Specified case study of a tropical rainforest involving themes of water and carbon cycles

3.1.1.6 Water and carbon cycles

What you need to know
A case study of a tropical rainforest setting to illustrate and analyse key themes in water cycles.
A case study of a tropical rainforest setting to illustrate and analyse key themes in carbon cycles.
Their relationship to environmental change and human activity.

Located in the southern Indian Ocean off the east coast of Africa, sub-tropical Madagascar is the world's fourth largest island. Heavily forested until the 1970s, with unique species and biomes, Madagascar has experienced significant deforestation as population growth has increased the demand for food production and economic progress. With a current population of over 25m that, in 1960 was a mere 5m, a five-fold increase in people has had significant environmental impacts on the island. But those impacts then proliferate into wider consequences for water and carbon systems on the island and, ultimately, globally.

Over 70% of Madagascar's population live in rural areas and work in agriculture. As forest has been cleared to extend the amount of cultivable land, the island has lost over three quarters of its trees throughout human history on the island. More recently it has been at a slower rate and by 2010 forest covered around 21.6% of the island. Most of the causes of deforestation can be attributed to logging (valuable hardwoods such as Ebony and Rosewood), land conversion to agriculture (including both commercial plantations and subsistence farming), wildfires and fuelwood collection. All these have a basis in population increase and much of the forest clearance is carried out by traditional slash and burn methods.

Madagascar's tropical rainforest occupies a narrow belt of the island in the wetter north and runs down the entire eastern region. It extends from low altitude forest up to lower montane slopes of the eastern ridge of highlands. Easterly winds approaching the island from the southern Indian Ocean rise up these highlands and drop considerable relief (orographic) rain on the windward east-facing slopes.

Water cycle impacts

Soil erosion on cleared land in Madagascar is severe with erosion gullies in the highlands having soil loss rates seven times the global average. Increased surface runoff carries not only water but sediment into tributaries of rivers that slows channel discharge and damages land for cultivation. Reduced soil infiltration has resulted in reduced groundwater availability and drier soils under intense heat can result in soil-sealing; effectively turning the soil into an impermeable surface that, when intense rain does fall again, results in greater overland flow and even less infiltration. Drastically reduced transpiration rates have led to a drier atmosphere locally and longer-than-normal dry seasons as rain-bearing clouds are less liable to form.

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Carbon cycle impacts

Forest clearances result in an immediate increase in atmospheric carbon. As the forest is burned biomass carbon is rapidly transferred to the atmosphere as smoke and slashed leaves and stems rapidly decompose on the soil surface. The humus layer of soil may also be incinerated removing carbon from a longer term store. The crops that replace the natural forest are far less efficient at drawing down carbon from the atmosphere in photosynthesis and many of the grazing animals that are put on the land become emitters of methane, which has over twenty times the greenhouse gas potency of carbon dioxide. While many of the consequences on the water cycle are regional in scale, those of the carbon cycle become part of a global impact.

Life on earth

Deforestation of natural habitats endangers some of the world's most isolated and unique species on Madagascar. The island has exceptional biodiversity and hosts 50 species of lemur, 15 of which have become extinct in recent decades. In total over 3000 of its plant and animal species are threatened with extinction. This comes not only from habitat clearance, but local environmental change as soils are lost, the local atmosphere becomes drier and global temperatures rise, but also because of changing ocean and wind patterns resulting from warmer seas and air.

Changing the perspective

In September 2013 the government of Madagascar and the Wildlife Conservation Society (WCS) announced that at least 400 000 hectares (1 500 sq miles) of the Makira Forest was to be set aside from deforestation and allocated as Carbon Credit sales. By conserving the forest, the equivalent absorption of atmospheric carbon dioxide by this area of forest equated to 705 588 international carbon credits which could be bid for by purchasers of carbon credits (net CO2 emitters amongst businesses and industry, often in the developed world). The Makira REDD+ project will protect not just the forest but the biodiversity within plus human livelihoods. REDD+ (Reducing Emissions from Deforestation and forest Degradation) is an international framework that allocates carbon credits to the equivalent carbon that is stored in a forest that has been guaranteed long-term protection. It also invests in low-carbon strategies for sustainable development, trains local people in the sustainable management of forests and teaches how to improve their existing carbon stocks. By monetising the carbon stored in forests, and their potential to draw down atmospheric carbon, value can be placed on conservation that exceeds the economic value of destruction.