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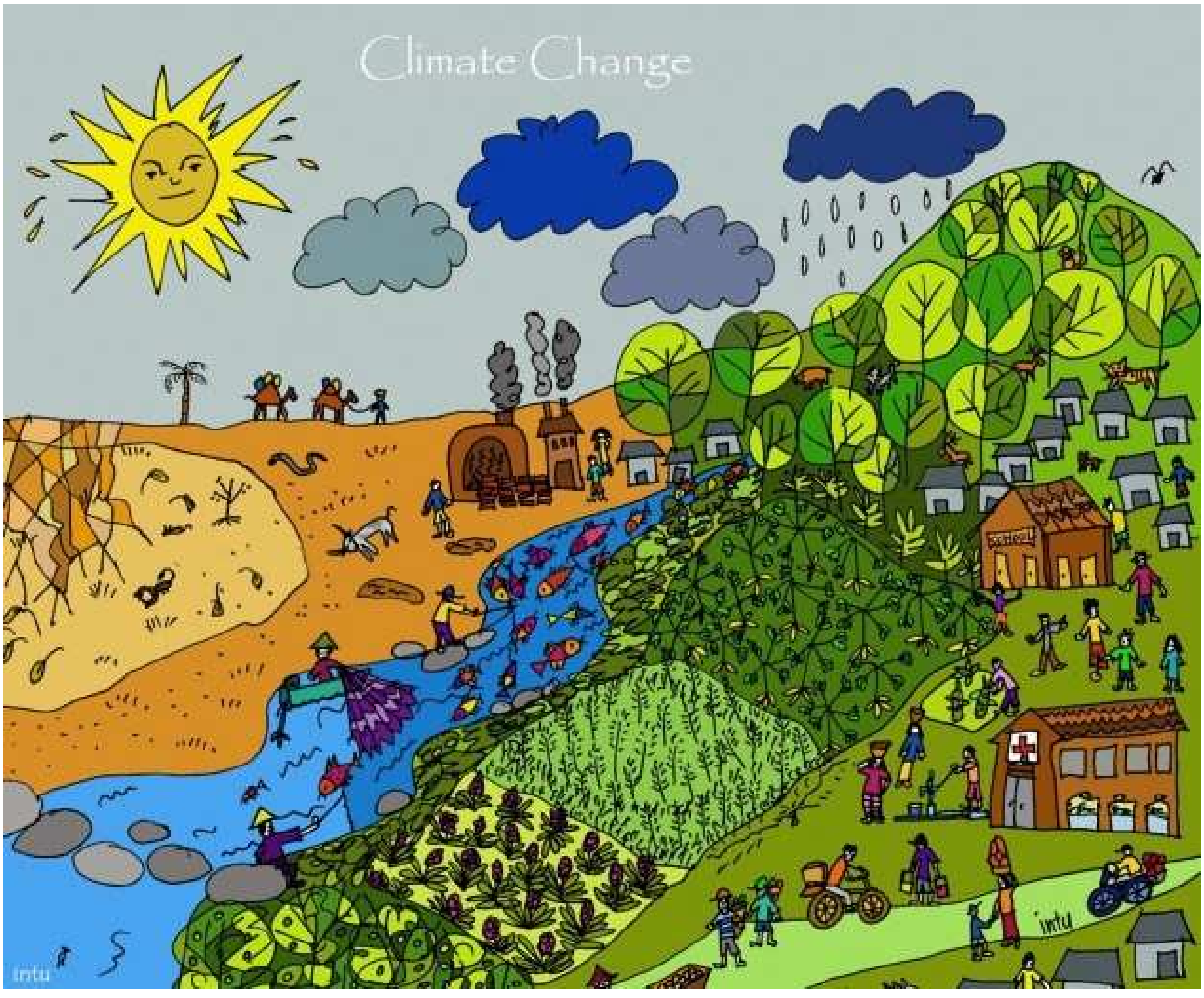
Forestry and Land Use; impact on climate change

A report prepared as course requirement for EL4
Climate Change and its Impact on Energy Sector



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Introduction

"Climate is the statistics of weather, usually over a 30-year interval. It is measured by assessing the patterns of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Climate differs from weather, in that weather only describes the short-term conditions of these variables in a given region." (Wikipedia, 2017) Climatic conditions differ with respect to geo-spatial location, which encompasses the latitude, longitude and altitude of a particular place, and in the atmospheric conditions, which is not only determinative of place, in particular, but is of global significance, i.e. has trans-boundary effects.

Climatic anomalies have been observed in modern times, and have been addressed as climate change. The cause for the variations in atmospheric conditions may have direct or indirect consequence of human activities, such as, deforestation and burning of fossil fuel. "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen." (IPCC, 2014) Increased trend in average global temperature, sea level and atmospheric green house gases (GHG) have been prominent observations to emphasize changing climate. Since, industrialization, energy intensive production has lead to heightened use of fossil fuel, primarily coal, and petroleum products. Rising global population is another phenomenon, which has put stress on ecosystem, by increased extraction of natural resources, and changing in land use. "Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity." (IPCC, 2007) Changes in global climatic pattern, which is governed by precipitation, temperature, frequency of occurrence of extreme weather conditions, have been frequent in recent times. One of the changes, rise in global average surface temperature, is caused due to increased concentration of GHG in atmosphere. Similarly, the rise in ocean temperature is another alarming phenomenon of global warming, which can alter climatic condition by melting of polar cap ice, change the precipitation trend, rise in sea level due to thermal expansion of water and melted ice.

Along with huge ocean surface, which covers 71% of earth's surface, terrestrial biosphere also plays vital role in regulating climatic conditions. Land is in constant play with atmospheric composition of carbon dioxide, through means of soil and vegetation. Humans are changing the natural rate of exchange of carbon between the atmosphere and the terrestrial biosphere through land use, land-use change, and forestry activities. (IPCC, 2000) Increasing global population is putting pressure on natural ecosystem, by activities such as conversion of forest into agricultural land, extraction of natural resources through mining. The global net forest loss between 2000 and 2010 was 5.2 million hectares per year, and the total forest cover is roughly 31% of total land coverage, just above 4 billion hectare. (Earth-Policy, 2012) Hence, the study of climate change with respect to change in forestry and land use is justifiable, since its interconnectedness to pervade changes in global atmospheric conditions and climatic variations. Numerous studies have concluded with strong relationship between forestry, land use and climate change. This report encompasses their relationship with reference to contextual studies.

Objective

The generic objective of the report is to study the relationship between forestry, land use and climate change. The specific objectives can be stated as follows:

- To study relationship between forestry-land use and climate change in reference to modern studies.
- To address mitigation, adaptation measures and coping strategies.

Methodology

The scope of study has been confined within literature study. This is report prepared as a requirement of course, “Climate Change and its impact in energy sector”, as class project. Literature study pertaining to forestry and other land use changes and its impact on climate changes were studied, which were published by institutions ranging from Inter-governmental panel to academic journals.

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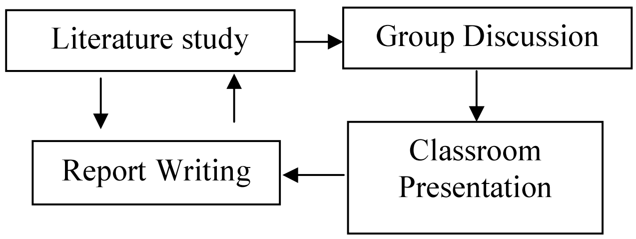


Literature Keywords

Forestry and other Land Use; Climate change; Global Warming; Green House gas; Carbon Cycle; Radiative Forcing

Listed keywords were used to search literature in internet. The sorting of relevant notes were done to produce bricolage of literature and support the study structure. Papers which dealt with climate change, forestry and other land use changes have been studied to produce findings in this report. Reports, studied were from IPCC, journals from authors pertaining to academic background. Books, which were referred as text books were studied in conjunction to other sources. The class project was assigned as group project with member of two. Group discussion on topic and literature findings went hand in hand with structuring of presentation and report. Classroom presentation outcomes, feedback and suggestions from external jury were incorporated in report writing. Literatures were further consulted during report writing, for new approaches to further matter of study.

<u>Findings and Discussion</u>
The headings for this section have been structured with respect to objective of the study. Firstly, observations and statistics related to climate change have been presented to provide background on climate change and its impact. Then, the core objective of relating forestry and other land use (FOLU) with climate change has been discussed in forestry and land use; factors influencing climate change. Theories behind global warming with reference to carbon flux and radiative forcing is presented in this section. Global and regional contexts are presented in the second section. The third section presents Nepal's scenario of forestry sector. Information on forest and its policy are key contents of this section. Finally, the Mitigation and adaptation measures have been presented, which are recent outcomes from climate change policy summaries and coping strategies.

Forestry and land use changes; factors influencing climate change

Modern science has evolved to theorize the relation between the thin layer of atmosphere that surrounds the entire biosphere and creates climate. Forest and land use have significant impact not only on shaping micro climate, but also affects global carbon cycle. Forest acts as carbon sequester or sink as it takes the Carbon dioxide from air and turns it into plant material. Soil also interacts with air to exchange their content. Through processes of respiration and through the decay of organic matter or burning of biomass, forests release carbon. A carbon 'sink' is formed in the forest when the uptake of carbon is higher than the release. Carbon stocks in forest areas comprise carbon in living and dead organic matter both above and below ground including trees, the understory, dead wood, litter and soil. On a global scale, vegetation and soils are estimated to trap 2.6 gigatonnes (Gt) of carbon annually. Yet there are still many uncertainties about the workings of the carbon cycle: the Intergovernmental Panel on Climate Change (IPCC) estimates that the amount of carbon absorbed in the soil and vegetation amounts to anything between 0.9 and 4.3 Gt annually.
Carbon stocks in land-based ecosystems are distributed irregularly between tropical and northern latitudes but are mostly concentrated in forest ecosystems and wetlands. Recent research suggests tropical forests play an even more important role in absorbing carbon than previously thought, taking up 1 Gt of carbon every year, or about 40 per cent of the total for land based absorption.
The conversion of forested to no forested areas in developing countries has had a significant impact on the accumulation of greenhouse gases in the atmosphere, as has forest degradation caused by over-exploitation of forests for timber and woodfuel and intense grazing that can reduce forest regeneration.

"Climate change can affect forest by altering the frequency, intensity, duration and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides." (DALE et al., 2001)

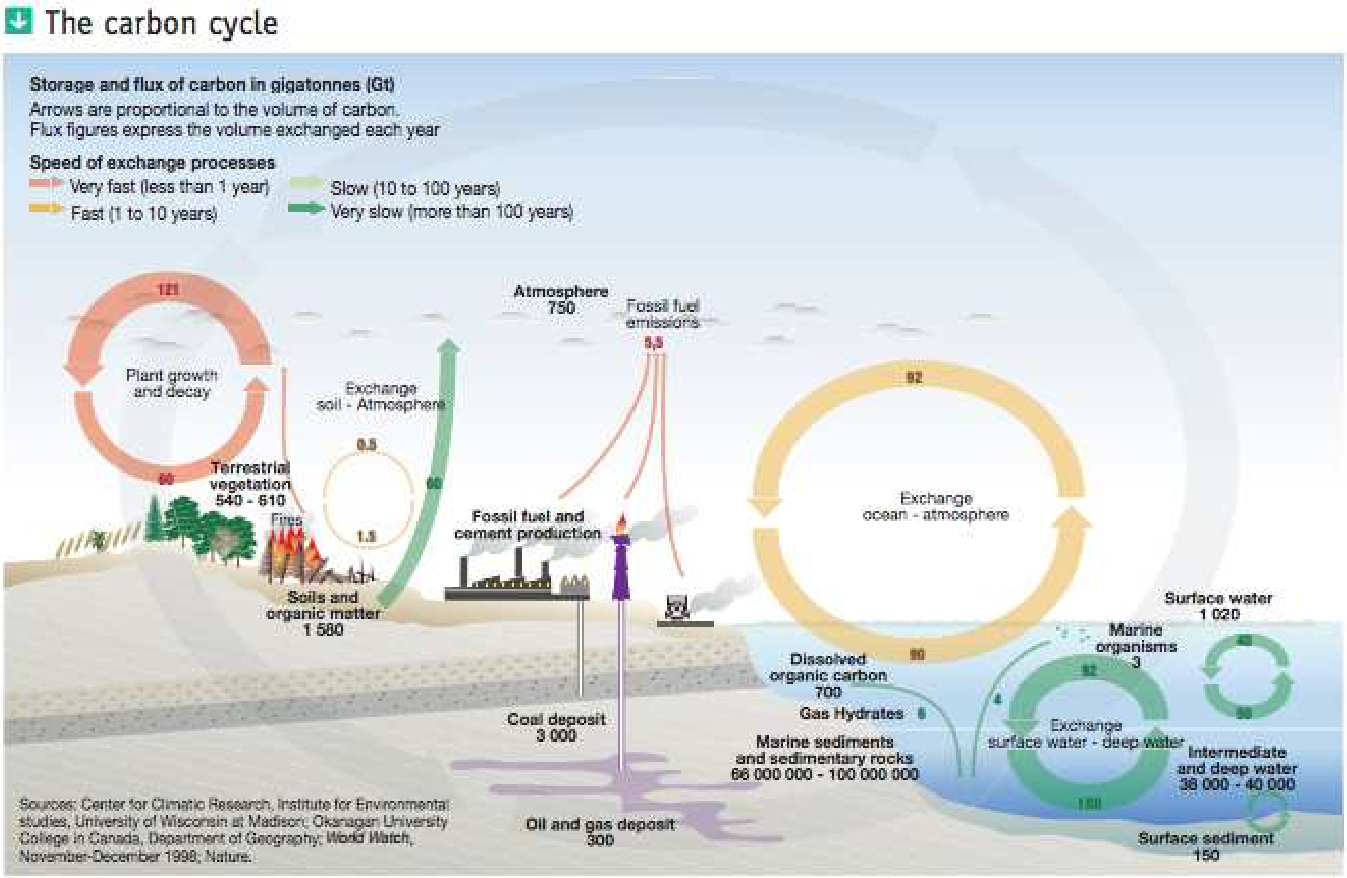


Figure 1: Global carbon cycle

Scientists are continuing to investigate just how much carbon is emitted as a result of deforestation and forest degradation. The most vital issue is to estimate the true level of global deforestation and forest degradation and the resulting release of carbon stock from the biomass and the soil. In its 4th Assessment Report of 2007 the IPCC said carbon emissions as a result of land-use change – mainly due to deforestation in the tropics – were running at 1.6 Gt of carbon per year in the 1990s, or around 17.4 per cent of the world's total anthropogenic (manmade) emissions of greenhouse gases. However this figure represents only the mid-range estimate, with the IPCC using a range of between 0.5 to 2.7 Gt per year. A particularly serious impact of deforestation on global climate change is the destruction of forest areas located on peat bogs. Peat areas in tropical zones such as Indonesia and Malaysia only cover about 40 million hectares. Yet when cleared, the destruction of the forest, plus the draining of carbon rich peat land, results in a massive release of CO_2 : it is calculated that such activities now release about 0.5 Gt of CO_2 a year, or 8 per cent of total annual anthropogenic emissions. In the boreal zone, there are vast expanses of forests on bogs and peat land. The loss of surface permafrost in these areas due to rising temperature will increase the net carbon storage due to vegetation growth, but this increase will be offset by methane emissions (WWF 2008). Under the United Nations Framework Convention on Climate Change, the Kyoto Protocol was adopted in 1997 with the objective of setting targets to reduce greenhouse gases that cause that cause climate change. During the first Kyoto commitment period (2008-2012), tree plantation projects were considered eligible for carbon credits under the Clean Development Mechanism (CDM), whereas sustainable forest management was excluded from the CDM for a number of political, practical and ethical reasons

(Grif- fiths 2007). Since carbon emissions from deforestation represent close to one fifth of all anthropogenic greenhouse gases, an initiative was created at the Climate Conference in Montreal in 2006 to “Reduce Emissions from Deforestation and Degradation” (REDD). REDD carbon credits are at the moment included only on the voluntary market.

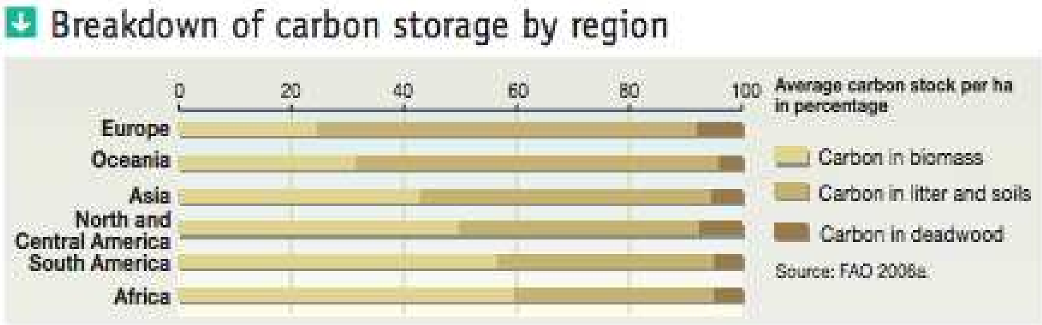


Figure 2: Carbon storage by region.

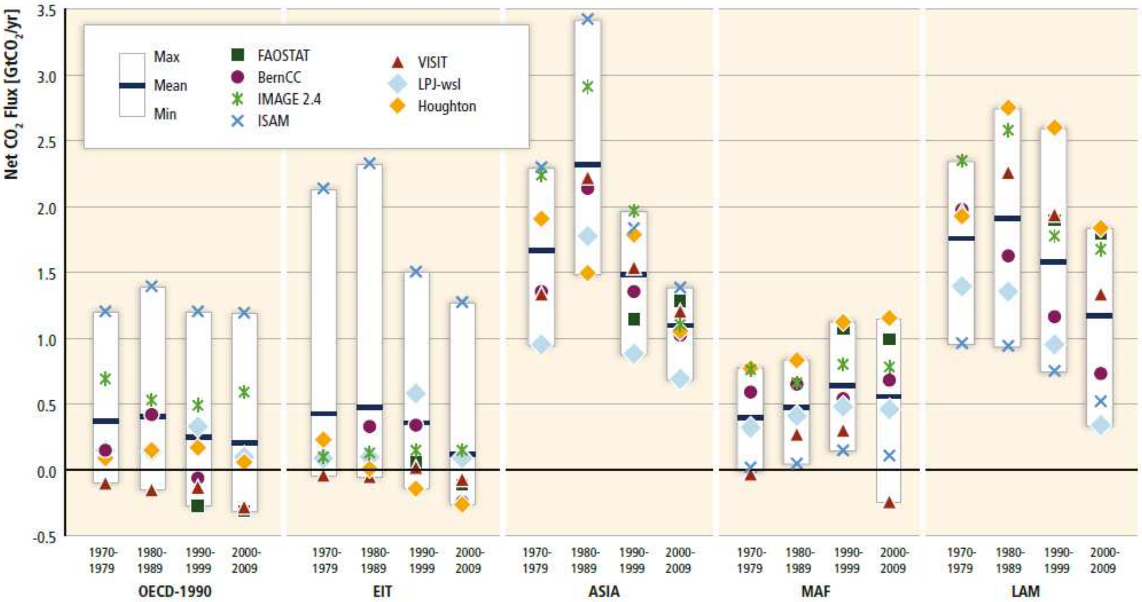


Figure 11.7 | Regional trends in net CO_2 fluxes from FOLU (including LUC). Houghton bookkeeping model approach updated to 2010 as in Houghton et al., (2012) and five process-based vegetation models updated to 2010 for WGI Chapter 6; (Le Quéré et al., 2013): LPJ-wsl: (Poulter et al., 2010); BernCC: (Stocker et al., 2011); VISIT: (Kato et al., 2011); ISAM: (Jain et al., 2013), IMAGE 2.4: ((Van Minnen et al., 2009), deforestation only). Only the FAO estimates (FAOSTAT, 2013) include peatlands.

Figure 3: Regional Trend of Net CO2 flux

Forestry and Other Land Use Emissions and Removals

Greenhouse gas emissions and removals in FOLU consist mainly of CO2linked to the oxidationand fixation of organic matter following human disturbance. Non-CO2 emissions are linked toloss by fire of biomass and organic soils. The estimated emissions data include processes on forest-land (net forest conversion and forest), cropland and grassland, the latter two dominatedby emissions from drainage and fires on organic soils.

In 2010, world total annual GHG net emissions from FOLU were 2,816 Mt CO2 eq. This level is 8% lower than the decadal average 2001-2010. The FOLU net emissions were the result ofremovals by sink in Annex I countries of -860 Mt CO2eq, combined with emissions by sourceof 3,676 Mt CO2eq. in non-Annex I countries.

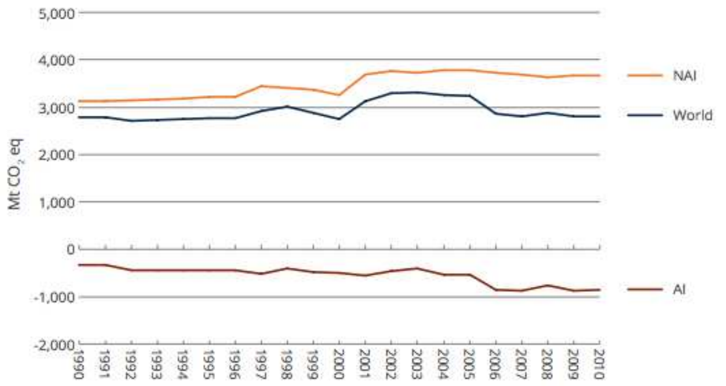


Figure 4 Historical trend of FOLU emission and removals (source: FAO 2014)

2001-2010 Trends: Global

Over the period 2001-2010, annual net emissions decreased by -10%, from 3,133 to 2,816 Mt CO2 eq. Just as in 2010, this was the result of a growing net sink in Annex I countries (i.e., +54%, from -557 to -860 Mt CO2eq), combined with a stable though large net source from non-Annex I countries, from 3,690 to 3,676 Mt CO2 eq. From 1990 to 2010, the net sink in Annex I countries increased by 157%, while the net source in non-Annex I countries increased only slightly, by +0.7%.

At regional level, all continents except for Europe (offsetting about 10% of global FOLU emissions by source) were emission sources, dominated by the Americas (37%), Africa (28%)and Asia (22%).

All land use categories were globally net emission sources. The largest was forest-land (63%), followed by cropland (25%) and grassland (11%) Non-CO2 emissions from burning biomass (forest and peat fires) contributed 1% to the total.

FOLU accounted for about a third of anthropogenic CO2 emissions from 1750 to 2011 and 12 % of emissions in 2000 to 2009. (IPCC, 2014) Similarly, Kalnay and Kai (2003) estimated 40% of the global temperature rises is coming from land use changes, Marland estimated 50%.

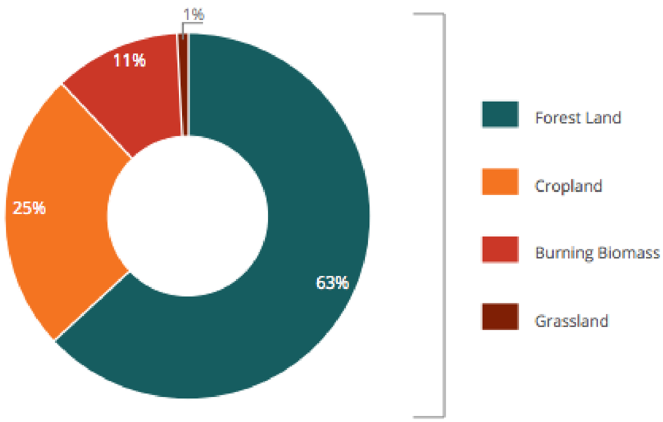


Figure 5 FOLU emission and removals by sub-sectors (source: FOA 2014)

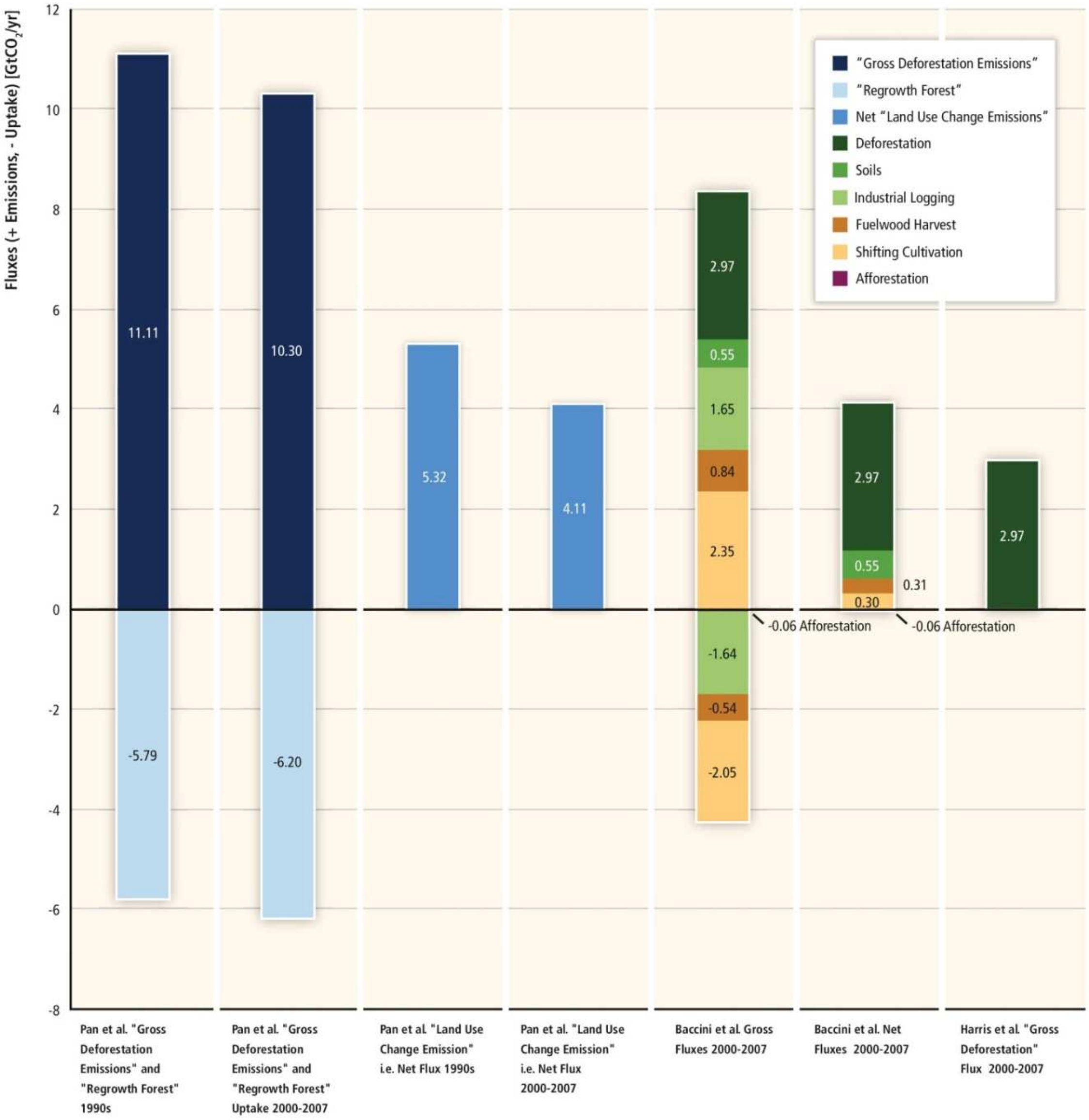


Figure 11.8 | Breakdown of mean annual CO_2 fluxes from deforestation and forest management in tropical countries ($GtCO_2$/yr). Pan et al. (2011) estimates are based on FAO data and the Houghton bookkeeping model (Houghton, 2003). Baccini et al. (2012) estimates are based on satellite land cover change and biomass data with FAO data, and the Houghton (2003) bookkeeping model, with the detailed breakdown of these results shown in Houghton, (2013). Harris et al. (2012) estimates are based on satellite land cover change and biomass data.

Figure 6: Annual Fluxes from various studies

The figure presents annual net fluxes of CO_2 adopted from numerous studies which depicts the cause of emission as deforestation. Afforestation and forest regeneration has also been considered in some of these studies. Pan and et al. presents net land use change, which is accountable for net global emission of 4.11GT CO_2 per year, from studying trends from 2000-2007. Because trees can survive from decades to centuries and take years to become established, climate-change impacts are expressed in forests, in part, through alterations in disturbance regimes. (DALE et al., 2001)

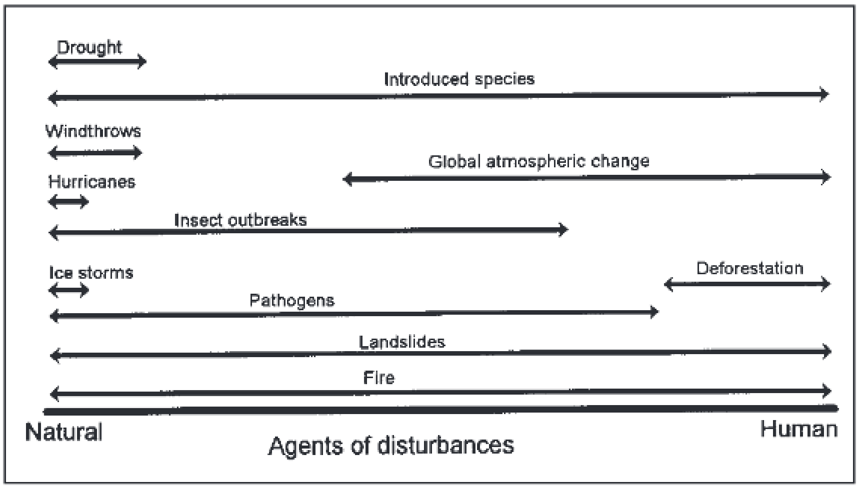


Figure 7: Natural and anthropogenic agents of forest disturbances that result from climate change. The length and position of the arrow relates to the extent of natural versus anthropogenic influence on the agent. (DALE et al., 2001)

Nepalese context

Nepal locates from 26°22' to 30°27'N in latitude and 80°04' to 88°12'E in longitude. The country spans approximately 885 km from east to west, and the north-south width varies from 130 km to 260 km. The variation in altitude is 60masl, in southern plains (Terai) to 8848masl, the highest mountain of world, Mount Everest. This variation in landscape has resulted in biodiversity. 147,181 Sq. Km is the total area of Nepal, among which 14% is flat lands of south, and the rest 86% is hilly and mountainous region (GoN, 2015). Due to the wide range of climatic and topographic conditions across the country, almost every known forest type (except for tropical rain forest) is found in Nepal. (GoN, 1997) The people of Nepal have traditionally depended on forests for the supply of fuelwood, fodder, timber and other forest products. This heavy pressure on forests together with the land use practices that are not compatible with the terrain of the country, has resulted in serious environmental problems. (GoN, 1997)

(Negi & Negi, 1994) divides Nepal into four types of forest regions. This broad classification of forest regions takes into account the varieties of geographical areas and are as follows;

- Outer or Siwalik region
- Lower Himalaya or Midlands region
- Main Himalayan region
- Arid region

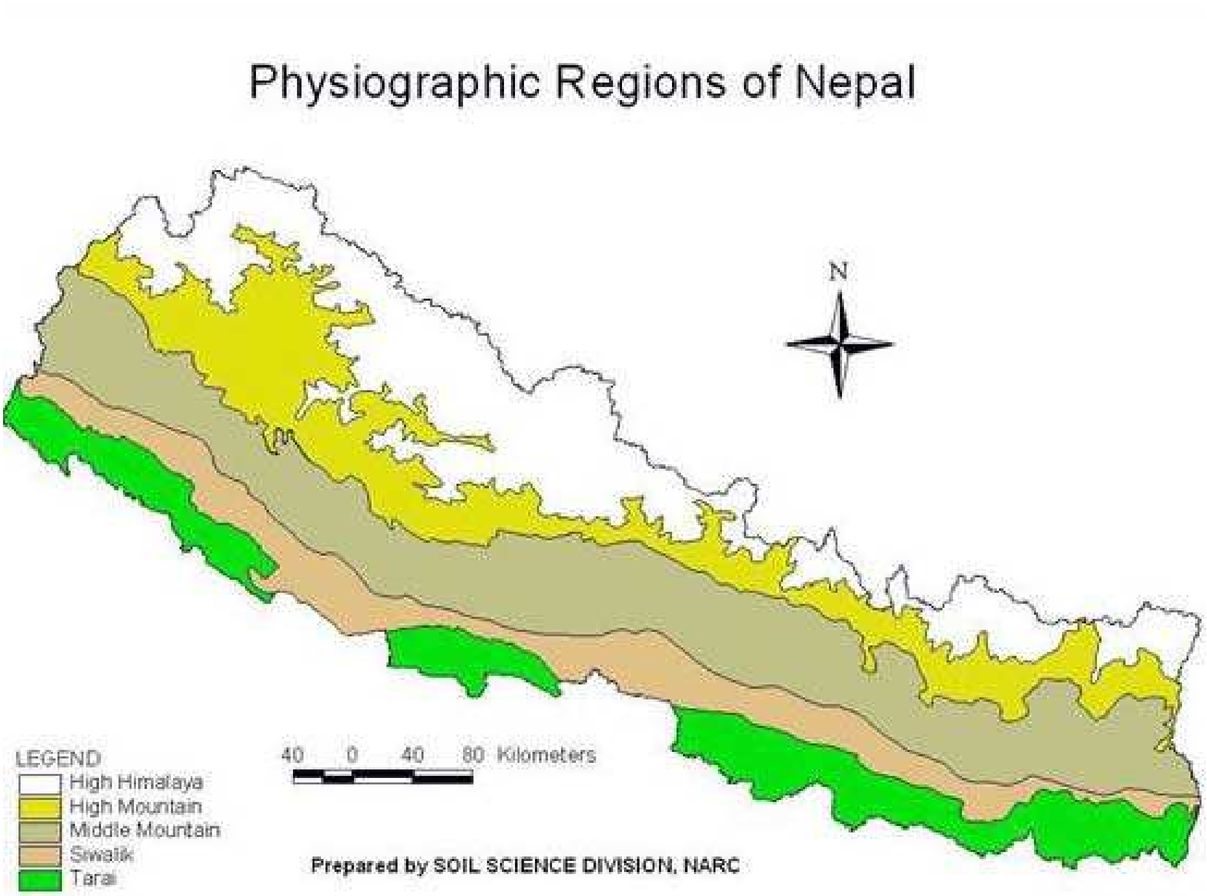


Figure 8: Geographical regions of Nepal

Some of the types of forests categories are as follows:

- Sal forest
  - Bhabar and Terai sal forest
  - Dun sal forest
  - Hill sal forest
- Tropical Deciduous Riverine forest
- Tropical evergreen forest
- Sub tropical evergreen forest
- Sub tropical semi-evergreen hill forest
- Terminalia forest
- Sub-tropical deciduous hill forest (upto 1300 masl)
- Schima-castanopsis forest (700-2000 masl)
- Khair-shisam forest
- Chir pine forest
- Lower oak forest (upto 2700 masl)
- Middle oak forest
- Upper oak forest
- Castanopis forest

Ministry of Forests and Soil Conservation is governmental body which is associated to forestry. Departments under this ministry are;

- Department of Forest
- Department of Soil Conservation
- Department of National Parks and Wildlife Conservation
- Department of Plant Resources.

Similarly, parastatals and development boards:

- Nepal Rosin and Turpentine Industry
- Herb Production and Processing Company
- Forest Products Development Board
- Forest Research and Survey Centre Development Board.

Reserved areas, national parks amount to 14% of total land area of Nepal. The number and kinds of environmental initiatives, protected areas and wildlife resources are as follows:

- National Park: 8
- Strict Nature Reserve
- Wildlife Reserve:4
- Hunting Reserve:1
- Conservation Area: 2
- protected watershed (Soil and Watershed Conservation Act)

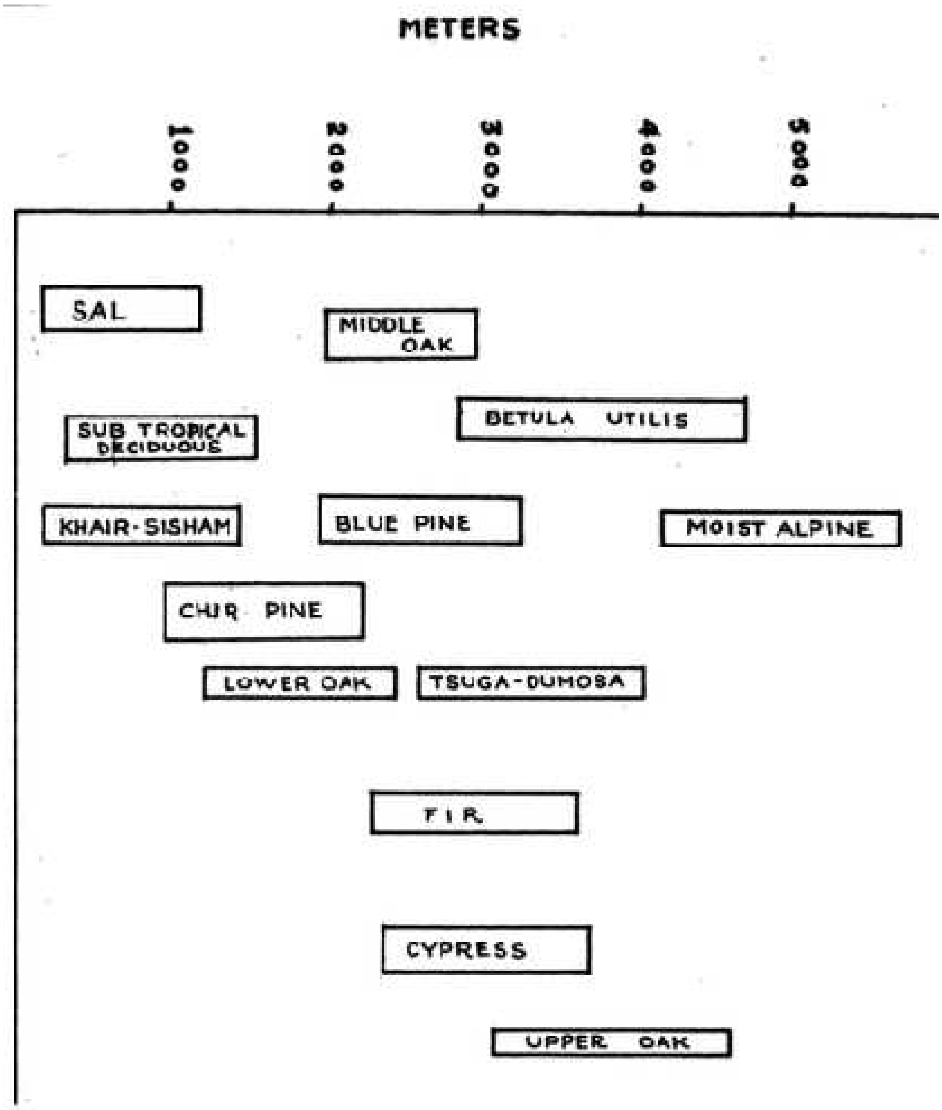


Figure 9: Altitudinal distribution of forest types (western Nepal). (Negi & Negi, 1994)

The share of agriculture, forestry and fishery in the GDP is about 60% with forestry contributing about 15%. (GoN, 1997)Listed below are forest produce which have been promoted in recent times.

- Wood energy
- Wood based industries
- Timber harversting
- Saw milling
- Furniture industry
- Plywood
- Wooden Handicrafts
- Paper mills
- Non-wood forest product
    - Resin
    - Turpentine
    - Mining (stone quarries)

According to Food and Agriculture Organization, Global Forest Resources Assessment (WorldBank, 2017), the total forest area of Nepal has reduced from 48 thousand sq. km to 36 thousand sq. km. from 1990 to 2015. The average annual rate of deforestation from 1990 to 2000 was 2.09%, while from 2000-2015 was 0.47% of total forest area. This shows the reduction in deforestation rates. However, it has been observed in news and media that, the illegal logging has increased in recent times. Together with logging, the shifting of settlement in forest territory is also a prominent threat to encroachment of forest area.

1.Mitigation and adaptation measures

Mitigation activities in the AFOLU sector can reduce climate forcing in different ways:

- Reductions of carbon losses from biota and soils, e. g., through management changes within the same land-use type (e. g., reducing soil carbon loss by switching from tillage to no-till cropping) or by reducing losses of carbon-rich ecosystems, e. g., reduced deforestation, rewetting of drained peatlands.
- Enhancement of carbon sequestration in soils, biota, and long lived products through increases in the area of carbon-rich ecosystems such as forests (afforestation, reforestation), increased carbon storage per unit area, e. g., increased stocking density in forests, carbon sequestration in soils, and wood use in construction activities.
- Changes in albedo resulting from land-use and land-cover change that increase reflection of visible light.
- Provision of products with low GHG emissions that can replace products with higher GHG emissions for delivering the same service(e. g., replacement of concrete and steel in buildings with wood, some bioenergy options). (IPCC, 2014)

Table 2. Coping strategies for dealing with disturbance effects on forests.

Managing the system before the disturbance

To reduce vulnerability:

- Altering forest structure (e.g., tree spacing and density, standing dead trees, or coarse woody debris on forest floor)
- Modifying the landscape structure (e.g., the size or location of management activity)
- Changing species composition (e.g., planting alternative species)

To enhance recovery:

- Altering structure (e.g., enhancing advance regeneration)
- Adjusting species composition (e.g., planting alternative tree species)

Managing the disturbance

- To reduce the opportunity for the disturbance to occur (e.g., regulating nonnative species introductions or use of fire)
- To reduce the impact of the disturbance (e.g., rapid response to control insects, pathogens, or fire)

Managing recovery

- To speed recovery (e.g., adding structural diversity, planting late-successional species, or reducing environmental stress)
- To reduce vulnerability to future disturbances (e.g., managing tree density, species composition, forest structure, and location and timing of management activities)

Monitoring for adaptive management

- To measure the state of the forest with and without disturbance
- To determine interactions between disturbances

Figure 10: Coping strategies, adapted from (DALE et al., 2001)

The strategies are in co-ordinance with the causes of disturbance in forest system. The strategies are inferential with stages of disturbances, before, during and after disturbance. Monitoring and adaptive management is crucial in continuation and maintenance of forest system. Similarly, MoFSC has come up with Nepal Forestry Policy, 1988. Some stated scopes for forest management are as follows:

- Production and Utilization
    - basic priority products of fuelwood, fodder, timber, and medicinal plants.
- Conservation of ecosystems and genetic resources
    - conserve the forests, soil, water, flora, fauna and scenic beauty
- Social aspects of land use
    - Community forestry
    - multiple utilization of land for integrated farming systems
- Role of the private sector
    - private forests on leased and private land to be promoted
    - plans for the production and acquisitions of raw materials

Payment for Ecosystem Service (PES)

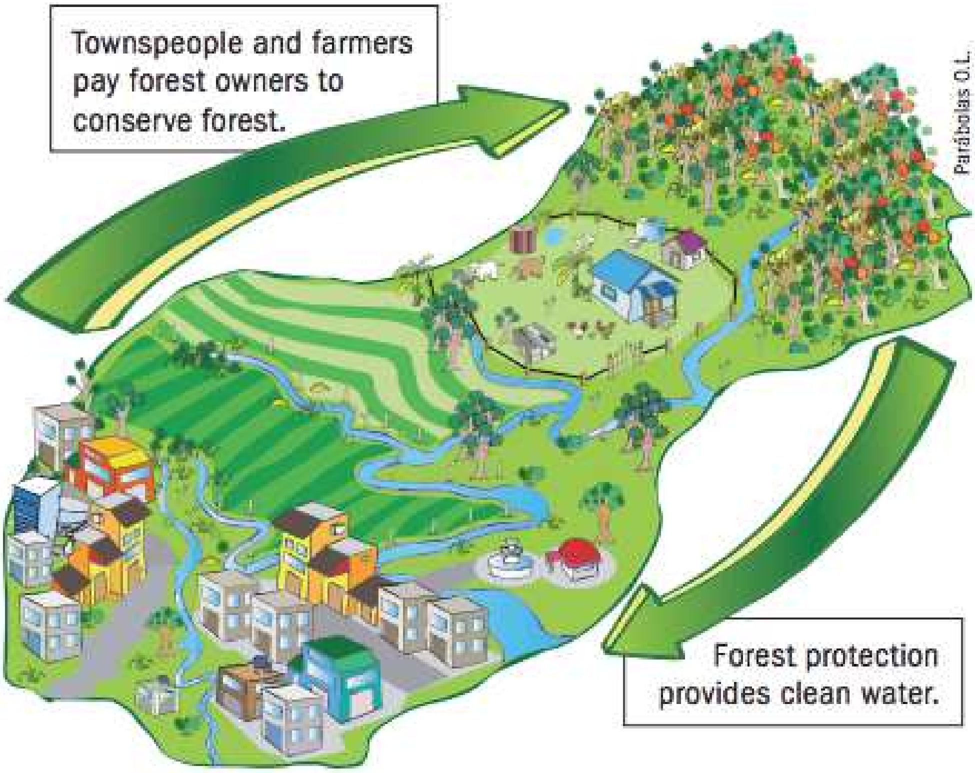


Figure 11: Town, farm and forest relation. PES depiction.

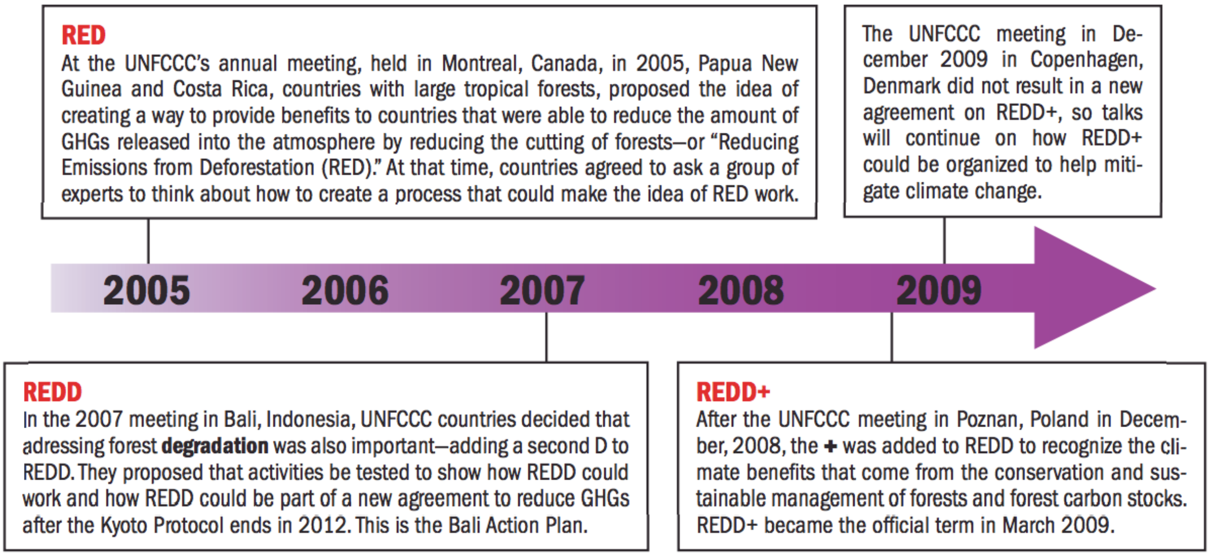
A payment for ecosystem services activity (sometimes called a scheme) works like a trade activity. For example, a PES activity would include:

- a person or a group of people (such as the community or government),
- that offers a service (such as forest conservation) and
- a person or group of people who provide the community or government with payment or benefits in exchange for the service they receive (such as clean water).

In a typical PES mechanism, sellers of ecosystems services are landowners or forest right holders and buyers can be government agencies (federal, state, and local), non government organizations or private individuals and corporations. PES transactions include public payments (e.g. federal, state, and local government payments); voluntary transactions (e.g. sale of forest carbon offset credits in the voluntary carbon market); compliance-driven transactions (e.g. payment mechanisms developed in response to government regulation) or combined payments where different sources of funds are pooled to make payments. Payments are made through formal and informal contracts that place financial values on stewardship services and range from one-on-one informal agreements to large-scale public systems that shift economic investments towards desirable land stewardship. (FAO, 2014)

Reducing Emissions from Deforestation and Forest Degradation (REED+)

REDD+ is an international mechanism under negotiation within the UN climate talks and other international forums which will provide compensation to governments, communities, companies or individuals in developing countries for actions taken to Reduce Emissions from Deforestation and forest Degradation below an established reference level. In essence, it aims to incentivise forest protection over forest destruction. REDD+ is expected to be an integral part of a new climate agreement and to include a system for monitoring activities and ensuring they deliver results. (GlobalWitness, 2010)



<u>Corruption risks</u> (GlobalWitness, 2010)

Based on real cases in countries undergoing 'REDD+ readiness' or in projects under the CDM, the following corruption risks have been identified:

• **Inappropriate validation**
Bribery, corruption or conflicts of interest can influence validators' decisions with regard to projects. Fraud can also take the form of project sponsors presenting inaccurate or misleading data.

• **Overestimation of carbon benefits**
There may be strong incentives to overestimate the amount of carbon emissions reduced / carbon stocks enhanced. Agencies responsible for measuring, reporting and verifying emissions (MRV) may also be subject to political pressure from state elites wanting to maximise the potential of emission reduction schemes to generate revenues.

• **Verification of fictitious projects**
MRV governance weaknesses could result in verification of projects that never took place or developers seeking payments for illegitimate projects.

• **Double-counting and fraudulent trade of carbon credits**
There have been instances of commercial fraud in carbon credit trading on global carbon markets, including

practices such as selling fictitious credits for non-existent or illegitimate projects, or with the same credits sold to multiple buyers. Such practices are made possible by poorly regulated carbon markets and the intangible and complex nature of carbon credits.

• **Misappropriation of carbon rights**

In some countries corrupt carbon brokers and project developers may be taking advantage of opaque negotiation processes to take over local landowners' carbon rights in a fraudulent manner, in some cases with the complicity of government officials.

Figure 12: Promotion of Forests by WWF

Conclusion:

It is clear that forest and land use have role in global carbon balance, thus affecting atmospheric conditions. Trees and soil act as carbon sequester. Plants uptake carbondioxide from air and converts it into plant matter, this phenomenon differs with season. Hence, during fall, it is expected that, vegetation will not uptake CO2 as it does during summer and spring. The falling of leave in return might aid in carbon emission in form of methane. Similarly, soil also facilitates plants growth thus aiding to forest growth. IPCC's fourth assessment report mentions, use of biochar, to improve soil fertility and enhance carbon sequestration.
Amongst anthropogenic sources for CO2 emission, deforestation is one of the highest contributors. Forest degradation, and conversion of forest land into other land use, such as agriculture, mining seem to be main factors for deforestation.
Climate change is related to forest and land use through two facets; one through terrestrial carbon exchange mechanism while the other is through radiative forcing, change in surface albedo. The former factor influences net uptake of CO2 from atmosphere. Hence, it is important to maintain forest area in terms of net carbon uptake. Similarly, the later, change in land use triggers change in surface albedo. It has been concluded from many studies that change from forest land to cropland has had negative global warming effect, by increasing surface albedo. Similarly, the change in land use might induce higher concentration of aerosol in atmosphere. In this case also the net effect would be increase in reflection of solar radiation from atmosphere, hence increased albedo. Thus, incease in aerosol concentration would also trigger net global cooling effect. However, this increase in aerosol particle in atmosphere would be detrimental to health conditions, exacerbating respiratory, skin, eye diseases.
Various forest conservation strategies have been formulated. Some of which pertain to improvement of forest system by natural means while, some strategies, depend on intervention of human in utilizing and managing forest resources. Promotion of native plant specimen enhances performance and is less susceptible to diseases and pathogens, which might degrade entire forest. Similarly, soil conservation strategy is vital in retaining the top, humus soil. Places in South Asia, which exhibit annual average rainfall of 2m are prone to landslide and flooding. The down pour leads to draining of top, fertile soil with the flow of water, depositing it into the low lands. The conservation of soil will ensure retention of humus soil, thus providing vegetation to grow with better soil nutrients, therefore enhancing forest growth. Programs like PES and REED+ have promoted stage for global participation in process of conserving forest land. However, few cases exhibit degraded forest due to inapt monitoring and implementation.
Forest not only has association to climate change, but its close associates are the bio-diversity. The loss of bio-diversity due to deforestation and land use change has shifting balance on intricate eco-system. Forest disturbances not only results in climatic anomalies but also influences biodiversity, both flora and fauna.

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