UN-REDD PROGRAMME | ACADEMY

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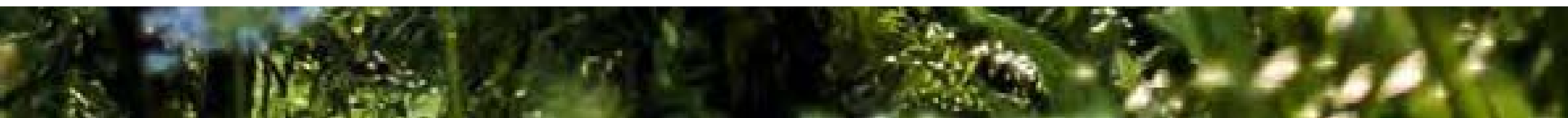
CLIMATE CHANGE AND THE ROLE OF FORESTS

# REDD+ ACADEMY

## LEARNING JOURNAL

EDITION 3 - DECEMBER 2018



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# ABOUT US

## UN-REDD

The UN-REDD Programme is the United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

The UN-REDD Programme supports nationally-led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including Indigenous Peoples and other forest-dependent communities, in national and international REDD+ implementation.

## REDD+ACADEMY

The REDD+ Academy is a coordinated REDD+ capacity development initiative led by the UN-REDD Programme and the UNEP Environmental Education and Training Unit, which seeks to match the scale of the global climate change mitigation challenge and enable systematic, focused capacity development to deliver REDD+ on the ground.

The REDD+ Academy is a comprehensive response to capacity building needs identified by the countries receiving support from the UN-REDD Programme. The main aim of the REDD+ Academy is to empower potential "REDD+ champions" with the requisite knowledge and skills to promote the implementation of national REDD+ activities.

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Our training targets two key groups of beneficiaries: the delegates to the United Nations and others who develop intergovernmental agreements establishing global norms, policies, and programmes, and the key national change agents who turn the global agreements into action at the national level.

MONIKA GAIL MACDEVETTE

DIRECTOR, A.I.
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Dear Learner,

Welcome to the second edition of the REDD+ Academy Learning Journals. The journals provide you with state of the art knowledge on REDD+ planning and implementation, developed by some of the world's leading experts at the UN-REDD Programme.

The journals have been designed to accompany you in your learning journey and equip you with the necessary knowledge to understand the various components of REDD+, from the basics to the finer points of setting reference levels, monitoring, allocation of incentives and stakeholder engagement.

With deforestation and forest degradation being the third largest source of greenhouse gas emissions globally, action to reduce deforestation and to rebuild forests globally is vital. By realizing social and economic benefits, REDD+ is also fundamental to delivering on the Sustainable Development Agenda.

Following the adoption of the Paris Agreement, the focus of many developing countries is now firmly on REDD+ implementation. I encourage you to take the REDD+ Academy online course, and apply your knowledge to make REDD+ a national and a global success!

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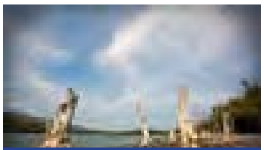

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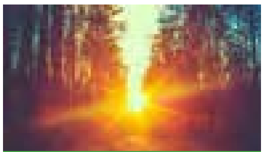

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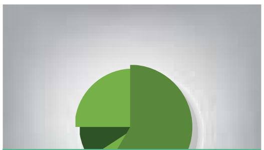

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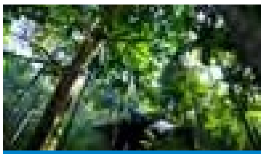

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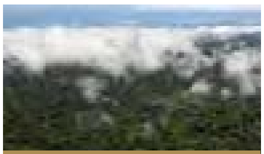

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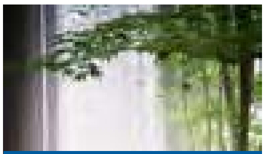

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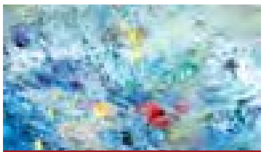

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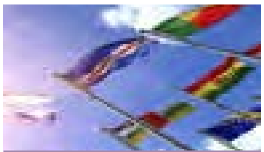


GOOD GOVERNANCE



## ACTIVITIES

# Climate Change and the Role of Forests

This module shows evidence that the climate is changing and the clear link with human activity. It then presents the role of forests in climate regulation.

**The module includes sections about:**

- Evidence of human-induced climate change and factors influencing climate
- The regulatory role of forests
- How human activity impacts the climate-related functions of forests

**What do you already know about this topic?**

# 1. CLIMATE CHANGE AND THE ROLE OF FORESTS

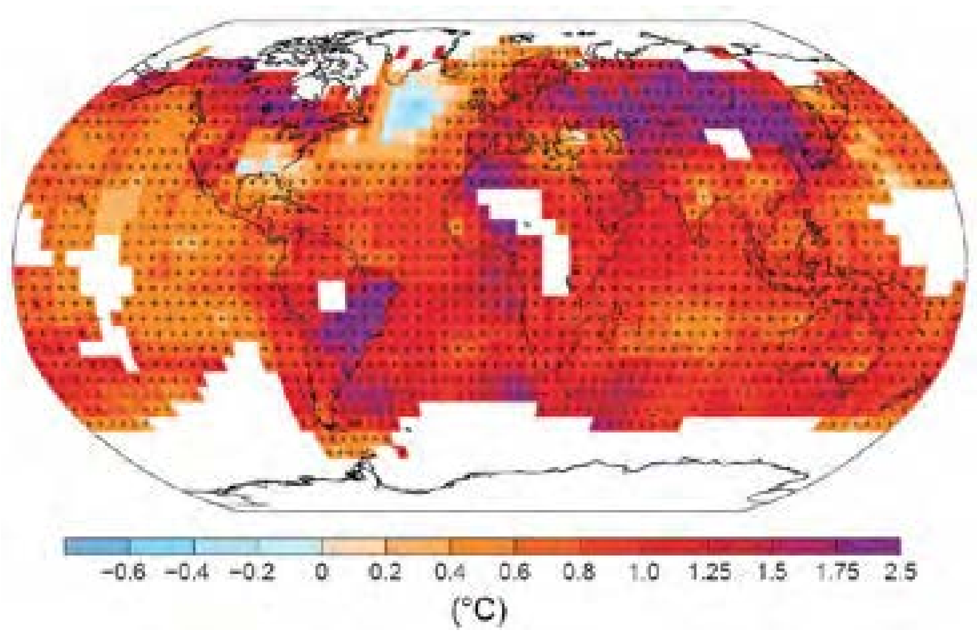
## INTRODUCTION

There is increasing evidence from around the world that the Earth's climate is changing and that human activity is the primary cause. As the Intergovernmental Panel on Climate Change (IPCC) notes in its Fifth Assessment (IPCC, 2013): "It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century". These changes are most obviously seen in increasing average temperatures and rising sea levels. Figure 1 shows the estimated change in average annual temperature around the world between 1901 and 2012, using combined land and ocean surface temperature. Apart from a few light blue areas which represent falling average temperatures, most of the world has experienced an increase in average temperatures represented by the orange/red and purple areas. In white areas there were insufficient data to map. The global average temperature increase over the 1880 to 2012 period was 0.85°C.

**REFLECTION POINT**

Have average temperatures in your region increased or decreased?

**Figure 1 Map of the observed surface temperature change from 1901 to 2012 derived from temperature trends determined by linear regression from one dataset[1]**

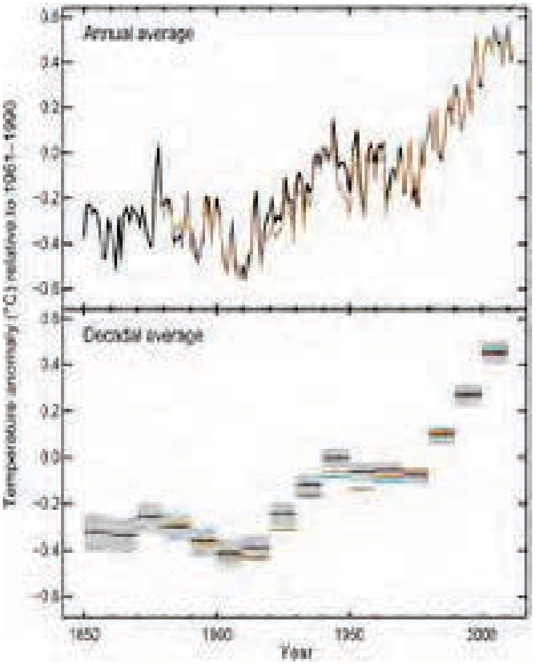



Source: IPCC (2013)

Figure 2 shows how temperatures varied between 1850 and 2010, in comparison to the average temperature of 1961-1990. The graph shows, for example, that in 1850 the average temperature was 0.4°C degrees cooler than the average temperature between 1961 and 1990. The top graph presents averages for individual years, while the bottom one shows the average for decades.

1 Trends have been calculated where data availability permits a robust estimate (i.e., only for grid boxes with greater than 70 per cent complete records and more than 20 per cent data availability in the first and last 10 per cent of the time period). Other areas are white. grid boxes where the trend is significant at the 10 per cent level are indicated by a +

**Figure 2 Observed global mean combined land and ocean surface temperature anomalies**

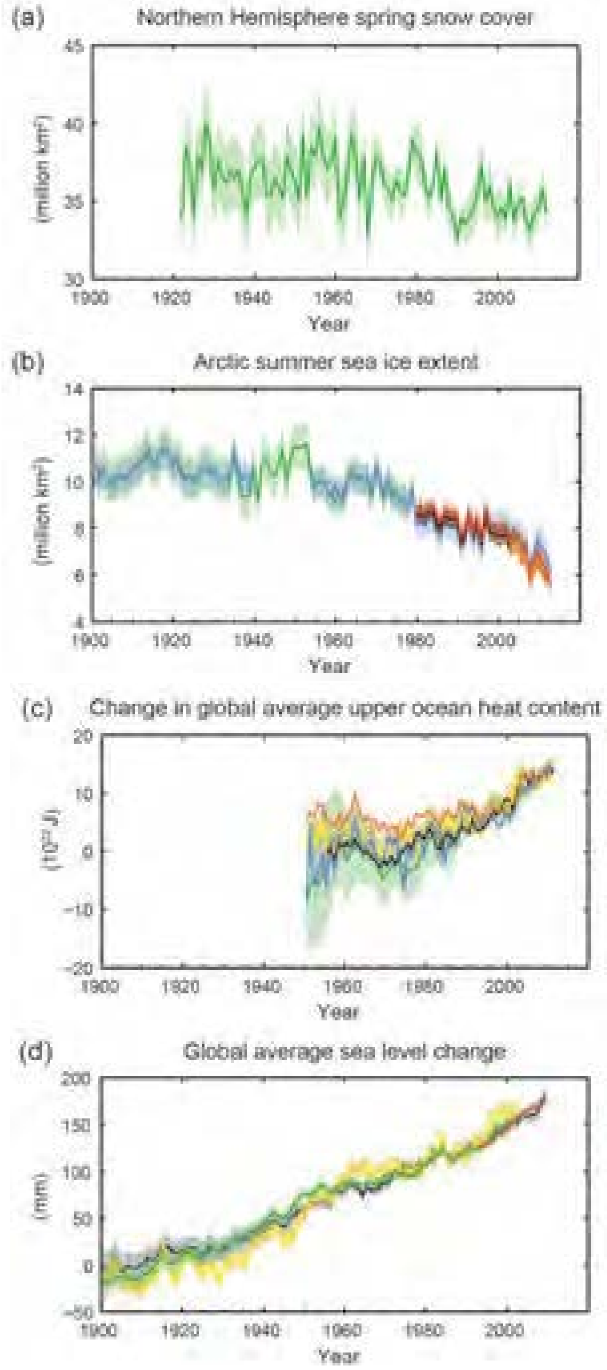



Source: [IPCC (2013)]

Figure 2 clearly shows that over this period average temperatures have been increasing, and that the three last decades have been the hottest, each successively warmer than any preceding decade since 1850.

The rise in surface temperature is not the only evidence of a changing climate: Figure 3 illustrates change measured in several other ways.

**Figure 3 Multiple observed indicators of a changing global climate**




Source: [IPCC (2013)]

Figure 3(b) shows that northern hemisphere snow cover and Arctic summer ice are falling, particularly since 1960. The melting snow and ice ends up in the oceans, which contributes to higher average sea levels (around 15 cm already over the observed period). Meanwhile, global upper water layers have warmed since 1950, when measurements started. Rising global temperatures have been accompanied by other changes in climate, including rainfall, resulting in more floods, droughts, and heat waves (EPA, n.d.).

According to the IPCC (2014) such climate change can result in the alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, all of which can have serious implications for biodiversity as well as human well-being and livelihoods. People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized within societies are often especially vulnerable to and disproportionately affected by changes in climate and ecosystem services. For example, this tends to be the case for women in many societies. Given their roles in communities and households, they are often heavily dependent on, but have unequal access to land, water and other natural resources (including forests). They also often experience unequal rights and limited mobility and decision-making power (UN Women, 2015).

**REFLECTION POINT**

Have you already noticed impacts of climate change? (e.g. changes in the timing of the seasons and species movements, or in the frequency of extreme events).

What changes or events within your country have been attributed to climate change?

Are you aware of the predicted threats from a warming planet to your country or region?

## WHAT IS CAUSING CLIMATE CHANGE?

As mentioned previously, humans are the most likely cause of recent changes in the earth's climate, but the climate system is complex, and is influenced by several natural effects such as variations in solar radiation, the natural greenhouse effect, naturally occurring aerosols, water currents, etc.

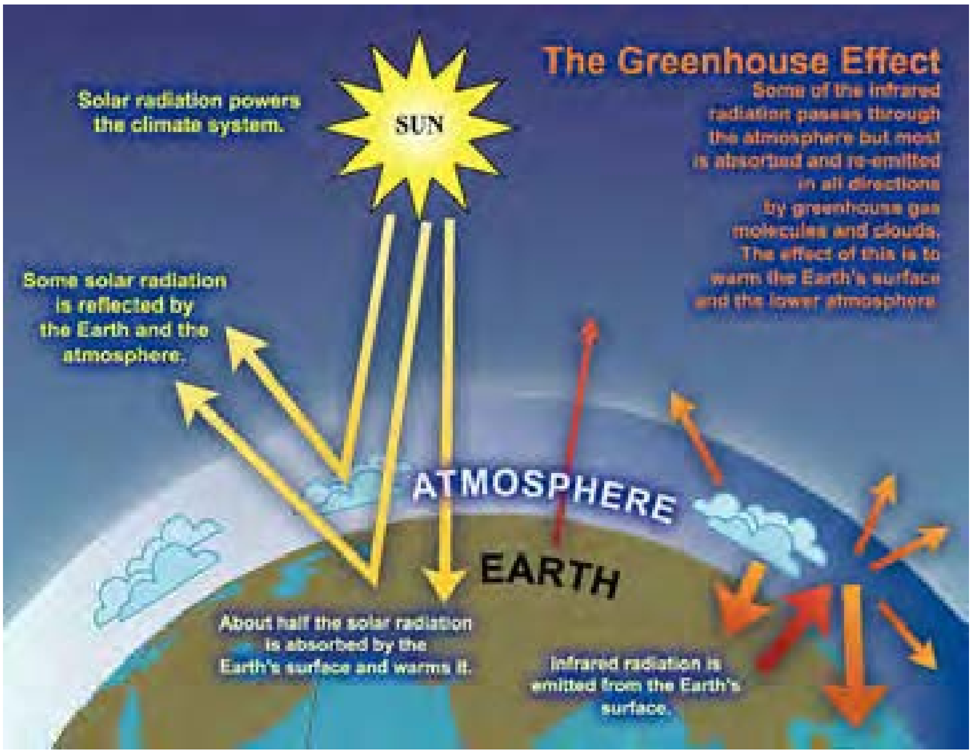
### The Greenhouse Effect

The IPCC (2007) has provided a clear description of how the greenhouse effect resulting from Earth's climate system warms the planet, and how it is modified by human activities:

*"The Sun powers Earth's climate, radiating energy at very short wavelengths, predominately in the visible or near-visible (e.g., ultraviolet) part of the spectrum. Roughly one-third of the solar energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds is absorbed by the surface and, to a lesser extent, by the atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. Because the Earth is much colder than the Sun, it radiates at much longer wavelengths, primarily in the infrared part of the spectrum (see Figure 1.4). Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, including clouds, and reradiated back to Earth. This is called the greenhouse effect. The glass walls in a greenhouse reduce airflow and increase the temperature of the air inside. Analogously, but through a different physical process, the Earth's greenhouse effect warms the surface of the planet. Without the natural greenhouse effect, the average temperature at Earth's surface would be below the freezing point of water. Thus, Earth's natural greenhouse effect makes life as we know it possible. However, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming.*

*The two most abundant gases in the atmosphere, nitrogen (comprising 78% of the dry atmosphere) and oxygen (comprising 21%), exert almost no greenhouse effect. Instead, the greenhouse effect comes from molecules that are more complex and much less common. Water vapour is the most important greenhouse gas, and carbon dioxide ($CO_2$) is the second-most important one. Methane ($CH_4$), nitrous oxide ($N_2O$), ozone ($O_3$) and several other gases present in the atmosphere in small amounts also contribute to the greenhouse effect. In the humid equatorial regions, where there is so much water vapour in the air that the greenhouse effect is very large, adding a small additional amount of $CO_2$ or water vapour has only a small direct impact on downward infrared radiation. However, in the cold, dry polar regions, the effect of a small increase in $CO_2$ or water vapour is much greater. The same is true for the cold, dry upper atmosphere where a small increase in water vapour has a greater influence on the greenhouse effect than the same change in water vapour would have near the surface".*

**Figure 4 The greenhouse effect**




Source: IPCC (2007)

## REFLECTION POINT

Are the following statements true or false?

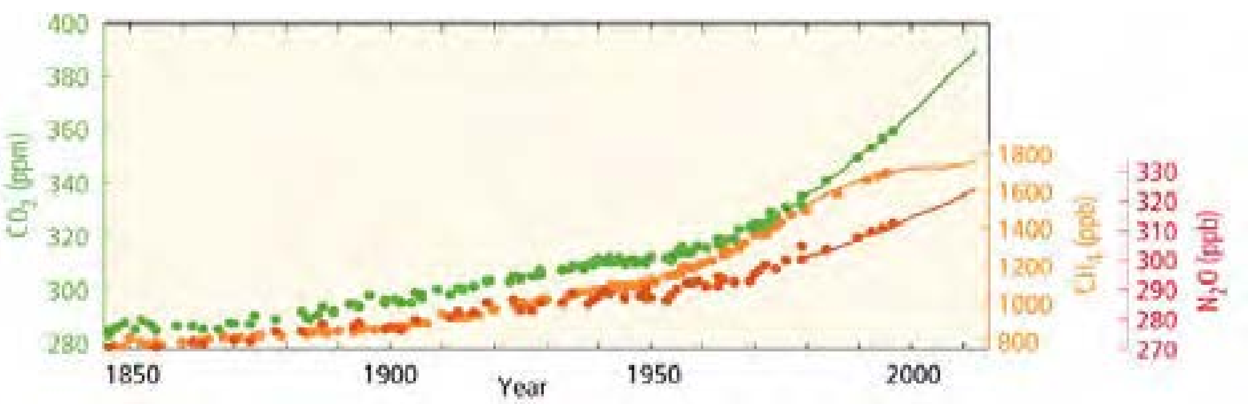
Without the greenhouse effect the planet would be too cold to support human life.

Climate change is a result of the increase in the concentration of greenhouse gases, mostly from anthropogenic sources, such as the burning of fossil fuels, agriculture and deforestation.

There is broad scientific consensus that the primary cause of recent (and future) climate change is anthropogenic (i.e. human-induced), resulting from the emission of GHGs to the atmosphere.

The observed warming of the climate system is unequivocal, and the largest contribution comes from the increase in the atmospheric concentration of $CO_2$, largely as a result of burning fossil fuels, cement production and land-use changes. The IPCC states it clearly: it is extremely likely (95 per cent certainty) that human influence has been the dominant cause of the observed warming since the mid-20th century. Figure 1.5 shows how the concentration of atmospheric $CO_2$, $CH_4$ and $N_2O$ have increased in the recent past.

**Figure 1.5 Globally averaged greenhouse gas concentrations**




Source: IPCC (2013)

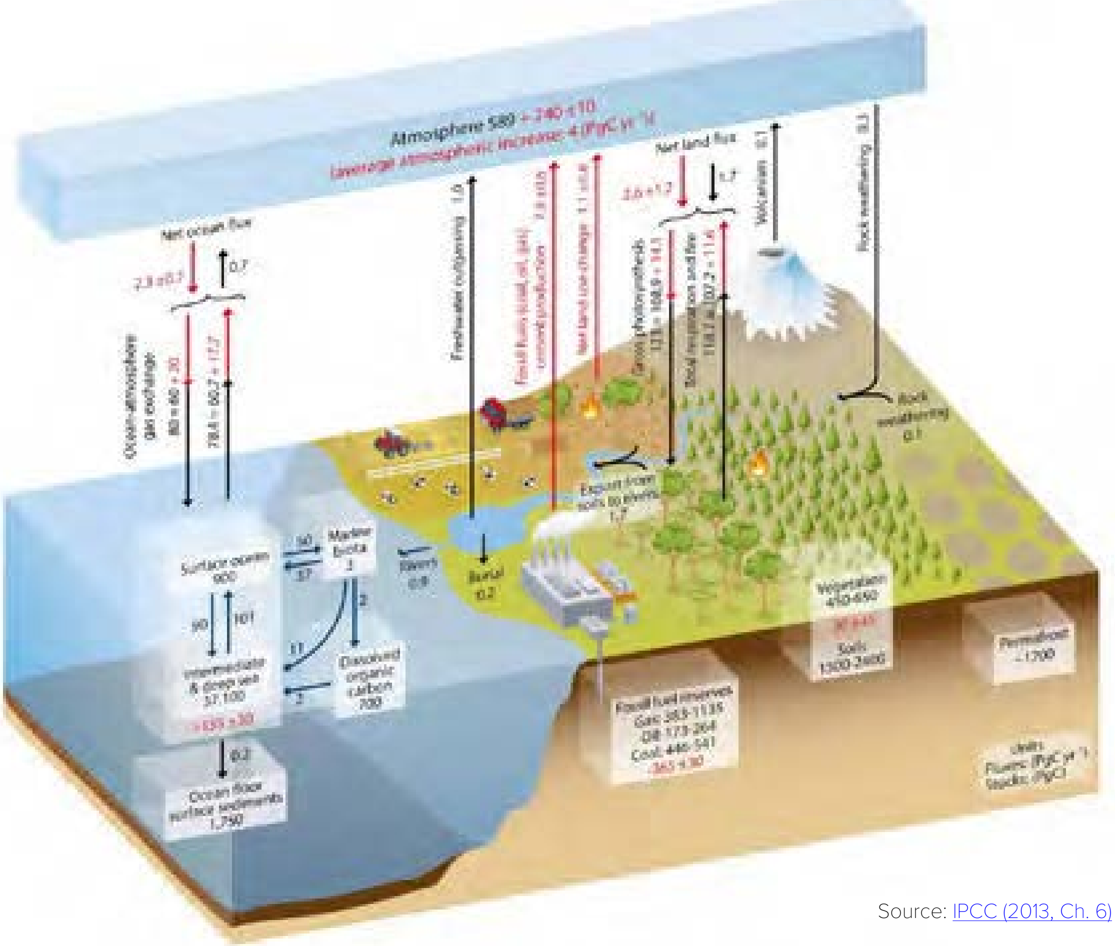
## HOW DOES CLIMATE CHANGE LINK TO THE CARBON CYCLE AND FORESTS?

Carbon can be found in various forms and locations. These include living organisms (including trees and other plants), fossil fuels (coal, oil and gas) and $CO_2$ in the atmosphere. The absolute quantity held in a given form at a particular point in time is called a stock, and changes in these stocks are referred to as fluxes. Carbon flows between stocks through a number of processes collectively known as the 'carbon cycle'. The fluxes include natural processes such as plant growth and respiration, and human interventions such as the burning of fossil fuels and the destruction of forests. Figure 6 below illustrates the global carbon cycle with its stocks and flows, which are shown in two ways:

- How they were before large-scale human intervention (roughly before 1750 – black figures and arrows)
- How they were changed by human intervention since the industrial revolution (red figures and arrows)

Before 1750, the fluxes were generally in equilibrium, the amount going into and out of each stock being about the same. Human actions, such as the burning of fossil fuels, cement production and land use change are creating disequilibrium, through increasing emissions. These bigger fluxes from 'sources' (stocks from which carbon is being released to the atmosphere) are compensated partly by bigger fluxes into 'sinks' (through processes or mechanisms that remove carbon dioxide from the atmosphere), particularly the ocean and land sinks (this will be revisited later).

**Figure 6** **Global carbon cycle for the 1990s**



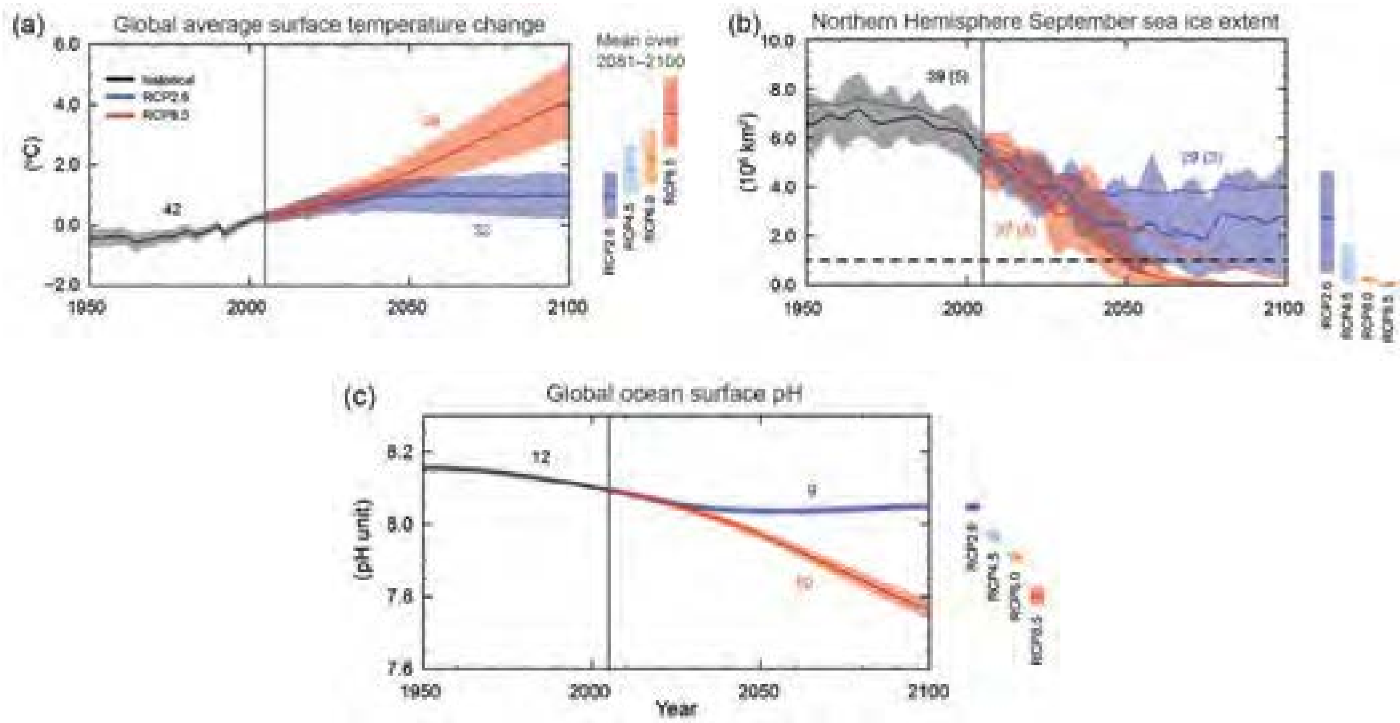

Source: IPCC (2013, Ch. 6)

The carbon cycle means that vegetation (including forests), soils, oceans and the atmosphere are connected, and it is important to consider the role vegetation and changes in vegetation cover play in controlling overall greenhouse gas emissions and hence climate change. Overall, the IPCC (2013) estimates that net $CO_2$ emissions from land-use change represent about 10 per cent of total anthropogenic emissions).'Net emissions' means that absorption by recovering and new forests is taken into account.

## Expected changes in the future

Several scenarios have been developed to provide an idea of what the future climate could look like, and to provide a basis for working out the practical implications of climate change. The scientific community has produced Representative Concentration Pathways (RCPs), which are projections based on emission scenarios which describe several ways in which emissions could fluctuate up to 2100. RCP 8.5 presents a continuous growth of emissions, RCP 2.6 presents a scenario of sharp emission reductions and RCPs 6 and 4.5 present intermediate situations. These projections are useful for informing decisions related to future climate. The projections for change in temperature are shown in Figure 7. These changes will strongly affect the environment and human societies around the world, with the most severe impacts on developing countries and those who face inequalities and social exclusion on the basis of age, class, gender, ethnicity and/or disability. Such marginalized groups will have significantly reduced abilities and resources to cope with and respond to climate change impacts, which in turn could further deepen existing inequalities and undermine their health, education and overall livelihoods.

**Figure 7 Simulated surface temperature time series from 1950 to 2100**




Source: IPCC (2013)

Figure 7 shows that unless important action is taken to reduce emissions, there will be drastic changes in the climate and in variables such as ocean acidity which will strongly affect the environment, human welfare and livelihoods.

Current international agreements have set a goal that the rise in average global temperature should not go higher than 2°C above pre-industrial levels, and if possible, limit to 1.5°C. We are already about half way to the upper limit with 1°C of warming from pre-industrial levels (Met Office, 2015). The link between emissions since the 1850s and temperature increases means that emissions need to be capped at a certain level of cumulative emissions (the level that corresponds to the 2°C increase). If emission rates stay at the current levels, the remaining budget 'quota' would be used up in about 30 years.

In other words, unless strong mitigation actions are urgently adopted, the limit of a 2°C temperature rise will quickly be passed and a much more uncertain climate future awaits. In the landmark Paris Agreement under the United Nations Convention on Climate Change (UNFCCC), representatives from 195 countries and regional organisations have agreed to avoid dangerous climate change.

**REFLECTION POINT**

What does 'RCP' stand for? Why are RCPs so important?

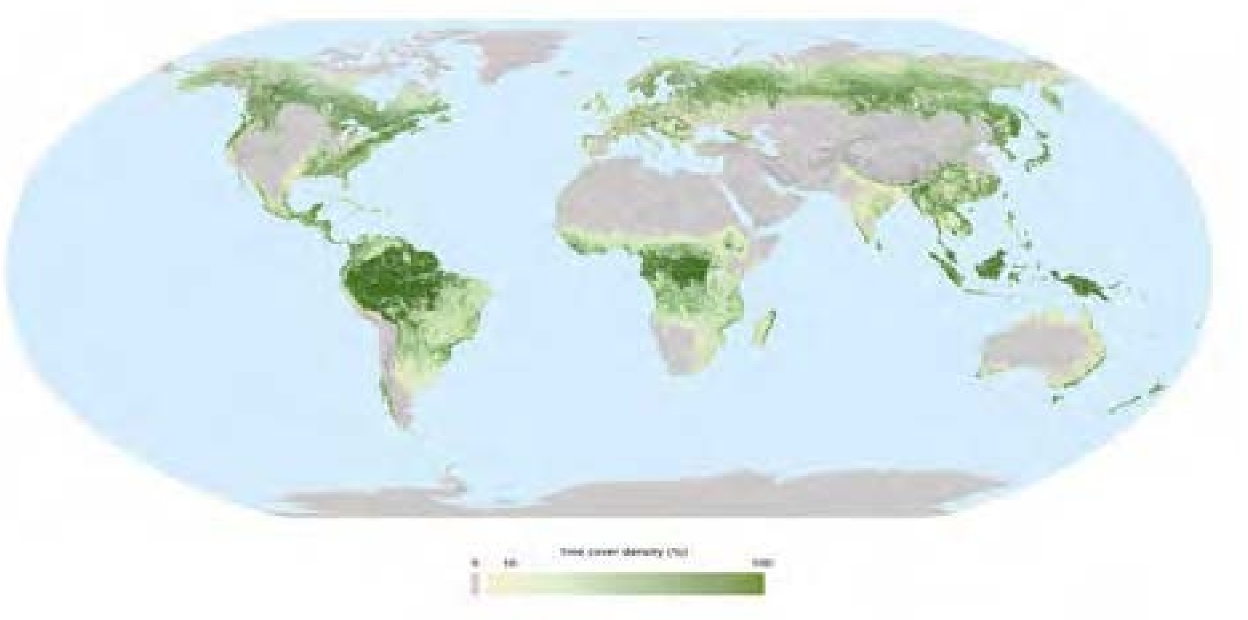
## THE EXTENT OF FORESTS AND FOREST CARBON STOCKS

Globally, forests cover about 4 billion ha or 31 per cent of the world's land surface (compared to a pre-industrial area of 5.9 billion ha). Most forests occur in the tropics and in large areas of the northern hemisphere in Canada, the US, Europe, Siberia and China, as shown in Figure 8. A recent global survey has estimated that there are 3.04 trillion trees with a diameter of more than 10 cm at breast height, or the equivalent of 420 trees for every person on the planet (Crowther et al., 2015).

The different forest (and other) biomes contain varying amounts of carbon, as presented in Figure 1.9. At a global scale, tropical forests contain the largest carbon stock (547.8 million tons in tropical and subtropical forests). There are also differences within tropical areas, with mangrove forests and swamp forests containing particularly high levels of biomass[2] in their vegetation cover and soils.

2 Biomass is the total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass. The quantity of carbon contained in biomass varies slightly between vegetation types but on average, a ton of biomass equates to half a ton of carbon.

**Figure 8 Forest cover in 2010**



Source: FAO (2010)

**Figure 9** **Carbon storage by ecosystem**

Source: Trumper et al. (2009)

Forests also provide subsistence and income for more than 1.6 billion people, including approximately 60 million indigenous people. Those who rely on forests for their livelihoods are among the poorest people on the planet, and they are disproportionately female (UN-REDD Programme, 2011).

How much forest is there and where is it situated? Are there different types of forested ecosystems (e.g. mangroves, swamp-forests)? Do any local communities or indigenous people live within these forested ecosystems?

## Emissions from forest carbon stocks

As forests contain substantial stores of carbon, their degradation and or conversion to other land cover causes the release of some of the carbon stored within them. Forest degradation can be defined as human activities that reduce the carbon stocks and other ecosystem functions of a forest, but that fall short of deforestation, for example selective logging. The level of emissions depends on the amount of carbon originally stored in the forest, the extent to which the vegetation cover and soil structure is damaged or destroyed, as well as what happens to the land afterwards. Particularly high emissions will result if the vegetation is completely destroyed and then the area is burned afterwards, as is carried out during slash and burn agriculture in some parts of the developing world.

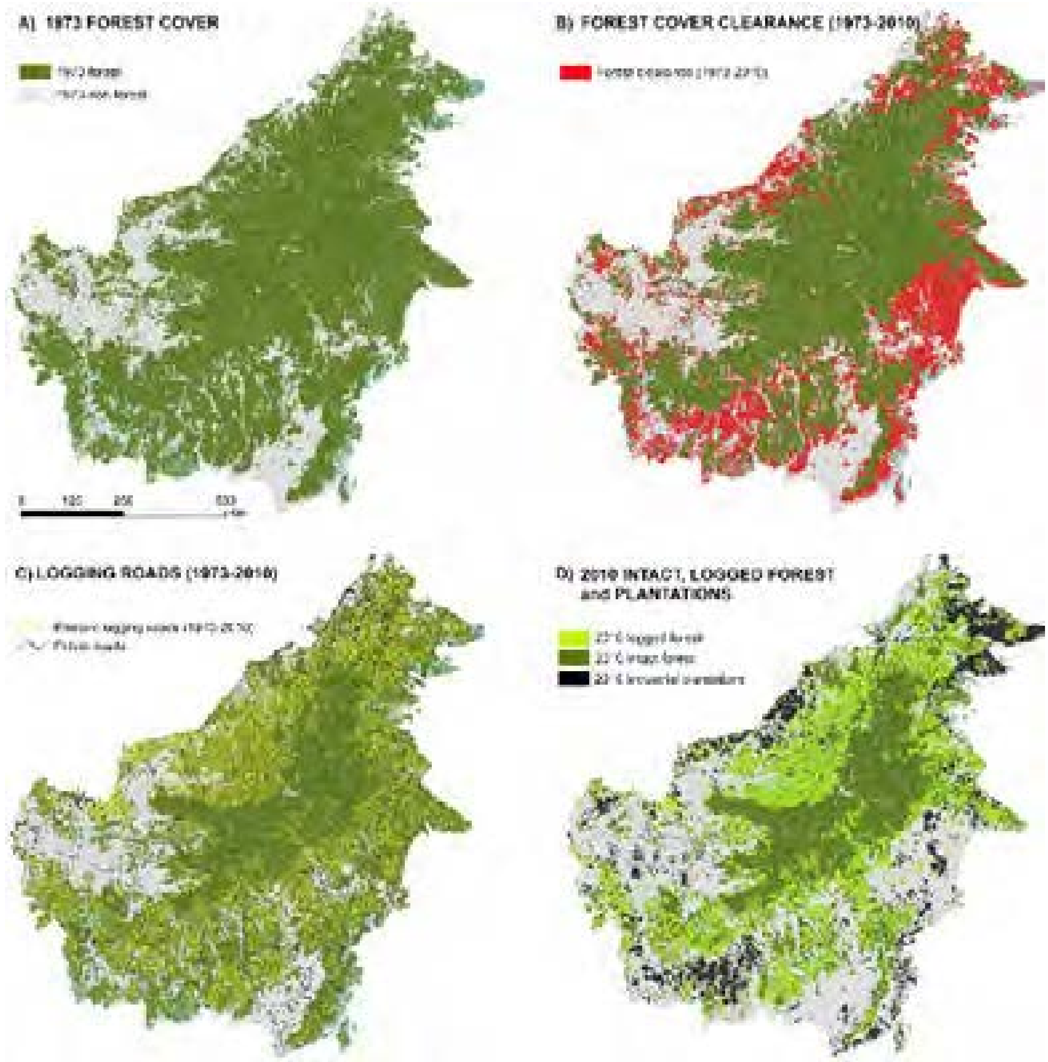
The extent of forest destruction is very high in some areas. For example, a recently published study on deforestation in Borneo shows that deforestation has reduced the once high forest cover on Borneo (75.7 per cent) by one third, as shown in Figure 10.

**REFLECTION POINT**

Referring to figure 9, what different ecosystem types are there in your country?

How much forest is there and where is it situated? Are there different types of forested ecosystems (e.g. mangroves, swamp-forests)? Do any local communities or indigenous people live within these forested ecosystems?

**Figure 10** **Evolution of forest cover on Borneo Island**




Source: Gaveau et al. (2014)

Historically, deforestation occurred largely in the US, Europe and Eastern Europe. Today, the highest deforestation rates are observed in tropical rain forest regions. Figure 11 also shows that the US and Europe have reversed the trend and are now increasing their forest cover. This highlights an important issue, that although the destruction of forests causes the release of carbon dioxide, their restoration can act as a sink for atmospheric carbon. As mentioned previously, the net contribution of land-use change to global emissions is about 10 per cent of the total (0.9 gigatons of carbon (GtC[3]) per year), which is the contribution calculated by combining both emissions due to deforestation and the sequestration of carbon due to forest recovery. The gross emissions from deforestation and degradation are larger than the net emissions (about 2.8 ± 0.5 GtC/ yr for the 2000s (IPCC, 2013) because of the significant regrowth that compensates for the gross emissions.

There are several causes of deforestation and forest degradation, which are addressed more in depth in: ***Drivers of Deforestation and Forest Degradation.***

3 1 petagram (Pg) = 1 gigaton (Gt). Carbon has less mass than $CO_2$, such that 1 GtC is equal to 3.66 $GtCO_2$.

**Figure 11** **Historical Forest Carbon Balance 1855-1995**


Source: GRID-Arendal (2015)

# CARBON SEQUESTRATION POTENTIAL OF FORESTS

Forests are not only potential sources of carbon emissions to the atmosphere; they can also act as carbon sinks, sequestering carbon. Forests sequester carbon both as they grow when they are being restored and as part of the terrestrial carbon sink.

More than 2 billion haworldwide may offer opportunities for restoration. In areas that were deforested but are not currently densely populated or cultivated it may be possible to undertake some form of restoration, ranging from complete reforestation of closed canopy cover to more mosaic restoration that includes restored forest areas interspersed with other land uses including agroforestry, small scale agriculture and settlements. Such restoration sequesters carbon, with the level of sequestration depending on the extent of recovery of plant biomass and soil carbon. This potential is illustrated in Figure 12.

**REFLECTION POINT**

Why is it so important to understand the link between deforestation and climate and forest degradation and climate in addressing climate change issues?

**Figure 12** Forest and landscape restoration opportunities


Source: WRI (2015)

The observed increases in atmospheric $CO_2$ are lower than would be expected if anthropogenic emissions were considered alone, due to the combined action of natural land and ocean sinks which removed an average 55 per cent of the total anthropogenic emissions every year during the period 1958–2011 (IPCC, 2013). The increased storage of carbon in terrestrial ecosystems not affected by land use change is partially caused by enhanced photosynthesis at higher $CO_2$ levels, and it means that intact forests are helping to act as a buffer against anthropogenic $CO_2$ emissions.

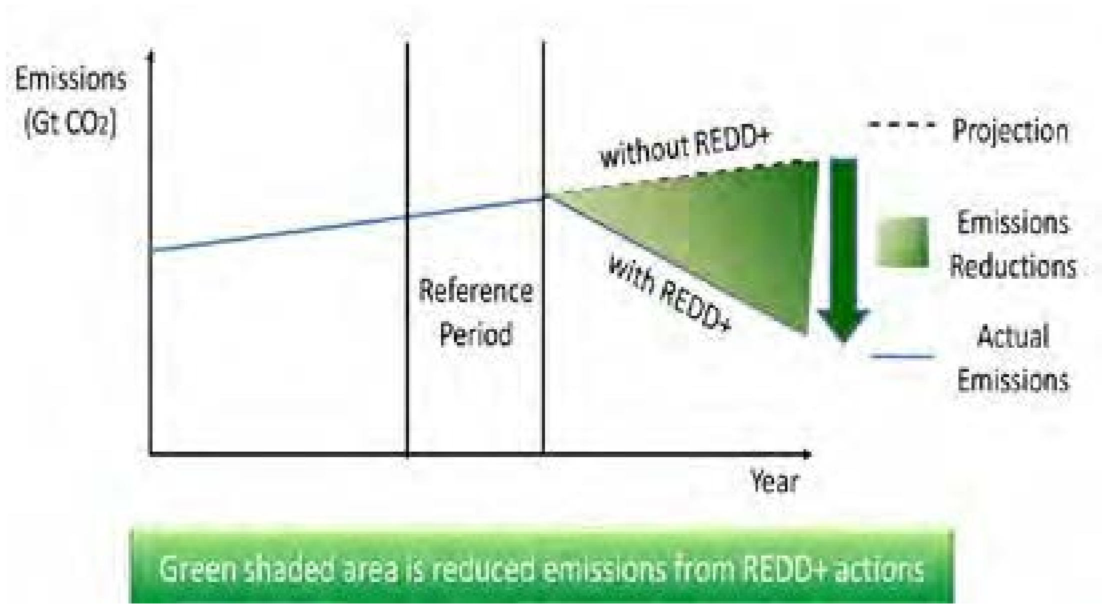
## Forests and climate change mitigation

The links between forests and the carbon cycle mean that actions that affect the forest sector can have a large impact on greenhouse gas emissions and so on climate change. The total amount of $CO_2$ entering the atmosphere can be reduced by decreasing emissions from both deforestation and forest degradation. Maintaining standing forests can preserve their role as a terrestrial carbon sink and restoring forests can increase the sequestration of carbon thereby decreasing the overall levels of $CO_2$ in the atmosphere. If all deforestation and forest degradation were halted, and the whole area suitable for 'wide-scale restoration' restored, emissions could be reduced by an estimated 9 gigatons of $CO_2$ per year by 2030 (in Miles & Sonwa 2015). How much of this potential is realized depends on national goals and policies, economic factors, and socio-cultural and institutional barriers that slow the speed of change.

Recognizing the potential role of forests in contributing to climate change mitigation, the UNFCCC developed REDD+, which includes reducing emissions from deforestation and forest degradation, the conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks.

REDD+ is thus a potentially important way to reduce total GHG emissions and thus mitigate climate change as illustrated by Figure 13.

**Figure 13 REDD = Reducing emissions from deforestation and forest degradation**




Source: UN-REDD Programme

**Match each term to one of the five definitions below:**

## EXERCISE 1

Deforestation

Forest degradation

Conservation of forest carbon stocks

Sustainable management of forests

Enhancement of forest carbon stocks

is the human-induced loss of carbon stocks within forest land that remains forest land

is the total conversion from forest land to non-forested land

is bringing the rate of extraction in line with the rate of natural growth to ensure near-zero net emissions time

is any effort to conserve forests

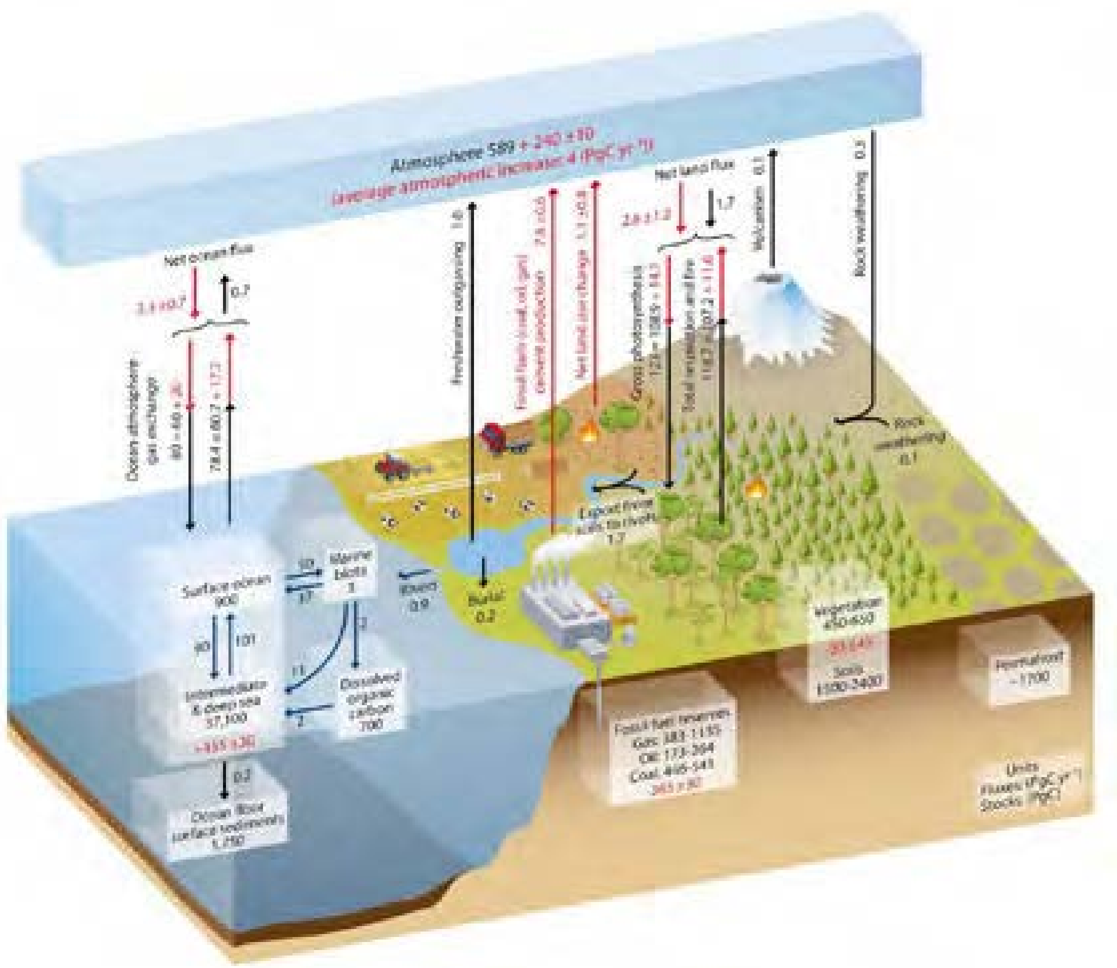
is (i) non-forest land becoming forest land and (ii) the enhancement of forest carbon stocks in forest land remaining forest land

# EXERCISE 2

**The figure below shows IPCC estimates of the fluxes in the carbon cycle expressed in petagrams of carbon per year (1 petagram (Pg) = 1 gigaton (Gt)). Carbon alone has less mass than CO2, such that 1 GtC is equal to 3.66 GtCO2.**

List the quantity of carbon associated with the following fluxes:

- Net land use change
- Fossil fuels (coal, oil, gas) and cement production
- Freshwater outgassing




Source: [IPCC (2013, Ch. 6)](IPCC (2013, Ch. 6))

## KEY MESSAGES OF THIS CHAPTER

- There is increasing evidence from around the world that the Earth's climate is changing and the IPCC has noted that "it is extremely likely that we are the dominant cause of warming since the mid-20th century;"
- The carbon cycle involves vegetation (including forests), soils, oceans and the atmosphere, and it is important to consider the role vegetation and changes in vegetation cover play in controlling overall greenhouse gas emissions and hence climate change;
- As forests contain substantial stores of carbon, their degradation and/or conversion to other land cover causes the release of some of the carbon stored within them; conversely, their restoration can absorb atmospheric carbon;
- The UNFCCC has developed REDD+ with the goal of reducing emissions from deforestation and/or forest degradation, while supporting the conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks, recognizing the potential role of forests in contributing to climate change mitigation.

## WHAT FURTHER QUESTIONS DO YOU HAVE ABOUT THIS TOPIC?

# NOTES

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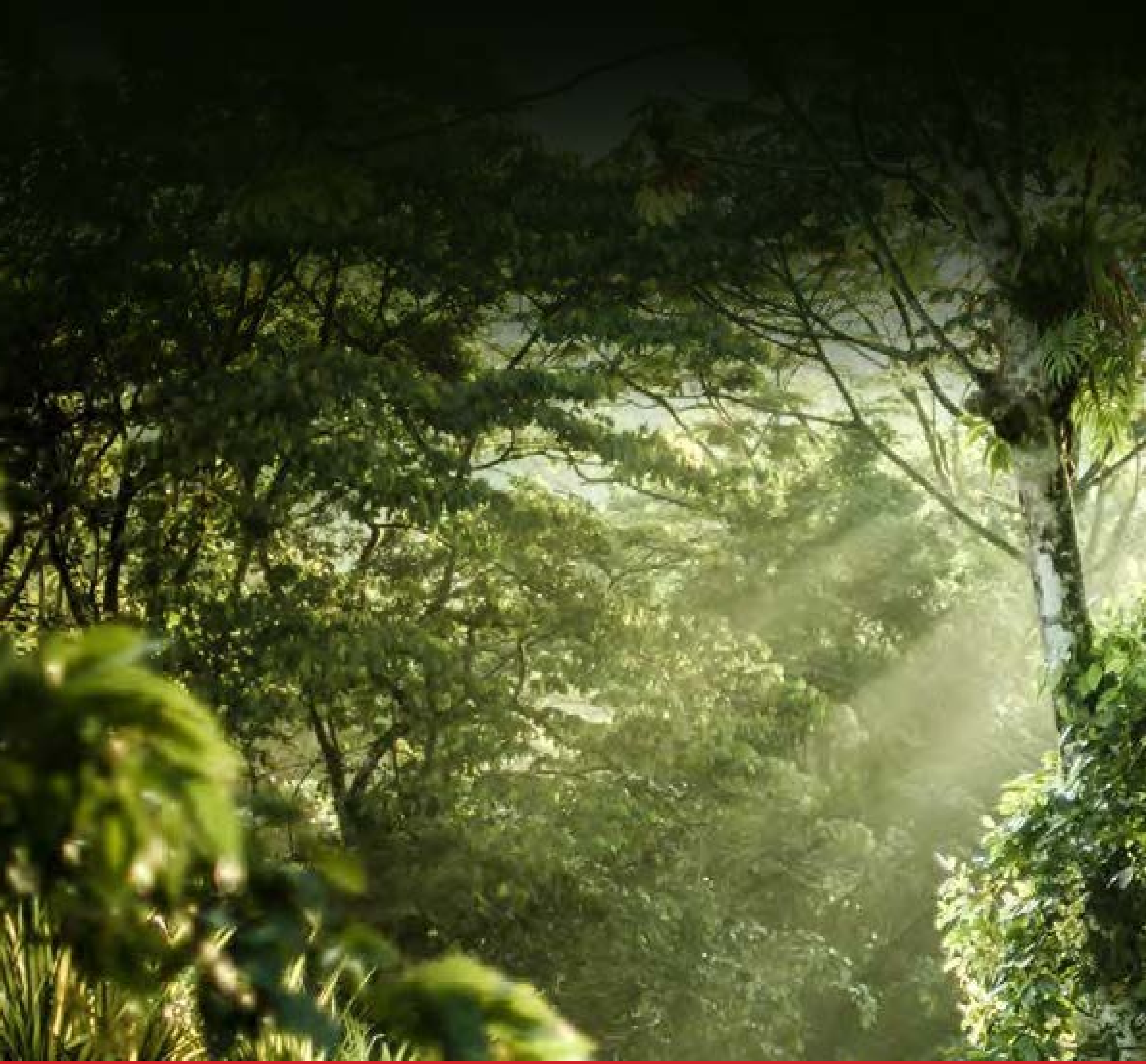

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