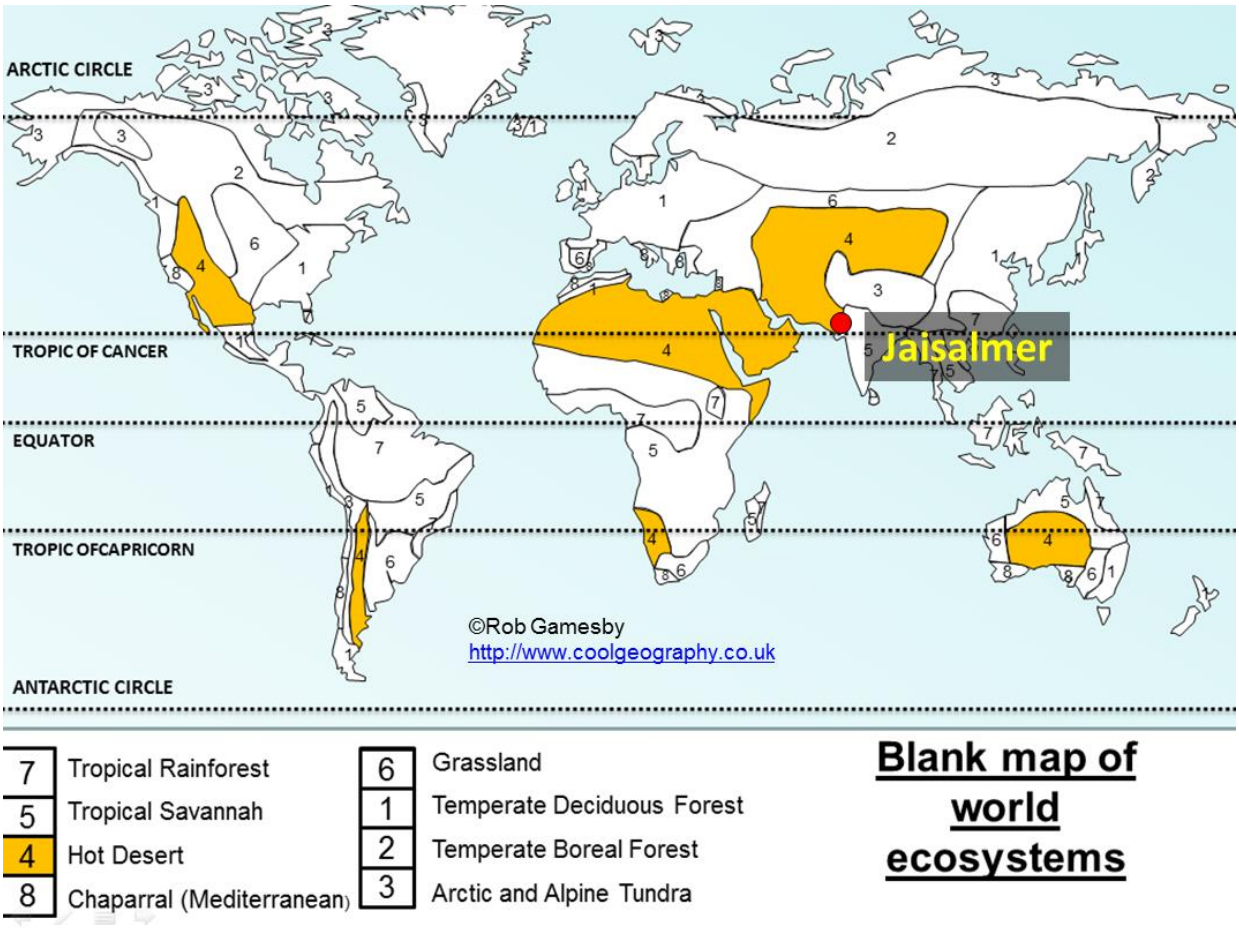

Figure 28 - Location of the hot desert biome

The physical characteristics of hot deserts.

The climate graph reveals the climate for Jaisalmer, located on figure 29 in the Thar Desert in Rajasthan. The desert is very dry and often hot. As can be seen there are many months when the average temperature is well above 30°C and day time temperatures can top 50°C!

You can also see that annual rainfall averages **less than 250mm per year**, and that rain often comes all at the same time. This poses big problems for plants, animals and people that live there. The rest of the year is **very dry**. There is a lot of direct sunlight shining on the plants. The soil is often sandy or rocky and unable to hold much water. Winds are often strong, and dry out plants. In the Thar Desert the **Loo wind** blows from south west to north east and can kill people who are exposed to it through heat stroke.

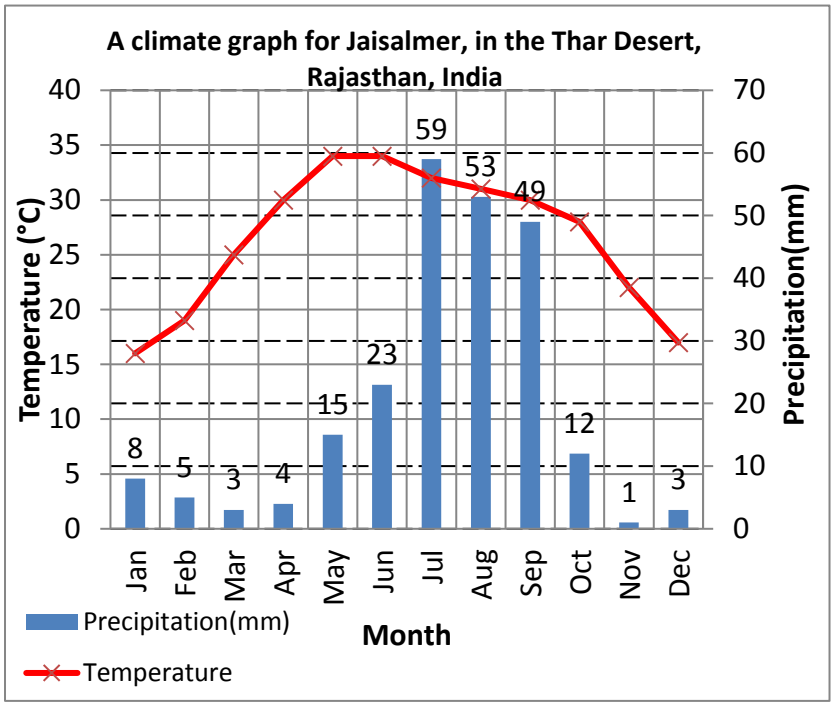

Figure 29 - climate graph for a typical hot desert environment, Jaisalmer, Rajasthan

The interdependence of desert climate, water, soils, plants, animals and people.

The living things that inhabit hot deserts are linked to each other and their physical environment. Many of the elements of the biome are interdependent upon one another. People are dependent upon their animals in deserts, for food, milk and as use as pack animals. For example, the Beja people use camels in North East Africa through Sudan, Egypt and the Sahara Desert.

As can be seen in figure 30, while plants rely upon soils for their nutrients, the soils rely upon plants to provide extra nutrients through dead vegetation and fixing chemicals from the air into the soil. Plants also help soils retain more water, by providing shade from the searing desert sunlight. Plants also tie the soil together, preventing soil erosion and excessive leaching of nutrients in wetter periods. Oases exist in low points in the desert, where water can be found closer to the surface and some agriculture is possible.

Just as in other biomes, food webs also exist. A hawk might prey upon a desert lizard or snake, which in turn feeds upon rats or insects, which feed upon desert plants such as cacti or annual grasses or flowers.

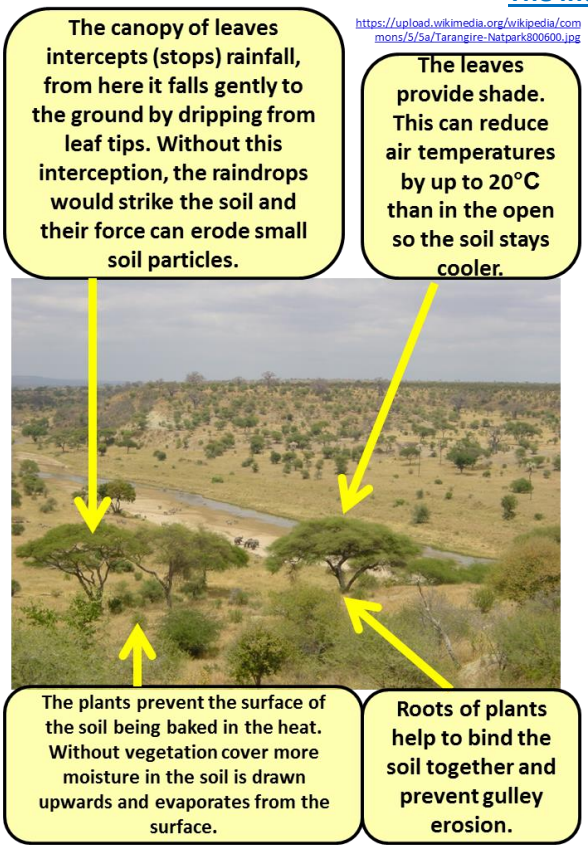

Figure 30 - Interdependence of soils and plants in deserts

2.9 How plants and animals adapt to the physical conditions.

The extreme nature of desert environments means that plants and animals must adapt to survive. Plants and animals are regularly exposed to extreme temperatures and drought conditions. They must also cope with extensive water loss.

Figure 31 – Desert Cactus by Imartin6 (Own work) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons

Desert Plant Adaptations

- **No leaves or small seasonal leaves** that only grow after it rains - this helps reduce water loss during photosynthesis. These plants conduct photosynthesis in their green stems.
- Plants can store water in their stems or leaves, these are called **succulents**;
- Many plants have **long root systems** that spread out wide or go deep into the ground to absorb water;
- **Short life cycles** - some plants germinate in response to rain, grow, flower, and die within one year. These plants can therefore avoid drought.
- **Leaves with hair** - these help shade the plant, reducing water loss. Other plants have leaves that turn throughout the day to expose a minimum surface area to the heat.
- **Spines** to discourage animals from eating plants for water;
- **Waxy coating on stems and leaves** - this helps to reduce water loss.
- Many plants are slower growing – this requires less energy. The plants don't have to make as much food and therefore do not lose as much water.

The cactus shown on figure 31 is well adapted for survival in the desert. They have many of the features listed above.

Desert animal adaptations

Animals also have to cope in the desert, using adaptations such as being **nocturnal** or living under ground to survive.

Figure 32 - A camel in the Thar Desert

Camels often live in deserts that are hot and dry during the day, coping with wind-blown sand and cold at night. They are well adapted for survival in the desert. Camels have:

- **Thick fur** on the top of the body for shade, and thin fur elsewhere to allow easy heat loss.
- Large surface area to volume ratio which maximises heat loss.
- **Large, flat feet** to spread their weight on the sand.
- The ability to go for a long time without water - they **lose very little through urination and sweating.**
- A fatty hump which provides energy in times of food shortages (they don't store water in their humps).
- The ability to tolerate body temperatures up to 42°C.
- Slit-like nostrils and two rows of eyelashes to help keep the sand out of their eyes.

Development of hot desert environments creates opportunities and challenges.

2.10 A case study of a hot desert - the Thar Desert

The Thar Desert is the world's seventh largest desert. It is a hostile environment that lies to the west of New Delhi and includes the deserts that cover portions of the Indian states of Gujarat, Punjab and Rajasthan, as well as the Punjab and Sind in Pakistan. Indeed, the desert straddles the border between India and Pakistan and covers over 200,000km^2. On its western margin lies the mighty **Indus River**.

The Thar Desert is not empty of human or plant life, it has some trees and animal life, and it has been colonised for a long time. It is known as the land of death, but hosts a variety of life. It is the most populated desert in the world with nearly 30 million people and is also the most densely populated with 83 people per km^2, it is known as the "**teeming**" desert. It is an environment with many **opportunities and challenges to development**.

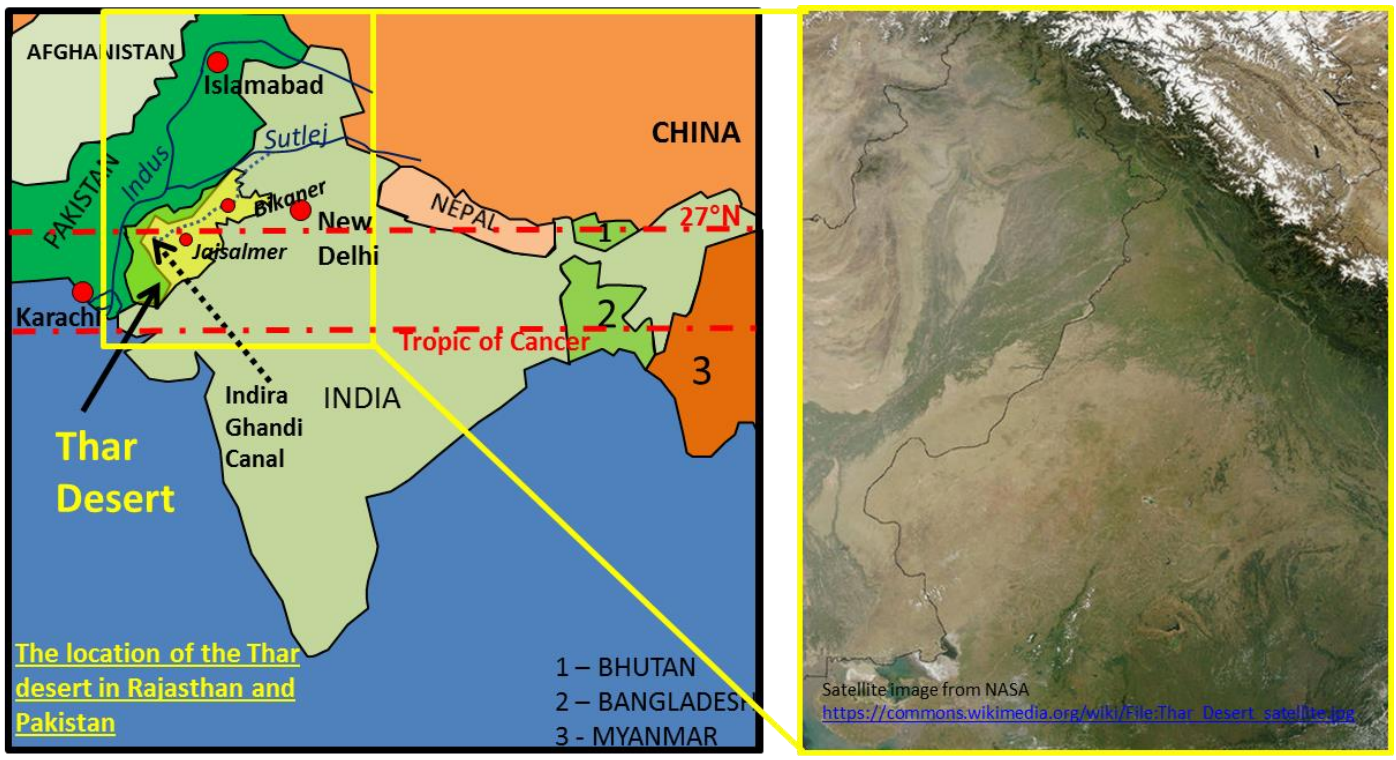

Figure 33 - the location of the Thar Desert

Development opportunities in hot desert environments:

Tourism

Jaisalmer is a desert city that has stood the test of time for nearly a thousand years. It sits on an ancient trading highway between east and west, on the silk and spice routes. The population has waxed and waned with changes in trade and drought. Recent times have seen the population grow by a third, as its booming tourist industry sucks people in. More than 600,000 people now call the area home. The city is struggling to keep up, especially in terms of water use. The fort gives the town its name, the golden city. The demand for water into the fort has gone up 12 fold, and the waste water passes under the foundations

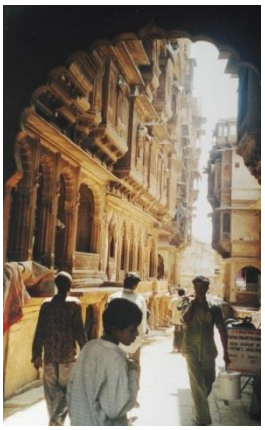

Figure 34 Jaisalmer city

and undermines them. The walls are subsiding and crumbling. People are coming as tourists because of its large fort, the history of the Maharajahs and because Jaisalmer is often used as a base to explore the nearby desert, in jeeps or by camel safari.

Even the fort is struggling due to increased tourism. Originally the fort relied upon wells, but water was piped in in the 1970s. They failed to put in proper drainage with the water and it is now at risk of collapsing in parts. Many tourist hotels are in the fort and this adds to the problem.

Subsistence farming

Figure 35 - A subsistence farming village in Rajasthan, the Thar Desert

Many of the people who live in the Thar Desert are involved in **farming**, but this is tough. The landscape has creeping dunes, harsh winds, searing summer temperatures and devastating droughts.

To combat this many of the people are **subsistence farmers**, farming enough food for themselves and their families with little for sale. There are depressions between the sand dunes that act as mini drainage basins. When it does rain the water collects at the bottom of these depressions and allows desert grasses to grow. This allows the animals to graze and people to live here in small settlements like **Pithorai**. People survive here by herding goats and women play an integral role in village life whilst the men are away with the animals. They have to fetch water twice a day. The houses are small and dark inside to keep cool in summer and warm in winter. The way of life is self-sufficient and the goats provide milk for the villagers. The women cook with butter milk as it saves water; similarly they do the washing up with sand! The women also have to collect firewood. Another group of farmers, the Raikas, are subsistence farmers who look after camels.

Commercial farming

The desert biome is under threat from **commercial farming**. A huge canal has been constructed from the River Sutlej across the desert. Initially it was 143km long but was extended as the **Indira Ghandi canal**. This brings water to major cities such as Bikaner and Jaisalmer, but also water to irrigate the land. The desert area now produces crops like cotton and wheat, which can grow in these areas with the additional water. The land is being fenced off and used for more intensive agriculture. Sprinkler systems are **irrigating** fields once grazed by animals.

Figure 36 Commercial farming in the Thar Desert

Mineral Extraction

Mineral extraction is the **removal of solid mineral resources** from the earth. In Rajasthan these resources include limestone and gypsum (for making plaster) are found in this desert - and are valuable for the building industry.

Figure 37 - Wind turbines, By Ashwin Kumar, via Wikimedia commons

Energy use

The desert is also used to generate energy. Close to Jaisalmer is the largest wind turbine farm in India. It consists of 75 wind turbines with a total capacity of 60 MW. The project provides renewable electricity to the Northern regional electricity grid. There are also plans to develop a huge solar farm across large parts of the desert.

Despite all of the opportunities the Thar Desert still poses huge challenges in terms of developing a hot desert environment. The extreme temperatures seen on figure 29, poor water supply in parts of the desert, and inaccessibility in more remote regions all threaten the lives and well-being of the people who live there.

Activities 2.10

1. Describe the location of the Thar Desert
2. Explain why the Thar desert is a difficult place to live
3. Outline 2 ways that plants can adapt to live in desert environments
4. Produce a table on the ways in which the Thar desert is used;

Land use	Description	Positives	Negatives

5. Is the Thar Desert under threat from development? Justify your view.

2.11 Areas on the fringe of hot deserts are at risk of desertification.

The causes of desertification

Desertification is the **process by which land becomes drier and degraded**, as a result of climate change or human activities, or both.

It is caused by a mixture of climate change and the issues raised by population pressure. As population increases they increase the numbers of animals they keep, such as goats, which eat more vegetation. They also farm the land more intensively, which extracts nutrients and removes the natural vegetation. People also collect more firewood to keep warm at night or for cooking. In addition, Climate change is making temperatures hotter and rainfall less reliable and more variable. All of these things reduce the amount of natural vegetation. There are no plants or leaves to intercept rain and soil is left exposed to hot sun so the sun bakes the soil and it cracks. When it rains, the rainwater runs over the surface of the soil rather than soaking in which means that soil can often be washed away. This means that the soil is degraded; losing fertility and structure. This completes the cycle, as even less vegetation can be supported and the environment declines further.

Key words

- **Intermediate technology (or appropriate technology)** – Technology that is suited to the needs, skills, knowledge and wealth of local people in the environment which they live.
- **Over-cultivation** – Exhausting the soil by over-cropping the land.
- **Overgrazing** – Grazing too many livestock for too long on the land, so it is unable to recover its vegetation.
- **Soil erosion** – Removal of topsoil faster than it can be replaced, due to natural (water and wind action), animal, and human activity.
- **Subsistence farming** – A type of agriculture producing food and materials for the benefit only of the farmer and his family.

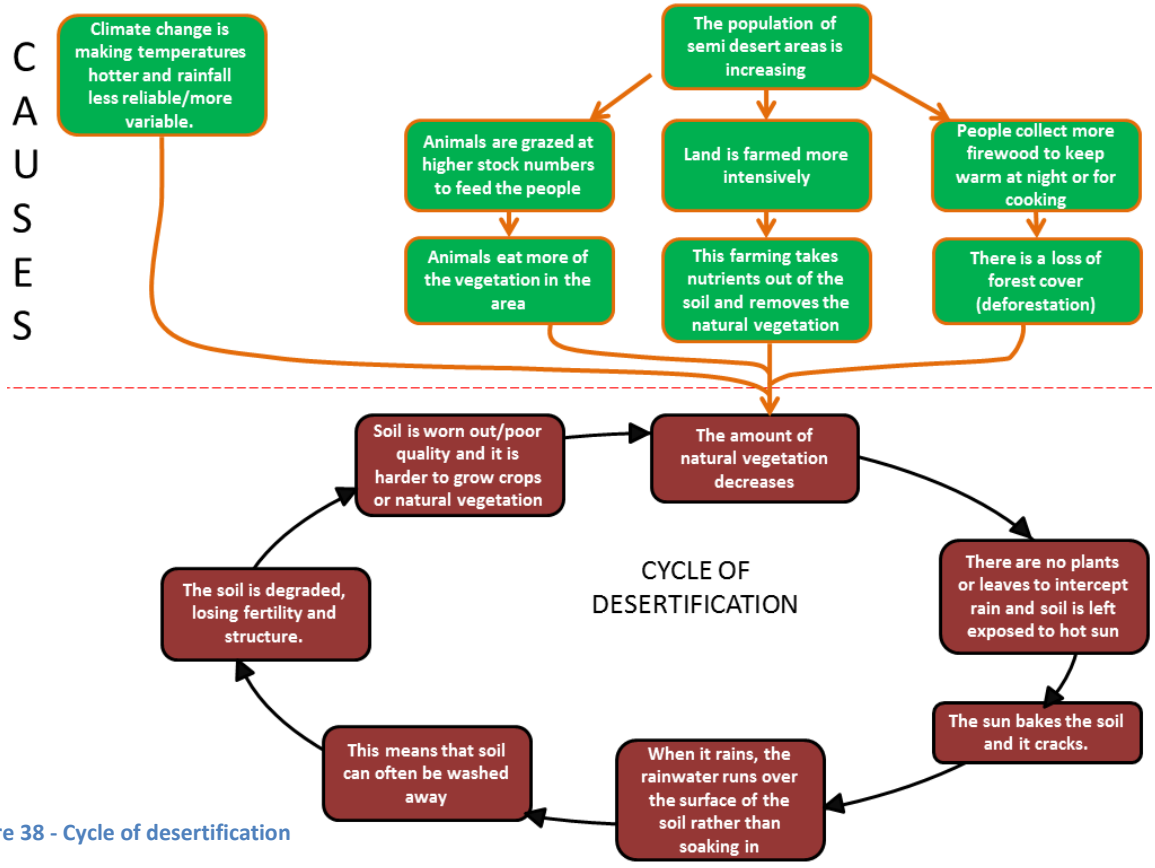

Figure 38 - Cycle of desertification

The effects of desertification

Desertification is a serious issue that affects over 1 billion people around the world. It can have a damaging impact on both people and the natural environment. In 2014 the UN stated that **20million people in the Sahel region of Africa faced hunger** and required $2 billion in food aid due to desertification.

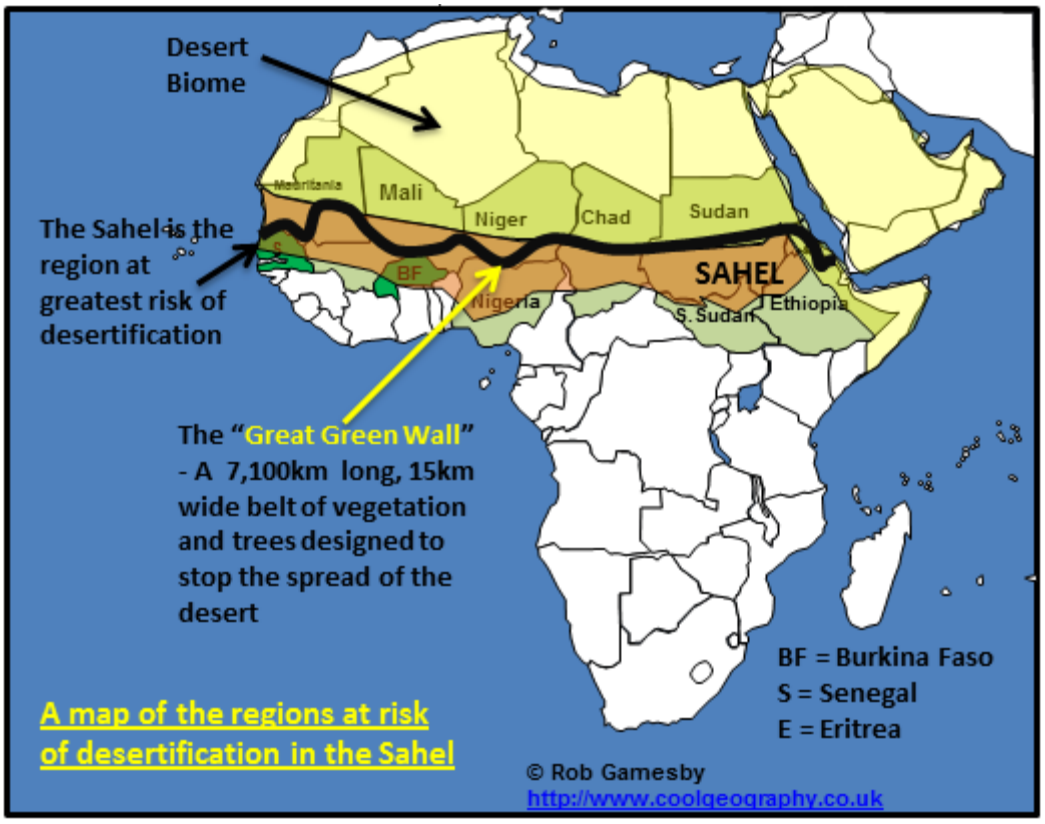

Figure 39 - a map of the Sahel and the Great Green Wall

The loss of vegetation can cause severe **soil erosion**. The nutrients in the soil get washed or **leached away** leaving soil infertile. The loss of vegetation also means that there has been damage to animal's habitats. In addition, **loss of species** affects the availability of local medicines. Population pressure has also stopped people and their animals moving from place to place as they traditionally did and using settled agriculture. This **settled agriculture** means that **people farm too intensively** which also drains the soil of its nutrients. This leaves the soil of poor quality where nothing can grow. This leads to regular crop failure. People also draw more water out of the soil for irrigation. Together with the drying of the soil this leaves deposits of salt (Salinisation) and means crops can't be planted. Lack of food and water can also mean farmed species such as cattle can die of starvation.

People have to migrate out of these desertified areas and often end up in shanty towns at the edge of big cities or in refugee camps. Food aid can be flown in but people can become reliant upon this. However, famines do happen and 250,000 people died in the Sahel drought of 1968 to 73. Desertification also means there are less tree cover and more grasses, which protect the soil less.

Activities 2.11

1. Describe the location of the Sahel
2. Explain how the process of desertification works
3. Explain how you could stop the process of desertification
4. What impact does desertification have on people and the environment?

2.12 Strategies used to reduce the risk of desertification

Desertification is not inevitable and with careful management of water resources, the soil and vegetation via tree planting we can limit the spread of deserts. We have even managed to reverse the effects of desertification. Many of the techniques used have used appropriate technology, which is suited to the needs, skills, knowledge and wealth of local people in the environment which they live.

Tree Planting - Senegal

In the Senegal region of the Sahel (a 5,000km long belt of land that separates the Southern part of Africa from the Sahara) the Food and Agriculture Organisation (FAO) of the UN is trying to help in the fight against desertification. Less than 50 years ago land in this region of the Sahel was productive Savannah, but is now dry desert because of decades of climate change and over intensive farming, forestry and land degradation. This has led to vegetation disappearing.

Figure 40 - An Acacia gum tree nursery in Senegal

A project focussing on **Acacia or gum trees** is trying to help. The FAO and forestry service have provided nursery's to grow seeds and seedlings. The locals were also taught how to sow and plant the Acacia trees, and how to extract and market the gum they produce.

They were also given a tractor and digger tool specially adapted to dryland conditions. It cuts **half moon shaped holes** which collect rainwater ensuring that the young plant roots will have enough water to survive the long dry season. This also massively reduces the amount of labour needed.

Figure 41 Tractor ploughing crescent shaped holes

Planting the trees reverses desertification by preventing soil erosion and providing nutrients for other plants and crops to grow. The tree is a native tree, it puts nutrients back into the soil, provides shelter for crops under its branches and provides fodder for livestock.

The knock on effects have been good for the whole community.

The Great Green Wall

The Great Green wall is a planned project to plant trees across Africa along the southern edge of the Sahara Desert to prevent the desert spreading south. It has been developed by the African Union to reduce the negative effects of desertification and land degradation on people, the environment and the economies of the countries affected.

Stone lines – Water and soil management

Desertification leads to outmigration in countries such as Burkina Faso in the Sahel. This idea was to lay stones along the contours of the land in long lines which traps the rainwater that falls. A **contour stone line** 25 to 30cm high with other stones behind is constructed. These stones slow down run off water and allow it time to infiltrate the ground and rich sediments to be trapped in the field. This results in less erosion and more water for the crops.

Farmers were trained in laying out contours using a simple **water tube level**. They marked out the contours and dug out a foundation trench. Large stones are then placed into this trench followed by smaller ones. Grasses can also be planted along the barrier. The villagers work together and it is a collective effort. The technique has spread from Burkina Faso to Mali and Niger. It is a technology that is low cost and requires skills that can be quickly learned.

Planting pits are also used to hold more water around the plant and homemade compost is used to provide a fertility boost for the soil. Barren land has been restored and vegetation re-established so the scheme has been a big success and sustained.

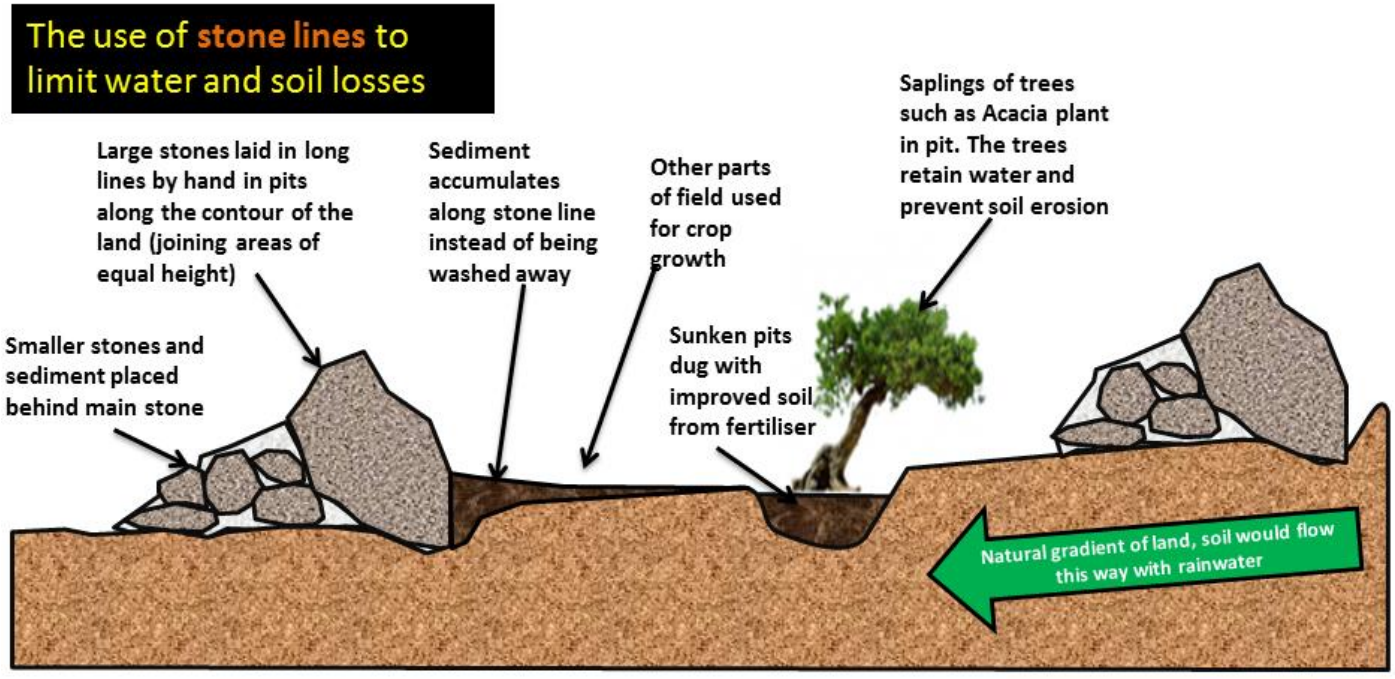

Figure 42 - Stone Lines

Activities 2.12

1. Explain how tree planting can help to reduce the impacts of desertification
2. Do you think the Great Green Wall is a good idea? Justify your ideas.
3. Can humankind combat the threat of desertification?

Figure 37 By Ashwin Kumar from Chennai, India (Wind Turbine Farms Uploaded by Ekabhishek) [CC BY-SA 2.0 (http://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons