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EU's approach to Use of Forest Biomass and Forestry in Nepal for Climate Change and Mitigation Factors

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<p>Biomass energy has a huge share in Nepalese primary energy consumption. Traditional practice of biomass usage is still practised in rural parts of Nepal though, its negative impact is well-known. On the positive note, efficient use of biomass can reduce impacts of traditional biomass usage and create energy security. Forest biomass has a huge share in the total biomass for energy use and it is very important to develop forestry sector for socioeconomic and environmental prospect.</p> <p>Forest in Nepal covers approximately 44.74% of the total land area in Nepal. Different approaches have been taken in Nepal for the Sustainable forest management practises. The most important provision issued in the Forest Act by Government of Nepal is Master Plan for the Forestry Sector and there are many programmes under forest management practises in Nepal. Community- based forest management practise has been one of the best possible solutions for forestry development in Nepal and has been successfully implemented in 38.5% of the total forest area in Nepal. Different steps have been taken in EU for Sustainable Forest Management and Nepalese forestry can make a considerable leap by learning from EU forest sector. EU approach such as commercialization of forestry sector, innovation in forestry, proper forest information system could be beneficial for Sustainable Forest Management in Nepal.</p> <p>Number of effects of climate change have been observed and is a challenging threat throughout the globe. Nepal has also faced numerous weather disaster events because of climate change. The variation in topography and social vulnerability has made Nepal more sensitive to different climate-related disasters and geological disasters. Climate change mitigation through forestry is an effective approach and Nepal has also been trying to combat climate change through forestry with joint effort of EU and other countries.</p>	
Keywords	Biomass, forest, climate change, EU

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List of Abbreviations

ADB	Asian Development Bank
AEBIOM	The European Biomass Association
AMS	American Meteorological Society
AR	Afforestation Reforestation
BVOC	Biogenic Volatile Organic Compound
CBFM	Community Based Forest Management
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
CIESN	Center for International Earth Science Information Network
CO ₂	Carbon dioxide
CBS	Central Bureau of Statistics
DNPWC	Department of National Parks and Wildlife Conservation
DOF	Department of Forestry
EU	European Union
FAO	Food and Agriculture Organization
FRA	Forest Resources Association
GEF	Global Environment Facility
GHG	Greenhouse Gases
GON	Government of Nepal
H ₂ O	Hydrogen dioxide (Water)
Ha ⁻¹ a ⁻¹	per hectare per area
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IPCC	International Panel on Climate Change
IUCC	Information Unit of Climate Change

ktoe	Kilo Tonnes of Oil Equivalent
KWH	Kilowatt Hour
LCA	Life Cycle Assessment
LULUCF	Land use, Land-use Change and forestry
MFSC	Ministry of Forests and Soil Conservation
MOEST	Ministry of Environment, Science and Technology
MOFE	Ministry of Forestry and Environment
MPFS	Master Plan for Forestry Sector
Mtoe	Million Tonnes of Oil Equivalent
NACRMLP	Nepal Australia Community Resource Management and Livelihood Project
NARMSAP	Natural Resource Management Sector Assistance Programme
NUKCFP	Nepal UK Community Forest Project
REDD	Reducing Emission from Deforestation and Forest Degradation
RWG	REDD Working Group
SAWEN	South Asia Wildfire Enforcement Network
TPES	Total Primary Energy Supply
Tg	Tera-grams
UN	United Nations
UNFCCC	United Nation Framework Convention on Climate Change
WB	World Bank

1 Introduction

In this thesis, the application of EU's forestry strategies and practices in Nepalese forestry has been studied. As biomass energy, is one of the primary renewable energies in Nepal and forest biomass has a huge share in it, measures to develop forestry sectors are important in Nepal. Current status of forest and changes of the land-use pattern, existing management practices in Nepalese forestry, approaches taken in EU's forestry sector and how Nepalese forestry sector can learn from it, have been discussed in this thesis. Also, climate change mitigation through forestry has been studied.

The major source of energy consumption in Nepal is biomass from forest, agricultural residues and animal dung. Most parts of the country still use firewood for cooking and heating purposes which is challenging in terms of both health and climate issues (IEA, 2015). Forest biomass is a major fraction of biomass sources for these household purposes.

Forest in Nepal covers 44.74% of the total area of the country (Government of Nepal - DOF, 2018). Nepal's forest is classified on the basis of different parameters like bioclimatic zonation, geographical locations, physiognomy and structural parameters, and floristic parameters. Considering these parameters Nepal's forest are classified as tropical, sub-tropical, alpine, temperate and sub-alpine forests. To meet the primary energy requirement, Nepal has been highly dependent on traditional energy sources such as fuelwood, crop residues, animal dung, and forest biomass is one of the important energy sources.

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, 2007).

Over the period of 1880 to 2012 the global average land and ocean surface temperature show a warming of 0.85 degree Celsius. During the last 40 years, nearly half of the anthropogenic CO₂ emissions have occurred (IPCC, 2015). Increased population, industrialization, biomass destruction has been the major source of emissions. Low reforestation and continuous deforestation for land use have been one of the major drivers for climate change. Changes in monsoon pattern, floods and landslides are major climate change

effects observed in Nepal (Ministry of Population and Environment, 2016). However, end-use efficiency improvement of biomass usage, low-budget renewable technologies, and reforestation could help mitigate the climate change factors and improve the health and living standard of people.

The European Union (EU) has 40 percent of land area covered with forest and woodland. The forest cover area is increasing steadily (approximately 0.4% a year (European Commission (EC), 2013). EU has been the world leader in reducing deforestation and forest degradation. Different regulations under FOREST EUROPE and LULUCF have been followed by EU and its member states to promote sustainable forest management for combating climate change, protecting biodiversity and supporting economically and socially for the rural and urban communities. Through REDD and REDD plus, EU Commission and member states have been supporting developing countries, for improving forest policies and regulations, strengthening and monitoring forest ecosystems to combat the issues of forest deforestation and degradation (European Commission (EC), 2013)

2 Biomass in Nepal

According to IEA statistics, energy is primarily supplied by biomass in Nepal. Energy Resources in Nepal has been principally categorized into three types: Traditional, Commercial and Alternative. All kinds of biomass used for producing energy with conventional practices are included in traditional energy. Likewise, entire energy resources with approved market values are categorized into commercial energy, whereas all indigenous energy resources are categorized under alternative energy resources.

In Nepal, the solid biomass fuels derived from plants and animals are only considered as traditional energy biomass fuels. Under traditional class, there are both woody and non-woody biomass derived from shrubs and grasslands, forests, agricultural residues (both harvested and processed), and animal waste (usually cattle dung) (Government of Nepal, 2013).

According to IEA, in 2016, 91% of the fuel used in Nepal is biofuel and waste used for cooking, which is equivalent to 9.55 Mtoe. Similarly, oil products and electricity account for 6% and 3% respectively (IEA, 2016).

In the year 2015, almost 77% of coal was used for the industrial sector but only 8% of biofuel and waste was used in industry. Almost 100% of the energy demand for transport sector is supplied by oil products. More than 90% of energy demand for cooking, agricultural and forestry is supplied by biomass (IEA, 2015).

Table 1 below indicates the overall final consumption of energy in the year 2015.

Table 1. Total Final Consumption of Energy by different sector in Nepal in 2015 (IEA, 2015)

Indicator	Coal (ktoe)	Oil products (ktoe)	Biofuel and Waste (ktoe)	Electricity (ktoe)
Industry	555	11	61	104
Transport	0	745	0	1
Residential	2	151	9394	169
Commercial	0	113	59	44
Agriculture/Forestry	0	125	0	9
Total Final Consumption	557	1154	9513	335

2.1 Introduction to biomass

Biomass refers to organic matters from plants and animals, or indirectly from plant-derived industrial, commercial or urban wastes, or agricultural and forestry residues. According to IEA statistics 2015, biomass fuels, approximately, contributed to 9.7% of global primary energy supply with 1.9% share in electricity production. With the rapid increase of fossil fuel consumption to fulfil energy requirement of huge population all over the world, it has been assumed that soon in the future natural gas and petroleum reserves will be scarce and therefore more use of alternative biomass energy resources is expected. Also, due to the growing environmental issues like climate change and fossil fuels' effect on the environment, the demand of biomass is increasing considerably.

Biomass is widely used as fuel for energy production and it is divided into five categories like virgin wood, agricultural residues, energy crops, food waste and industrial waste and bi-products (Forestry UK, 2018). Biomass energy has a huge potential to fulfil demand of future energy requirement. Forest biomass plays a vital role in biomass share contribution. It comprises of components from trees including the branch, foliage, root and stem. Residues from the forest accounts for about 50% of the total biomass but due to lack of availability of transportation and equipment they are usually left in the forest to rot (Sattar, 1996).

On the basis of different genetic organic matter, moisture content present in different biomass, the chemical and ash properties vary accordingly (Baxter, et al., 2010). Basically, biomass contains carbon and mixture of organic molecules containing hydrogen, oxygen, nitrogen and small quantities of other atoms, including alkali, alkaline earth and heavy metals (Forestry UK, 2018).

2.2 Role of biomass in Nepal

It has been accepted that the supply of economical and dependable energy is prerequisites for the socioeconomic stability of all the nations of the world. Ironically, there are many people especially in developing and underdeveloped countries who cannot have access to all kind of energy sources like electricity. Due to the lack of availability of resources, some communities have been compelled to use traditional energy sources. These sources have helped those communities to meet demand of their household needs. Along with traditional sources like agricultural residues and animal dung, fuelwood has been one of the important traditional energies in use.

Regardless of known negative impacts on the socio-environmental aspects of the country, a huge share of energy demand has been fulfilled by traditional energy resources in Nepal. Biogas use has decreased the consumption of fuelwood by 2 tons per year in Nepal which decreases the workload by 1100h/y. The use of biogas also reduces other form of non-renewable energy resources and workload (Gurung & Eun Oh, 2013).

The primary demand (especially cooking and heating) of the huge rural community in Nepal is supplied by biomass sources, such as fuelwood mainly from forest, residues from crops, as well as animal manure (Khanal, et al., 2011). With the huge demand of the growing population, conversion from a traditional biomass source to modern and

efficient bioenergy systems can play significant role in improving the energy scenario in Nepal (Pelkonen , et al., 2013). Though it has been found that the Asia-Pacific region will remain the world's largest wood deficit area, biomass has been the main source of energy in many countries of the Asia Pacific region till date (Väisänen , 2009).

Traditional use of biomass is common in Nepal, i.e. using open fires and simple low-efficiency stoves, for example, cooking and heating. These uses of biomass produce a huge amount of incomplete combustion products including carbon monoxide (CO), methane, particulate matter, non-methane, volatile organic compounds and others. Apparently, this result to the effect in the surrounding environment leading to air pollution as well as climate change. Till date, traditional form of biomass has been accepted and applied in many parts of earth where other forms of energy have not been accepted due to many reasons like poverty and difficulties due to the unavailability of resources.

Though, the use of traditional biomass energy has been perceived negatively, there are also some opportunities for its usage in a more efficient and environment friendly ways by improvising the technologies. This includes practices such as improved cookstoves and improved kilns which can help to replace open fires for cooking. These technologies help in reduction of indoor air pollution, rise combustion productivity and helps to achieve a higher heat transfer. Reduction of air pollution by replacement of open fires can reduce different respiratory health problems. Efficient use of biomass usage can also raise awareness about importance of forests and can promote in forest preservation and create energy security. The production of improved cookstoves and improved kilns for rural communities can also provide job opportunities to the locals. This can promote in charcoal production, drying of biomass (crop and forest litters) (Karekezi, et al., 2004).

3 Status of Nepalese forest (Forest Cover, Biodiversity and Classification)

According to a survey of Department of Forest Research and Survey, forest cover in Nepal accounts to 44.74% of the total area of Nepal (Government of Nepal, Ministry of Forests and Soil Conservation, 2015). For a country with huge geographical variations like Nepal, the best way to define ecological zones or life zone is based on the altitudes of the country. Figure 1 shows the forest cover in Nepal.

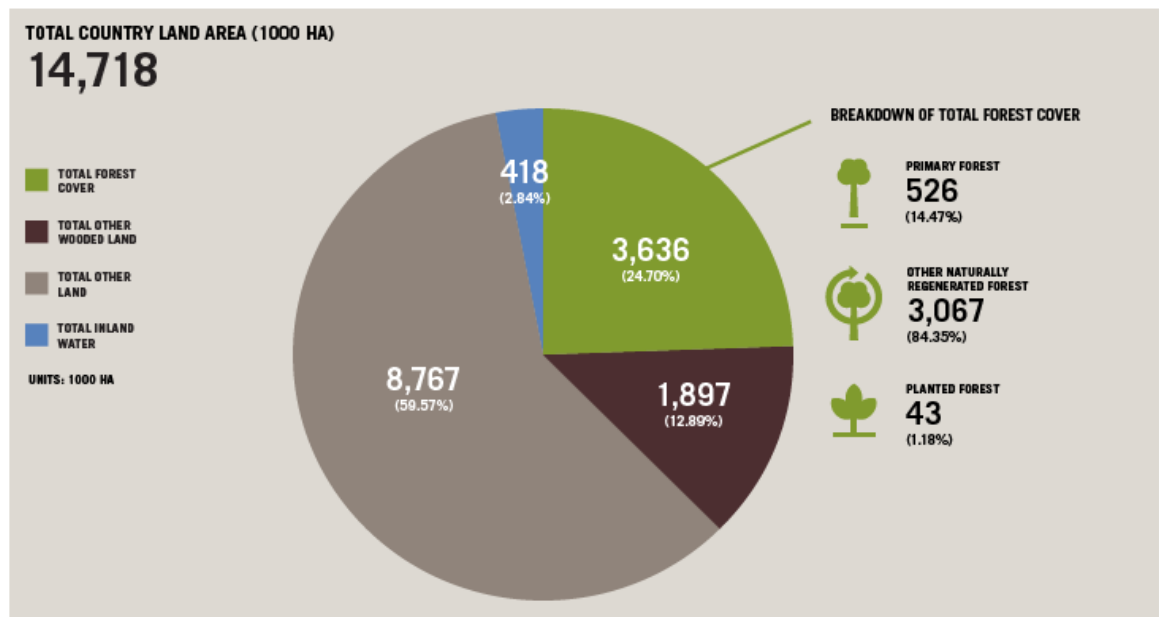


Figure 1. Forest Cover in Nepal (FAO, 2010)

There are different parameters set for the classification of forest. They are, for example, bioclimatic zonation, geographical locations, physiognomy and structural parameters, floristic parameters (Shrestha , 2008). Nepal is ranked twenty-fifth in biodiversity overall in the world with about 118 ecosystems, 35 forest types and 75 vegetation types (FAO , 2000). Biodiversity in Nepal gives an impression of the varied geographical and climatic features. Forest in Nepal is home for different kinds of wildlife, floras and faunas. Figure 2 shows the type of forests in Nepal as well as the preserved areas in Nepal.

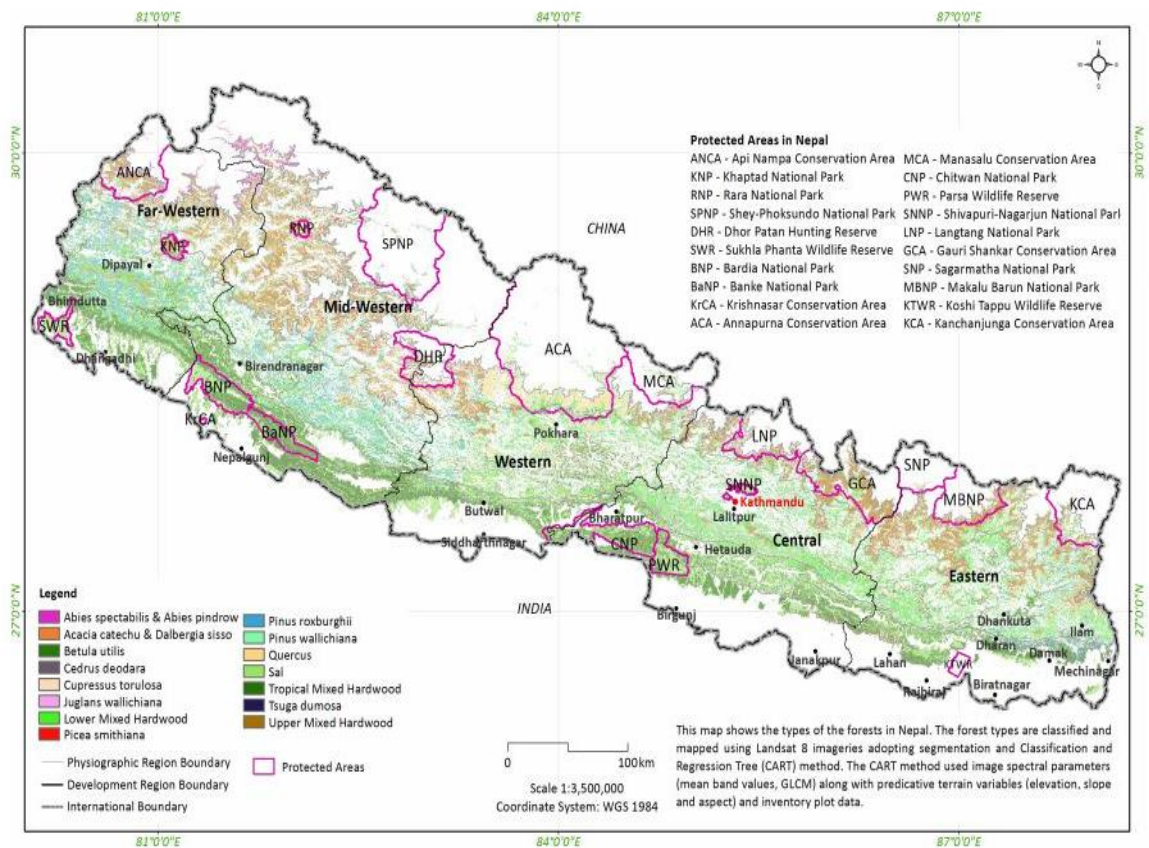


Figure 2. Type of forests in Nepal (FAO, 2009)

It is very essential to estimate the forest cover based on topography and development region for proper management and formulation of strategies to enhance forest development.

Table 2 shows the estimated forest cover by topography and 5 development regions of Nepal. The wooded land cover is not shown in the table which accounts to 0.65 million hectares.

Table 2. Forest cover by physiographic and Development Region in hectares (Government of Nepal (Ministry of Forests and Soil Conservation), 2015)

Development Region	Terai	Churia	Middle Mountains	High Mountains and High Himal	Total (ha)
Eastern	56,220	173,298	481,314	361,547	1,072,379
Central	95,219	430,029	479,295	264,124	1,268,667
Western	47,209	175,133	440,204	357,519	1,020,065
Mid-Western	85,618	414,795	428,187	662,122	1,590,722
Far-Western	127,134	180,489	424,807	277,597	1,010,207
National Total	411,580	1,373,743	2,253,807	1,922,909	5,962,038

3.1 Forest Management Practises in Nepal

There were number of plans and programmes introduced by Nepal Government for the Sustainable Forest Management practice in Nepal. One of the important provisions issued in the Forest Act by Government of Nepal was the Master Plan for the Forestry Sector (MPFS) in 1988 (Bhattarai, 2016). This plan was introduced and implemented under the joint efforts of GON and International donor agencies and had set some major objectives. The major long-term objectives of Master Plan for Forestry Sector are (Bhattarai, 2016):

- Fulfilment of basic requirements for timber, fuel wood, and forest products of the present and future as well as contribute in the food production and help in making interaction between forestry and farming effective
- Protection of land degradation due to different agents like soil erosion, floods, landslides and desertification

- Conservation of ecosystem and natural resources
- Contribution to the national and local economies by management of forest as well as creating employment and job opportunities to people

Some of the major mid-term objectives of the MPFS are listed below:

- Promotion of people's participation in development, management and conservation of forest resources
- Development of the legal framework required for engaging individuals and organizations for development, supervision and conservation of forest resources.
- Reinforcement of the administrative agenda and advancement of forestry sector to empower and smooth operation of their goals.

Nepal has been practicing the policies of Sustainable Forest Management (SFM) for a while. However, the harvested forest timbers that are sold to the national market do not follow the criteria set by SFM (Rytkönen, 2016). As defined by the Forest Act of 1993, there are six different types of forests categorized on the basis of ownership. They are national forest, government-managed forest, community forest, leasehold forest, religious forest and private forest. The description of these forest types is given in Table 3.

Table 3. Types of forest on the basis of ownership (Bhattarai, 2016)

Type of forest	Definition
Government-managed forest	Forests owned and managed by Nepal government
Protected Forest	National forests that have been declared protected by the government for environmental, scientific and cultural values
Community forest	National forest that have been handed to community for utilization, conservation and development of community well-being

Type of forest	Definition
Leasehold forest	National forest which is leased for specific purposes to an institution, forest-based industry or community
Private forest	Planted or protected forests of an individual based on the current law
Religious forest	Forest managed by Religious community for its religious value

3.2 Land Use Change and Deforestation in Nepal

Deforestation and forest degradation are issues of serious concerns in Nepal (Ministry of Forests and Soil Conservation, 2009). Generally, there has been a confusion between the two notions of forest degradation and deforestation of forest. However, FAO has tried to make it clearer by its definition of these two different practices.

Deforestation involves a decrease in the area covered by forest whereas degradation does not involve a reduction in the forest area but rather a quality decrease in its condition, this being related to one or a number of different forest ecosystem components (Vegetation layer, fauna, soil,..), to the interaction between these components, and more generally to its functioning (FAO, 2003).

According to Central Bureau of Statistics (CBS, 2008) on Environmental Statistics of Nepal, there is a decline in the forest area between the years 1991/1992 and 2001/2002 with an average of a minus 2.7 percent per year. This includes the fact that entire forests in all geographic regions have declined from 5.828 million hectares to 4.268 million hectares (CBS, 2008). Land use change resulting from human activities is one of the reasons causing deforestation and forest degradation (Tole, 1998). Land use and land cover change plays huge role on regional climate change. The assessment of the impacts is important to forecast the changes as well as find mitigating measures.

Commercial logging has been banned in Nepal; however, deforestation due to timber smuggling is still one of the huge problems in Nepalese forest industry. There are three major agents which causes deforestation in Nepal. They are: use of forest lands for agricultural purposes, illegal logging and forest fire, and overgrazing (Chaudhary, et al.,

2015). Also, encroachment, unsustainable harvesting practices, infrastructure development are also other causes. Besides these issues, lack of availability of cheap alternative energy resources is one of the reasons that has led to unsustainable fuelwood removal and has caused degradation of forest in Nepal. Similarly, extraction of medicinal plants and aromatic species from forest is one of the driving agents. Of many developing countries, Nepal was one of the early leaders in commencing innovative programs of forest management targeted for active participation of local communities (Agrawal & Ostrom, 2001). However, considerable development in forestry sector has not been achieved due to these major agents.

Degradation of forest is a very delicate procedure and therefore requires number of steps its mitigation. This includes practices such as encouraging people's participation in forestry, afforestation, commercialization of forestry, encouraging more sustainable forest-based products, promotion of alternative energy sources to reduce energy dependency and strengthening governance issues.

Transition of forest is a well-recognized phenomenon globally. This theory defines the changing land use patterns, causes of deforestation and manmade changes that are features of certain phases of commercial expansion within a country or region. The phenomenon is used to explain the U-shaped evolution that is high forest cover to decreasing forest cover and then again increasing forest cover especially observed in developed countries (The REDD Desk, 2016). With the huge concern of protecting all the species including birds, floras and faunas as well as variety of trees and its huge role in carbon storage, research has been done and explained in well elaborated forest transition theory. This phenomenon has been observed in over 30 countries and increasing in an alarming rate especially in many Asian countries (Liu , et al., 2017). Similarly, Nepal has also experienced this phenomenon. Despite having experienced largescale forest cut-offs in the past, Nepal has also considerable reforestation activities in recent years (Southworth, et al., 2012). There is a need for deeper research for finding agents which leads to deforestation and forest degradation in Nepal.

There are different approaches taken by different countries, and different sectors within countries for the land use change and prioritization between forests and agriculture. On the basis of geographical, political, socio-economic conditions of the country, forestry

and agriculture prioritization are different, and this is also one of the major factors in the land use change structure (FAO, 2016).

4 Environmental and socio-economic impacts of Biomass usage

Biomass for energy have many environmental and socioeconomic benefits. However, sustainable use of biomass is very important for both aspects. Both the environmental and socio-economic impacts of biomass usage are described below.

4.1 Environmental Impacts

Bioenergy is a potential form of energy for improving the quality of the environment by replacing fossil fuels and their emissions. It is an important form of renewable source of energy and an alternative to conventional energy sources in terms of economic growth, energy security and environmental concern (Stravroulia, 2003).

Parameterization of the greenhouse gases (GHG) emission is a key factor to implicate different actions for climate change. On the basis of results of the calculations based on LCA methodologies excluding land use change, the GHG emissions range for bioenergy systems as well as their fossil alternatives per unit energy output vary for different uses, such as heating, power and transportation (Berndes, et al., 2011).

The life cycle of greenhouse gas emissions from different bioenergy sources and fossil fuel energy sources based on uses (transportation fuel, electricity and heat) are provided in Figure 3.

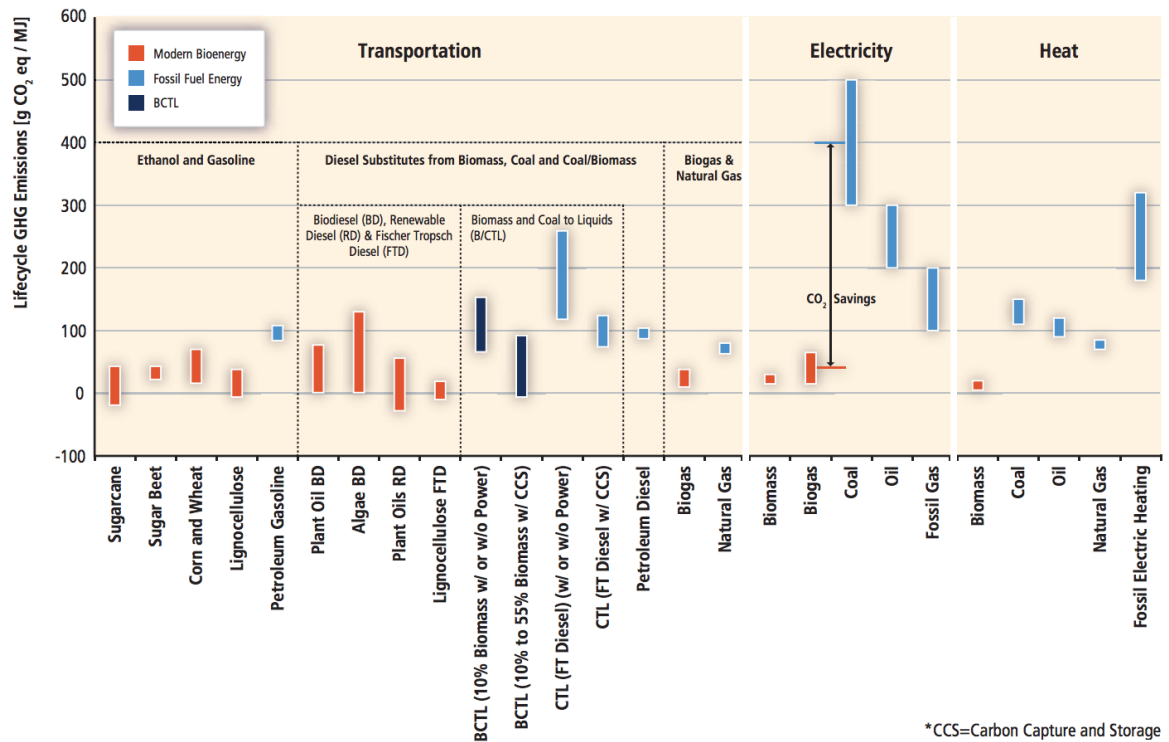


Figure 3. GHG emissions per unit energy output (MJ) from modern bioenergy compared to fossil fuel energy (IPCC, 2012)

Compared to conventional fuels, GHG emissions from biomass fuels are comparatively low, but sustainable use of biomass is essential to reach these low emission levels. Unlike other renewable energy technologies, bioenergy plays a vital role in the carbon cycle. As stated by UNFCCC and IPCC, the GHG balance is affected by land use change and equivalent emissions and removals. The GHG implications related to land management and land use changes in carbon stocks have many uncertainties. Changes in land and forest use either directly or indirectly for biomass production for fuels, can alter the terrestrial carbon stocks (Intergovernmental Panel on Climate Change, 2011). Burning of biomass for fuel in an expansive view coincides with multiple methods and varieties of vegetation. Therefore, studying the emissions from biomass burning also requires the burning sources (Delmas, 1994). However, biomass considerably emits less NO_x, SO_x and CO₂ and therefore can be used broadly for huge industries and power plants to generate electricity. Wood discharges CO₂ while we burn it for energy production, but the CO₂ discharged from the wood is well-adjusted by the amount absorbed while the tree grows.

4.2 Socioeconomic impacts

The socioeconomic impacts of forest and forest biomass are high but are relatively underestimated. However, well-documented materials having evidences about the socio-economic aspect of local and industrial utilization of forest biomass in developing nations are inadequate. The contribution of forest to the rural development is very significant. It provides jobs to millions of people all around EU and other parts of the world. Currently, forest biomass is one of the most important sources of renewable energy and It covers around half of the EU's total renewable energy consumption (European Commission (EC), 2013). Along with advantages like the environment friendly and sustainable form of energy, biomass also offers different socio-economic benefits to the society. For example, production of electricity by using biomass provide advantages from redeployment of surplus agricultural land and provide opportunity to flourish energy business on commercial scale under suitable geographic condition (Stravroulia, 2003). Woody biomass in EU has been used for the electricity generation. In EU-28, almost 60 % of total primary energy production of renewable energy was generated from biomass in the year 2016 (European Commission, 2017).

Biomass use also support the distribution of energy which decreases the pressure on other domestic fuels for various purposes. Several researches have proved that the increase in the biofuel's consumption pattern has enhanced the incorporation between energy and agricultural markets and consequently the influence bioenergy demand can have on the following (Tyner, 2010). Though the social functions of forest vary hugely due to different reasons like the level of development and traditions within the country, there are numerous social benefits of forests. Forests have recreational values and promote the tourism sector of the country. In developing countries like Nepal, availability of forest area for livelihood and employment opportunities generated by forestry sector is primarily noted as social values.

As mentioned earlier, one of the most important sources of energy is Nepal is wood. Many people in the rural poor community are benefited from the forest. Forests in Nepal are also a source of medicinal herbs, and people are using it to generate income, Tourism is one of the major income generation sources in Nepal and 45% of the tourists visit to protected forest areas to see the jungles and wildlife. Though, the economic role of forest is not evaluated and included in the country's Gross Domestic Product properly,

forestry has been playing significant role in economic development of Nepal. Nepal has been exporting Non-Wood Based Forest Products for many years. With the development of forest and forestry sector, Nepal has potential to export surplus wood products as well in the future (FAO, 2009).

5 Climate change and impact on forestry

According to Intergovernmental Panel on Climate Change (IPCC), "Climate change is described as any change in the climate over time, either due to natural variability or resulting use from human activity (IPCC, 2018)".

The components of climate system include atmosphere, biosphere, hydrosphere or other components and changes in any of these components are influenced by solar inputs and the human activities like industrialization and urbanization. This can be observed in Figure 4.

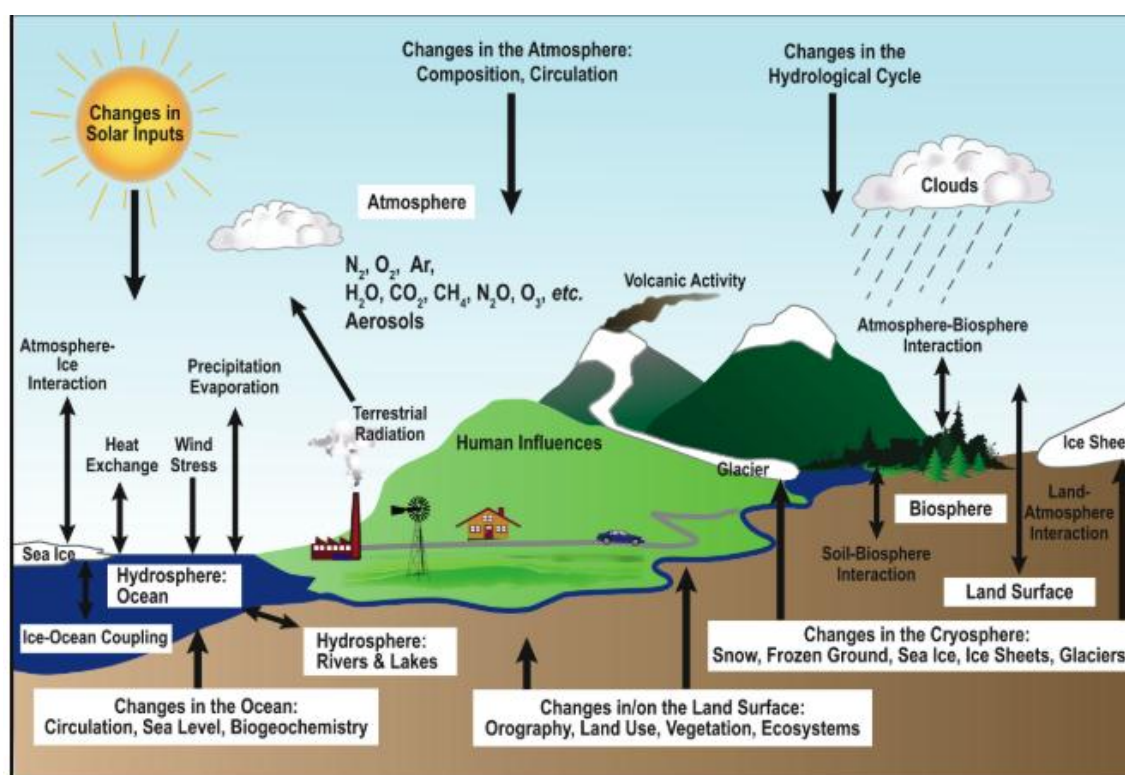


Figure 4. Representation of components of climate system (IPCC, 2018)

Climate change is a challenging environmental threat throughout the globe that has been observed and reported due to effect on the ecological changes on earth based on different barometers such as rapid changes in hydrological pattern and rainfall and variations in the trees and vegetation composition, alteration in characteristics of crops, decrease of production of crops and elevated exposure to climate-provoked aggravation including diseases. Therefore, climate stability is an indispensable factor for the whole human civilization and for other living creatures sharing the planet earth.

On the basis of Figure 5 published by IPCC from the year 1850 till 2012, average global temperature has risen approximately 1 degree Celsius. The temperature has increased notably from the year 2001 compared to previous years.

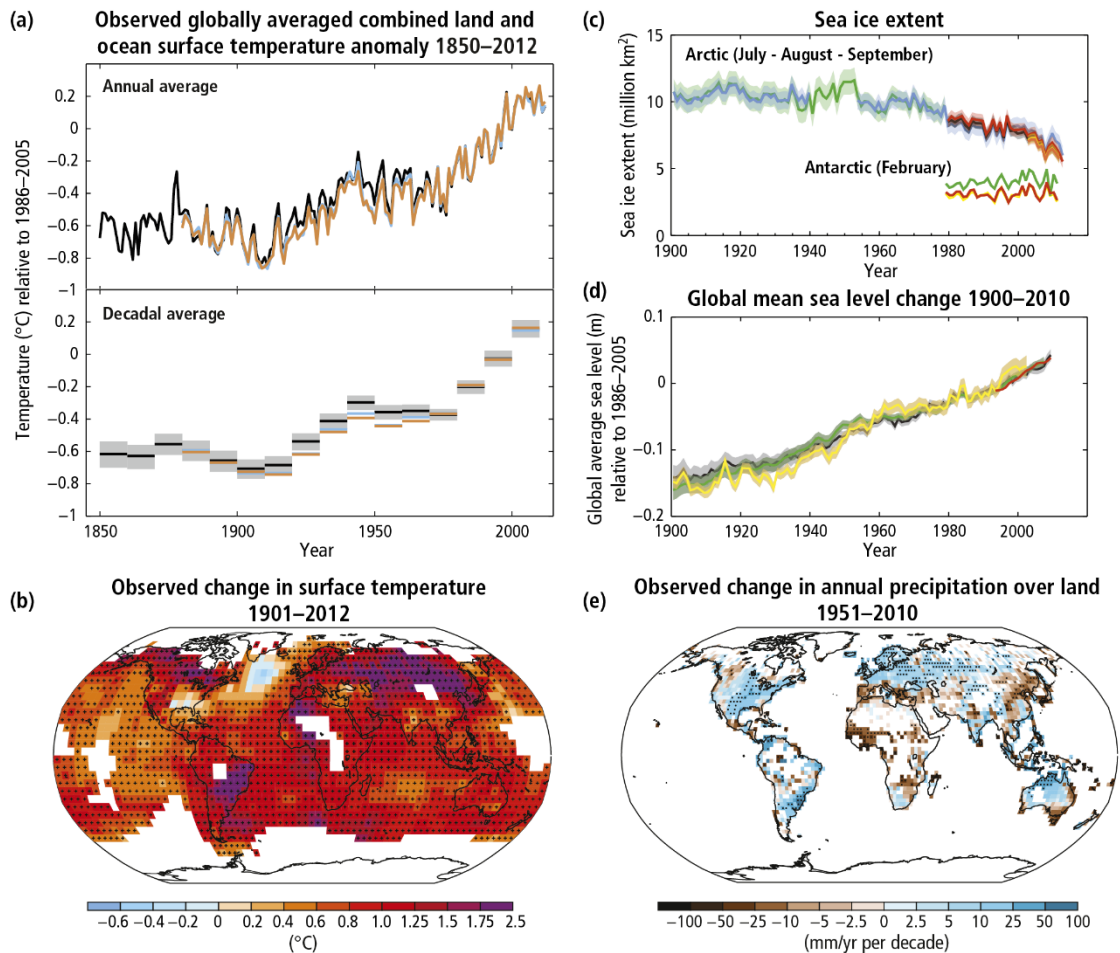


Figure 5. Climate change indicators a) Observed globally average combined land and ocean surface temperature (1850-2021) b) Observed change in surface temperature (1901-2012) c) Sea ice extent d) Global mean sea level change (1900-2010) e) Observed change in annual precipitation over land (1951-2010) (IPCC, 2015)

There has been an increase in the level of awareness about the risks resulting from global climate change. The IPCC has concluded with huge certainty that climate change is one various coexisting global change in the environment that simultaneously has effect on human health. There are evidences of climate change leading to global warming and

resulting to mortality, less cold-related death in temperate nations, higher rate of epidemics following floods and storms and significant health effects causing human migration due to sea level rise and escalated storm activities (World Health Organization, 2002).

In the 1990s the world had to face three times more economic losses compared to the 1960s due to the weather disasters. Therefore, due to these catastrophes, economically weaker countries have had more burden and faced poor economy, splintered infrastructures and many more crisis (Koike , et al., 2011).

5.1 Climate Change in Nepal

With the increased attention of climate change issues all over the world, Nepal is not an exception in this scenario. According to the Ministry of Population and Environment under the Government of Nepal, there has been an annual 0.6-degree Celsius rise in the temperature from the year 1975 to 2005. On the contrary, mean rainfall has undoubtedly decreased by an average of 3.7 mm (-3.2%) per month per decade. A projection has been made under various climate change scenarios for Nepal. It is projected that the mean annual temperatures will rise between 1.3 to 3.8 degrees Celsius by the 2060s and 1.8 to 5.8 degrees Celsius by the 2090s. Furthermore, it has been projected that annual precipitation would be in a range of 10 to 20% across the country (Ministry of Population and Environment, 2016). Despite many negative impacts of climate change the world has witnessed, some huge industrial sectors and political figures have been opposing the fact and have been claiming these issues as a hoax.

Over the last few years, we have faced numerous weather disaster events. These calamities and changes are the results of climate change due to activities such as pollution, population growth and excessive use of forest resources to fulfill the demand.

According to a journal published by American Meteorological Society, since 1977 there have been warming trends which range from 0.06 degree Celsius to 0.12 degree Celsius. Figure 6 below shows the pattern of temperature change observed by analyzing temperature data from 49 stations in Nepal between the year 1971 and 1994.

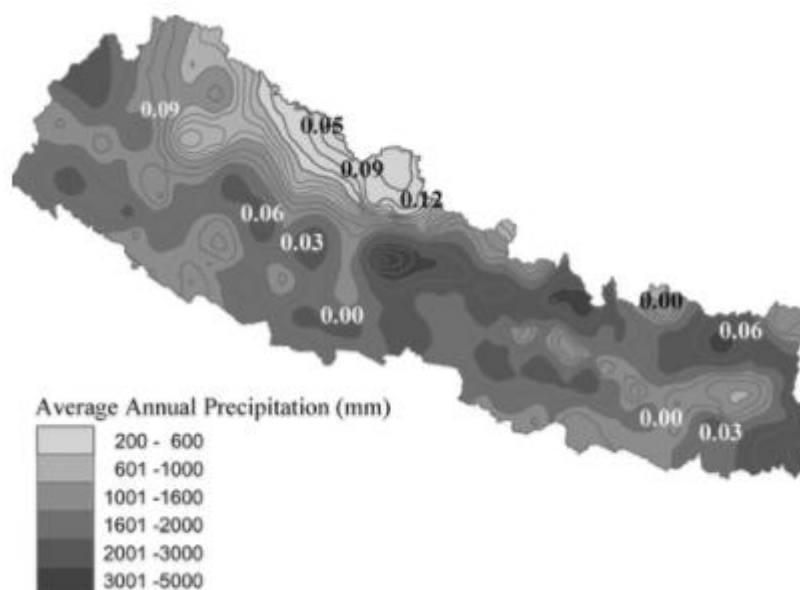


Figure 6. Observed Pattern of Temperature Change in Nepal, 1971-1994, superimposed in average rainfall data (Shrestha, et al., 1999)

The variation in topography and social vulnerability has made Nepal more sensitive to different climate-related disasters and geological disasters. Internal migration from the Himalayan to the Terai belt due to extreme weather events like floods, soil erosion, landslide, glacier melting has been observed in Nepal. This is a result of climate change phenomenon. Figure 7 and Figure 8 below show the hazard level of flood and drought respectively in Nepal. These maps are results of the collaboration among the Columbia University International Research Institute for Climate Prediction (IRI), Columbia University Center for Hazards and Risk Research (CHRR), and Columbia University Center for International Earth Science Information Network (CIESIN) (Global Facility for Disaster Reduction and Recovery, 2011).

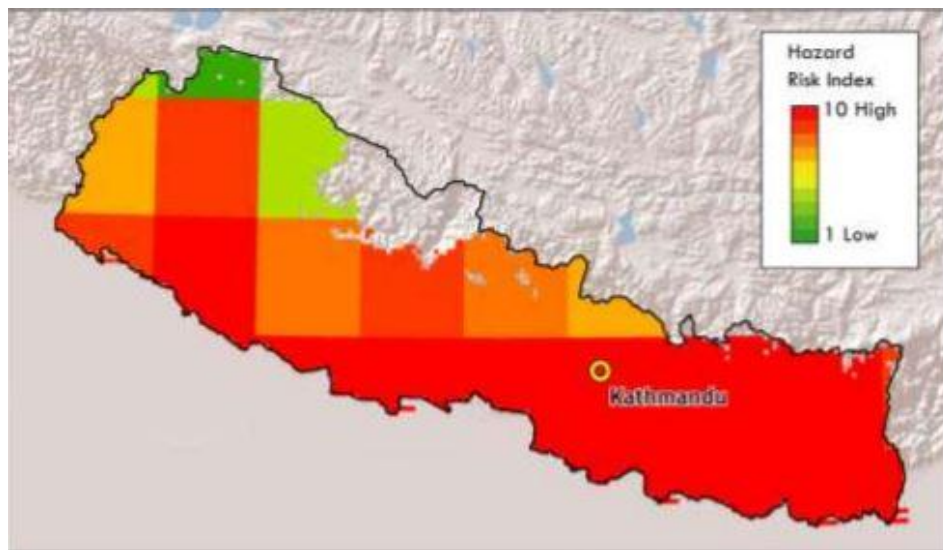


Figure 7. Flood hazard frequency in Nepal (Global Facility for Disaster Reduction and Recovery, 2011)

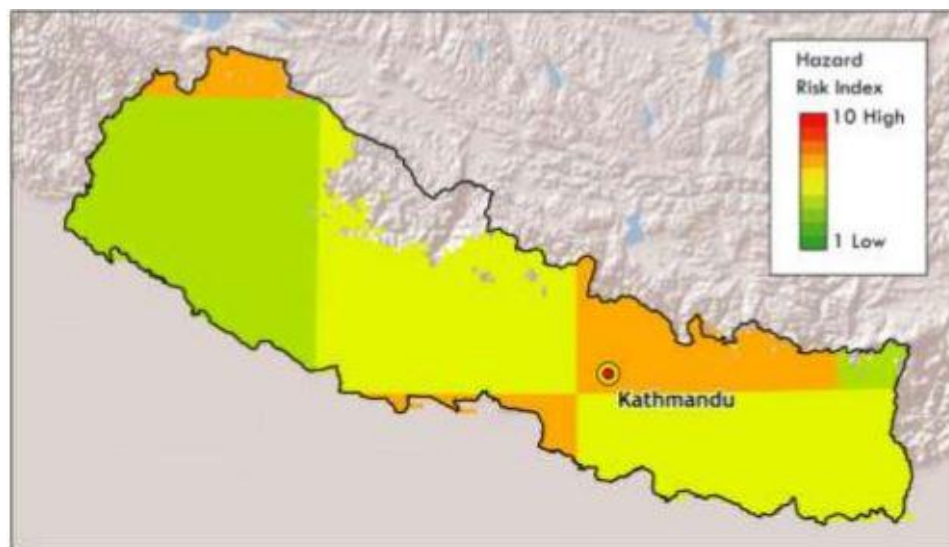


Figure 8. Drought hazard frequency in Nepal (Global Facility for Disaster Reduction and Recovery, 2011)

5.2 Impact of Climate change on forest sector

Climate change, forest and forestry are mutually related to each other. Climate change has a strong impact on forest ecosystems as well as the people relying on the forest resources. Due to the rise of temperature, water resources are drying, and carbon dioxide levels is increasing. Therefore, it has been assumed that there will be two different

levels of changes in the forest: physiology and uptake, and ecosystem functioning, which have effect on the products of forests and carbon sequestration capacity of forests (J., et al., 2008).

Climate change is likely to increase different disasters like drought, wildfire, and many other storm damages in the forest. Climatic deviations such as temperature increase, wildfires, snowfall, heat, and drought are related to climate change and therefore lead to vulnerable conditions for trees, herbs, animals and insects and every living organism in the environment (Government of Nepal (Ministry of Forests and Soil Conservation), 2011). A total of 66,131 recorded number of fires in the year 2017 according to statistics published by the National Interagency Fire Centre (NIFC) (National Oceanic and Atmospheric Administration (NOAA), 2017). These extreme weather events causes other effects like decrease in the production of timber, variations in land use pattern to fulfil the demand for cultivable land, affect to the species and harms to the forest ecosystem, variations in the accessibility of different non-timber forest products such as food, fiber and medicinal plants (Robeldo, et al., 2008).

Rise of the CO₂ and temperature continuously could result in drying out of forests. The Amazon rainforests which acts as a small carbon sink has been drying due to the rise in CO₂ and temperature according to the prediction of some climatic models. Consequently, large semi-arid regions are formed which turns large carbon sink to a major carbon source (COFORD , 2018).

6 Role of Forest for climate stability

Apart from being home for different species, floras and faunas as well as resource for woods, timber and so on, forest is a vital resource for goods and supplies as well as for the implications of climate regulations. In fact, forests act as a carbon reservoir that is continuously exchanging carbon dioxide with the atmosphere under influence of natural processes as well as human actions (Blanco, et al., 2003). Figure 9 shows the carbon chain in the forest.

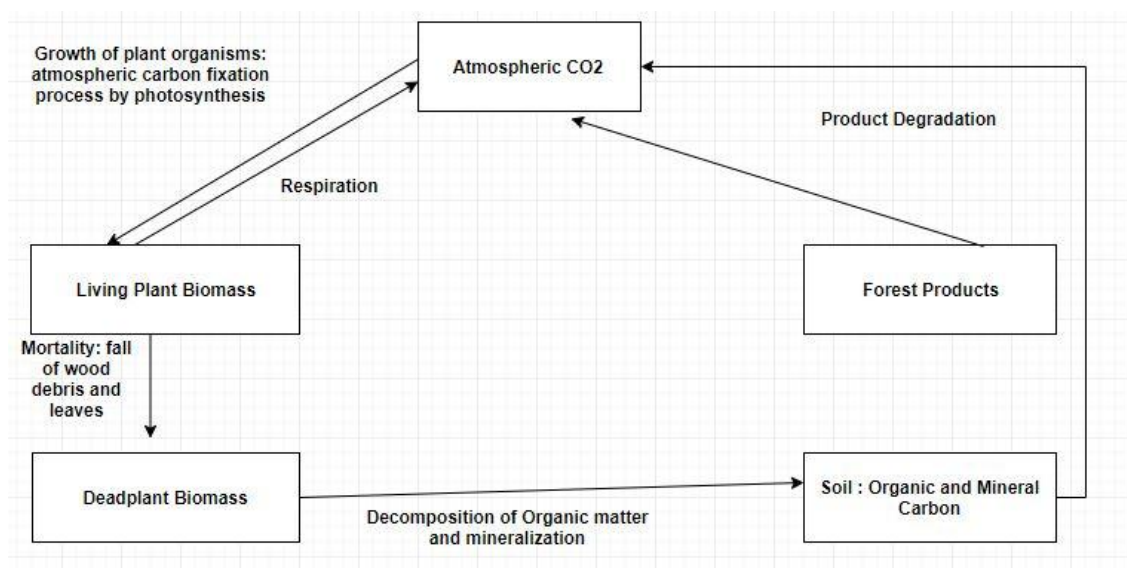


Figure 9. Forest Carbon Chain (Blanco, et al., 2003)

Forests in the world contribute to one-sixth of total carbon emissions when destroyed, overused or degraded in the current scenario. Trees in the forest absorb carbon dioxide and store it along with acting as a sink. In other words, forests act as both carbon sources and sinks in the atmosphere. Depending on various factors such as the tree species diversity, stand density and ways of forest management, there can be either positive or negative impact of forest on the global average temperatures (EASAC, 2017).

There is a continuous exchange of organic compounds and CO₂ between the atmosphere and biosphere according to different research by scientists (Laothawornkitiful, et al., 2009). These organic compounds are, therefore, known as biogenic volatile organic compounds (BVOC) and are obtained as by-product of photosynthesis as well as plant metabolism. Evidence has showed that isoprene and monoterpenes are important

BVOC's and play significant role in the climate change. These BVOC's have thermotolerance function and confer protection against high temperatures by generating huge quantities of the organic aerosol (Llusia´ & Peñuelas, 2003). The continuous exchange between climate warming and other global change drivers is shown in Figure 10.

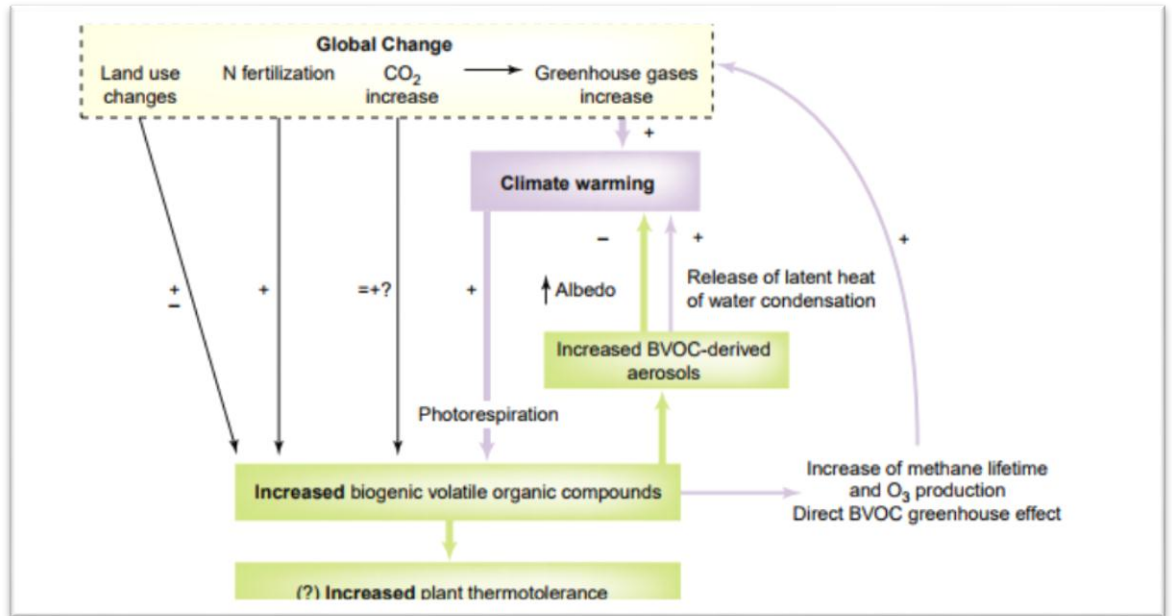


Figure 10. Interactions between climate warming (and other global change drivers) and BVOC's. Symbols '+' indicates positive effects and '-' indicates negative effect, '+-' indicates both positive and negative effects; '+?' indicates unknown whether there will be a positive effect or no effect (Llusia´ & Peñuelas, 2003).

As mentioned above in section 4.1, forest produce wood fuels as a substitute to fossil fuels and plays a significant role in reducing carbon emissions. Similarly forest also effect on the local precipitation and has aerodynamic effects. Rainfall in a specific area is either enhanced or decreased due to the change in the pattern of forest. Also, forest has important role during extreme events, such as, production of food during extreme weather events like drought. Similarly, in coastal areas, the influences of cyclones are reduced by forests (J., et al., 2008).

7 Mitigation strategies for climate change through forestry

Mitigation strategies to climate change are different steps taken for the reduction of atmospheric GHG. There are different processes adapted for mitigation such as the improvement of sequestration, reduction of emission, and inclusion of carbon sink. GHG emission is one of the alarming issues and for this reason it is crucial to address it and find out measures to reduce it. Forest is a capable source for the mitigation of climate change (BK, 2010). Figure 11 describes the climate change system and its adaptation alternatives. Carbon fixation and storage, and biodiversity conservation through sustainable forestry are adaptation alternative for climate change mitigation by engaging social, economic and political components.

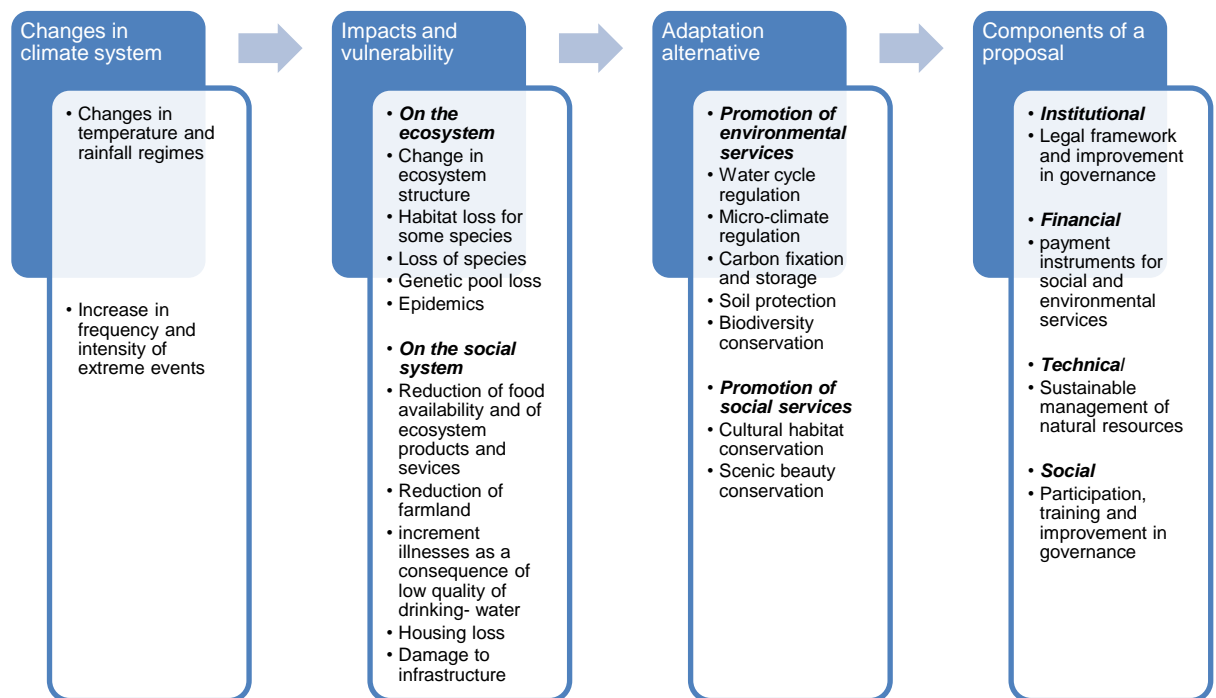


Figure 11. Relationship between climate change system, impacts and vulnerability and alternative adaptation (Robledo & Forner, 2005)

Different approaches taken in Nepal for climate change mitigation through forestry is described in this chapter.

7.1 Sustainable Forest Management (SFM)

Sustainable forestry means the practice of forest management to meet present environmental, economic and social needs while considering the future needs (Floyd, 2002). Management of forest keeping the present and futures demand in parallel is a very challenging issue. Six different criteria and indicators have been adopted by pan-European region for SFM: Forest resources and Global carbon cycles, Forest Health and Vitality, Productive function of Forests, Forests Biological Diversity, Protective functions (Soil and Water), and Socioeconomic functions (FOREST EUROPE, 2016). Various aspects of these SFM criteria are described in Table 4.

Table 4. Brief description of six different SFM (FOREST EUROPE, 2016).

Criteria	Description
Forest Resources and Global carbon cycle	Forest area, Growing stock, Age structure, Diameter distribution, and Forest carbon.
Forest Health and Vitality	Deposition and concentration of air pollutants, Defoliation, Forest damage, Forest land degradation and Forest soil condition.
Productive Functions of Forests	Net annual increment and annual fellings of wood, Roundwood, Non-wood goods, Marketed services on forest.
Forest Biological Diversity	Diversity of tree species, Forest regeneration, deadwood, Forest species, Protected forest, Genetic resources, Forest fragmentation.
Protective Functions (Soil and Water)	Soil, water and other ecosystem functions, Infrastructure.

Socioeconomic functions	Forest holdings, Forest sector workforce, Contribution of forest sector to GDP, Wood consumption, Net revenue, Trade in wood, Recreation forest, Investments in forest, Occupational, safety and health in forest, Forest sector workforce.
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Even though wise use of forests has been suggested since the earliest times, it has not been implemented effectively. Policies and regulations are the primary factors when it comes to forest management. This also includes various other factors like accounting of different forest issues (forest area, forest products and so on) and observation, forest management certification, stakeholder involvement and strategies for proper management of forest (Sola, et al., 2015). The limitations and actions for sustainable management of forestry in Nepal is mentioned below in section 10.1

7.2 Forest and carbon trade

Reduction of GHG emissions, especially CO₂ emission is very important for climate change mitigation and there are different strategies and approaches taken for this. Carbon trading is one of the important market-based approaches to combat climate change by reduction of emission through incentives. The concept is defined more precisely in the section below.

7.2.1 Forest and Clean Development Mechanism

Clean Development Mechanism (CDM) forest projects have been witnessed to be an effective way for climate change mitigation as well as beneficial to strengthen economy of the underprivileged category in rural areas (Gong , et al., 2010). Comprehensive agreements are propagated from the last few decades. One of the important agreements made is the Kyoto Protocol. It is an agreement under the UNFCCC, and each party in this agreement is bound to target to reduce GHG emissions by defined level.

According to Article 12 of the Protocol, “CDM permits a country that has emission reduction or limitation commitment under the Kyoto Protocol (Annex B) to implement emission reduction project in developing countries. To meet the Kyoto targets, such projects can earn saleable certified emission reduction credits (CER), each equivalent to one tonne

of CO₂” (UNFCCC, 2012). Working under the Clean Development Mechanism (CDM) could be an opportunity to earn profit. Therefore, the addition of LULUCF in the CDM showed interest towards forest-based projects (BK, 2010). CDM prioritize only Afforestation Reforestation (AR) activities for emission trading. Planting new forests and preserving preexisting forests can work as an effective method for carbon sequestration. CDM gives an opportunity for Nepal to participate in mitigating climate change through carbon sequestration in forests as well as strengthen the economy by earning from carbon trading.

7.2.2 Forest and REDD

Deforestation and forest reductions to fulfil human needs for agriculture, logs, human settlement and industrialization are increasing throughout the globe. As per the statistics published by Forest Resources Association (FRA), forests made 31.6 percent of the world’s land areas which is 4128 million hectares in 1990. In the year 2015, it dropped by 30.6 and forest accounts for 3999 million hectares (FAO, 2017). Forest is the second most important natural resource in Nepal and has been playing a vital role in the country’s natural, social and economic factor. Due to population growth and lack of decentralization, trend of deforestation has increased in Nepal. Comparatively Nepal’s deforestation rate is 1.7% which is higher than that of Asian average (1%) as well as the global average (1.3%) (Ministry of Forests and Soil Conservation, 2009).

Table 5 shows the deforestation and forest cover in Nepal in different time period.

Table 5. Deforestation rate and Forest Cover of Nepal in different time period (Ministry of Forests and Soil Conservation, 2009)

Period	Cover (million ha)		Total forest area (million ha)	Deforestation rate (in %)		
	Forest	Shrub Land		Terai	Hill	Overall
1964	6.4	-	-	-	-	-
1979	5.6	0.7	6.3	1.3	2.3	1.7
1986	5.5	0.7	6.2			
1999	4.27	1.56	5.83			
2000- 2005	3.74	-	-	1.4		

Considerable environmental impacts are observed due to destruction of forest. One of the major impacts that has been observed is Greenhouse Gases, GHG emissions. It contributes 20% of the total GHG emissions in the world (Dhital, 2009). Nepal is a small developing nation and doesn't contribute to high amount of GHG emission, but it is one of the most vulnerable countries to climate change in the world due to topographic variation as well as social vulnerability. According to national statistics, above 1.9 million people, are estimated to be highly vulnerable and other 10 million population is exposed to huge risks of climate change (Central Bureau of Statistics (Government of Nepal), 2017).

With the outbreak of REDD, many developing nations have been involved with this programme and under Ministry of Forests and Soil Conservation (MFSC), Nepal has also collaborated with the REDD programme. This programme was introduced by UN in the year 2008 for Reducing Emissions from Deforestation and Forest Degradation in the

developing nations. At the moment, 64 developing countries across Africa, Asia-Pacific, Latin America and the Caribbean are working under REDD programme. The main aim of the REDD project is reduction of emissions from forest and contribution to the sustainable development of the nation by boosting carbon stocks in forests in developing nations (UN-REDD, 2016).

At the Climate Conference 2007 held in Bali, after many debates about ongoing climate issues, the interconnection of forests and climate change was accepted. The Bali Action Plan acknowledged that forest is an inevitable part and cannot be overlooked to reduce and fight against climate change issues. Therefore, REDD could play significant role for the conservation of biodiversity and help to reduce poverty (UNFCCC, 2008).

7.2.3 Forest and REDD plus

Many developing nations have taken initiatives to study and find possible measures for mitigation of deforestation and forest degradation issues. Though, the outcome has not been very impressive due to number of reasons, such as, lack of awareness about sustainable forest management practices, inability to bring all the community, government and stakeholders together for a common goal to achieve SFM, lack of proper research on drivers of deforestation in specific area and required actions based on the variations, projection on forest development, but efforts are continuous from different national and international concerned organizations. Nepal has been continuously observing change in the climate change issues and different natural calamities because of deforestation and forest degradation. Therefore, Nepal has also actively been involved with different organizations and trying to implement different rules and regulations for the conservation of forest resources.

UNFCCC developed the REDD-plus mechanism for the reduction of emissions from forested lands that would offer incentives for developing countries based on the carbon storage in forests. It invests in low-carbon paths for the sustainable development and has been a platform to developing countries for enhancement of forestry sector governance. For the implementation of REDD-plus, MFSC established three -tier institutional management REDD multiple sectorial, Multi -Stakeholder coordinating and Monitoring Committee as the apex body; the REDD working group (RWG) for handling operational tasks and REDD Forestry and Climate Change Cell (REDD Cell) as the coordinating entity (Government of Nepal -Ministry of Environment, 2013). However, REDD-plus aims

to reduce emissions from deforestation and forest degradation by giving equal prioritization to aspects like sustainable management, preservation and the improvement of forest carbon stocks. The project empowers local communities and helps them to make profit from carbon sequestration of their forests (Habtezion, 2016).

8 EU Forest, Biomass and Climate Change Initiatives through forestry in Europe

In the EU, forests cover almost 42% of the land area which accounts to 5% of the total forests in the world. Forest in Europe has been increasing with varied offers for climate change mitigation as well as for forest sector development and its evolution to a green economy (Forest Europe, 2015). The forest ecosystem in the European Union (EU) is rich in diversity, extending different biogeographic and climatic variations. The three major forest zones are Boreal, Mediterranean and Temperate (Atlantic and Continental) zones in EU.

Contrary to the common belief that forest area has been decreasing all over the world, forests in EU-28 have been growing slowly over the few decades by putting effort on Sustainable Forest Management practices. EU-28 forests reached 26 billion m³ in the year 2015, while, in 1990 EU-28 forests cover accounted 19.7 billion m³ which means that forest stock has increased by 32% over the last quarter of a century (AEBIOM, 2015). Six countries in EU have been reported to have more than fifty percent of their land area covered by forests and other wooden land. These include Finland and Sweden accounting for 77% of the land area covered by forests and woodland, followed by Slovenia by 63%. The other countries are Estonia, Spain and Latvia each with shares between the ranges of 54-56% (AEBIOM, 2015).

Biomass in EU is used for various purposes like domestic heating, district heating and combined heat and power (CHP), also in commercial scale. More than 70% of biomass consumed in Europe consists of solid biomass, and the primary sources for it are forestry residues and agricultural by-products which include wood industry by-products, waste wood, wood from silviculture, tall fescue, switchgrass, short rotation coppices, hedges, and green waste. (AEBIOM (European Biomass Association), 2015). With the ongoing research for alternative resources to limited fuel as well as climate change debates, biomass cofiring has come into attention in EU. Cofiring is an alternative practice which is comparatively cheaper, efficient and eco-friendly for the conversion of biomass to electricity with mixture of biomass fuel (pellets) and coal in high-efficiency coal boilers (Tillman, 2000). However, the practice of biomass cofiring is feasible for large-scale powerplants and not in the context of countries like Nepal where biomass is used for traditional energy for the household purposes and in small scale.

With the ongoing debate of global warming and climate change issues and role of forests for the mitigation all around the world, this issue is getting more in surveillance also in EU. European forest sector remains a net carbon absorber in 99% of the 100-year simulations (Valade, et al., 2017). EU's forest carbon cycle is shown below in Figure 12. EU's Forest Carbon Cycle

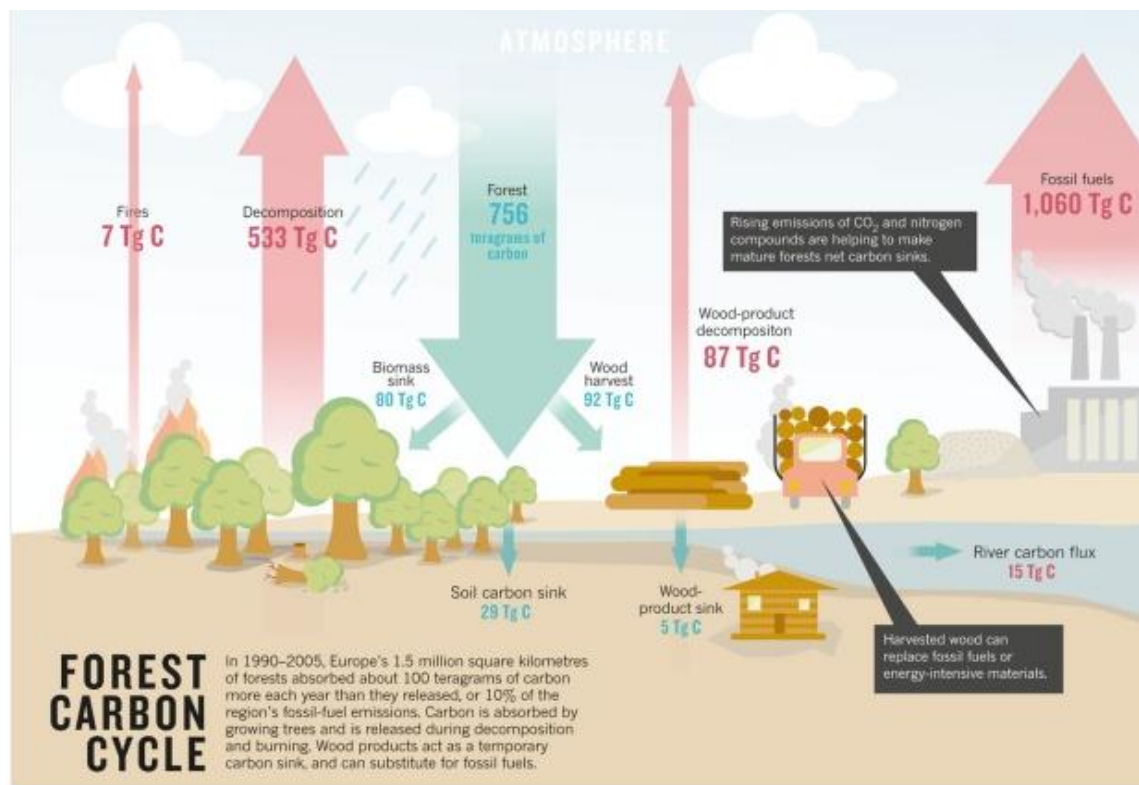


Figure 12. EU's Forest Carbon Cycle (Bellassen & Luysaert, 2014)

About 80 billion tonnes of carbon is accumulated in biomass in EU forests. The stock of carbon storage in EU's forest biomass has increased by 3 billion since 1990 which absorbs about 7% of the annual GHG emissions from this region (European Environment Agency, 2016). EU forests absorb about 100 Tera grams (Tg) carbon annually (Tg = 10⁶tn), equaling 10% of European fossil fuel emissions. The annual increment of wood in EU-28 forests amount to 720 million m³ where the net increment is 4.7 m³ ha⁻¹a⁻¹ (nearly 3.3 tons of CO₂ stored ha⁻¹a⁻¹).

8.1 EU forest Policy

The treaties of EU make no outline for the common forest policy, but there has been a long history of EU measures advocating certain forest-related activities, together with

member states mainly through the Standing Forestry Committee (European Commission, 2016). Nevertheless, there are varying policies and initiatives taken for different forests made by the community or inhabitant relying on the forest resources. Apart from the traditional use of forests for timbers and other forests products, forest has grabbed attention for different other factors like biodiversity reservoirs, climate regulations, wetland conservations, protection from natural disasters like flood, landslides and so on as well as renewable energy resources (European Commission, 2016). The role of forests in mitigation of climate change was already known since many years ago but not any concrete action was taken until the year 1989. In November 1989, the Noordwijk Ministerial Conference was held in Noordwijk, the Netherlands where 67 countries, 11 international organizations and the Commission of European Community (EC) had participated. The conference has been a critical milestone on the road to international emissions targets for carbon dioxide (Information Unit of Climate Change (IUCC) , 1993). The outcome of the conference was proposal for the afforestation of 12 million hectares every year (Schoene & Netto, 2009). Besides the Noordwijk Ministerial Conference, FOREST EUROPE is the pan-European top political procedure for discussion and collaboration in forest policies in Europe. It develops common strategies for 46 European countries and EU and the commitments sanctioned by the ministers works as an outline for sustainable forest management in EU and other European countries (Forest Europe, 2018).

Similarly, the Paris Agreement and the EU Climate and Energy Framework establish assertive and important targets for the climate change. Reduction of greenhouse gases (GHG) emissions by adaptation of alternative measures of fossil fuel has been a challenging issue in this technical era. So, the European Commission focuses on different areas like combatting illegal logging, reducing emissions from deforestation and forest degradation (REDD), sustainable forest management, support forest policies and research (European Commission, 2018) .

The European Commission is the EU's politically autonomous executive body which is solely in charge for formulating different laws and implementation of the decisions of European Parliament and the Council of the EU (European Union, 2018). Production of biomass in a sustainable way is needed for biomass to be effective in reducing greenhouse gas emissions. Therefore, in EU, all forest biomass should fulfill the criteria of Sustainable Forest Management that aims to protect all social, economic and ecological

function of forests. Also, impacts on biodiversity, site fertility, soil and watershed protection must be taken into consideration while extracting wood for energy in EU (European Commission, 2018). The following are the recommendations for energy installations of at least 1MW thermal heat or electrical power in EU (European Commission, 2018):

- Biomass usage from land that is converted from forest, high carbon stock areas, as well as biodiversity rich areas is forbidden.
- The life cycle of biofuels (cultivation, harvesting, processing, transportation, etc.) should have 35% less GHG emissions in comparison to fossil fuels. For new installations this amount had rose to 60% in 2018
- National biofuels support schemes should be favored for highly efficient installations.
- The monitoring of all biomass usage in the EU is encouraged to ensure their sustainability.

8.2 Land Use, Land Use change and Forestry (LULUCF)

The regulation for LULUCF is one of the pillars of EU's climate and energy framework, within the UNFCCC. The LULUCF includes carbon reservoir of both above and below ground biomass, dead organic matter of wood and litter, and organic soil carbon. It mainly deals with agendas for greenhouse gases and represents a number of complex and dynamic system with a number of specific features such as high uncertainty of emission or removal estimates, complexity in separating anthropogenic effects from very variable natural background emissions and removals, difficulty in differentiating the effects of anthropogenic mitigation actions beyond business as usual projections and understanding the potential of sink pools. Despite complexities, two different approaches have been implemented by LULUCF which are land-based and activity-based approach. Land-based approach reports emissions occurring in managed lands assuming all anthropogenic emissions. Activity-based approach reports and accounts activities that are occurred on subsets of lands, land identification and tracking (Glowacki, 2018). These activities in LULUCF can be good techniques to reduce GHG emissions in cost-effective way.

9 International Efforts for forest and climate change and their impact in Nepal

9.1 International support for forestry in Nepal

The Asian Development Bank (ADB), European Union (EU), The United Nations (UN), International Fund for Agricultural Development (IFAD), The World Bank (WB) and Global Environment Facility (GEF) are some joint development allies in the forestry and many other development projects in Nepal. Similarly, many align nations have been helping Nepal in the forestry sector. The list includes US, China, Australia, Japan, European nations like Norway, Denmark, Finland, Sweden, and so on (Ministry of Forests and Soil Conservation, 2009). Some of the notable past forestry projects in Nepal founded on foreign aid are listed below in Table 6.

Table 6. Major Foreign Assisted Projects in Nepal's Forestry Sector in past (Ministry of Forests and Soil Conservation, 2009)

Name of Projects	Countries/organizations support	Year of implementation	Budget
Natural Resource Management Sector Assistance Programme (NARMSAP)	Denmark	1998 - 2003	DKK 140 million
Nepal-UK Community Forest Project (NUKCFP)	UK	1993 - 2001	£ 7.45 million
Nepal Australia Community Resource Management and Livelihood Project (NACRMLP)	Australia	Feb 2003 - June 2006	USD 11.84 million.
Environment and Forest Enterprise Activity (EFEA) Project	USAID	1997 - 2002	-
	Netherlands	2000-2009	€ 15.8 million

Name of Projects	Countries/organizations support	Year of implementation	Budget
Biodiversity Sector Programme for Siwaliks and Terai (BISEP-ST)	SNV		€ 1.53 million
Livelihoods and Forestry Programme (LFP)	DFID	2009 - 2011	£ 26.2 million
Leasehold Forestry and Livestock Programme (LFLP)	IFAD LOAN	2005 - 2014	USD 12 million
	Dutch grant		USD 2.7 million
	Finland	2009 - 2014	USD 3.55 million

Some of the major ongoing forestry projects are Multi-Stakeholder Forestry Programme (MSFP), Adaptation for Smallholders in Hilly Areas (ASHA) project, and many small- and large-scale projects, for example, Strengthening Regional Cooperation for Wildlife Protection in Asia and South Asia Wildfire Enforcement Network (SAWEN) projects executed under Department of National Parks and Wildlife Conservation (DNPWC) (Ministry of Forests and Soil Conservation, 2009).

As mentioned above in section 7.2, the Kyoto Protocol is an effective agreement under CDM and a milestone in the history of forestry and climate change. The Kyoto Protocol made provision for the use of carbon sequestration by land use change and forestry (LULUCF) to mitigate GHG emissions.

9.2 The Paris Agreement

The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) and one of the only agreements which bounds all countries for common goal of undertaking ambitious efforts to climate change and adaptation, and support developing countries to do so (UNFCCC, 2018).

The central aim of Paris Agreement is to strengthen the global response of the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degree Celsius (UNFCCC, 2018) .

This agreement has been the most notable agreement on climate change till date as it establishes a method to mitigate GHG emissions and support sustainable development and defines a framework for non-market-based approaches to sustainable development. On 30th November 2015, representatives from different forest countries merged together and endorsed forests as an indispensable solution to climate change (UNFCCC, 2018). In the year 2017, on the conference held under the Presidency of Fiji, in Bonn, Germany from 6th to 8th November, 195 countries of UNFCCC have signed the agreement including Nepal and 176 countries have become party to it. However, United States of America is the only country which has withdrawn from Paris Agreement.

The agreement plays significant role to bring all developed, developing and underdeveloped nations together to combat climate change. Paris agreement can be very beneficial for Nepal and many other developing countries as it gives special consideration in terms of access to finance and adaptation. This means that by effective implementation of emission related commitment, Nepal can get financial aid and transfer of technology from EU and other developed countries which strengthen socioeconomic aspects of the country. This also enables for climate resilient and low carbon development followed by sustainable development of the country (Chhetri, 2016). Nepal can definitely use its experience and learning from the CDM to keep up with commitment in Paris agreement.

10 Limitations and actions for sustainable forest management

10.1 Limitations for sustainable forestry in Nepal

Sustainable forest management has gained huge attention with its increasing importance in the global environmental scenario. Sustainable forest management can be a milestone for environmental and human welfare in a long-term scale. Forest development follows a pattern based on different observations over a period of time all over the world which includes land use change including deforestation, urbanization, scarcity of timbers and other forest products and the rise of price of forest products and consequential substitution of silvicultural investment for harvests due to forest depletion (Kant & Berry , 2005).

Forest rules in Nepal depend on the types of forests. The basic policy document for forests regulations and policy making in Nepal is the Master Plan for the Forestry Sector, 1989 (Government of Nepal (Ministry of Forests and Environment), 2018). There are several factors affecting in the forestry sector. These include different forces such as demographic changes including population growth, migration patterns and economic instability like eco-tourism, poverty, economic growth. Other forces are ecological pressures such as climate change, natural disasters, deforestation and degradation, land desertification, etc. and socio - political issues such as political decentralization, policy reforms, devolutions, transition of society (FAO, 2009).

Implementation of the rules and regulations are very important for the development of the forest sector. While many other countries are funding and bringing different projects for the forestry sectors development in Nepal, there are factors such as bribery and difference in the working principles and methodologies within the country that has been hindering the process. Also, SFM programmes are introduced and policies are made to achieve SFM in Nepal, but there is a gap between the legislative part and implementation due to bureaucracy, lack of awareness and strictness in policy.

10.2 Actions for sustainable forestry in Nepal

Number of actions have been taken for the management and development of forestry sectors. The following actions have been helpful and can be implied further for the development of forest sectors:

10.2.1 Community Forest

The concept of community-based forest management (CBFM) is clear and has been adapted for several years. It has been found beneficial for the locals as well as for the government in different countries. Though the concept of CBFM had been used for several years, it came under the glimpse of government and supporting legal bodies only in late 1970s after the concept of decentralisation policies was introduced in many countries (Roe & Nelson, 2009). Nepal is one of the pioneers in commencing advanced forest supervision and management aimed at involving local communities and it has been found very effective (Harini, et al., 2005). Nepal successfully has implemented 38.5% of the total forest under community forestry programmes and has been beneficial to a lot of people in the rural communities (Pathak, et al., 2017). However, CBFM model needs to be varied according to the demand and diversity of the locality. Proper guidance and awareness should be given to people to achieve productive result. Also, promotion of CBFM is an important aspect to engage more people into community forestry which can be very beneficial for both the nation and locals in all socio-economic and environmental ways.

10.2.2 Transparency and accountability

A transparent and accountable system plays vital role in any development project and so it does in forest management. Several efforts have been made in Nepal for transparent and accountable system for progress in forestry sector, but the governance has not been strong enough due to bureaucratic system and unstable political condition. Though, peace management was announced in the year 2006; Nepal has not been able to make a considerable accomplishment in forestry according to statistics of World Bank Governance Indicators (2009) (Paudel, et al., 2011).

Nepal's Parliament executed Rights to Information Act in the year 2007 after going through many struggles by many local organizations, Non-Governmental Organizations (mainly human rights related institutions). In concept, legal and strategy documents like forest laws and procedural guidelines are accessible to the people but ironically, all people living in isolated countryside area and illiterate cannot get the information. Even though few government websites have published some statistics but, many of the legal papers and information are not free of charge and not easily accessible for common people. Also, the documents are very vast and difficult to understand (Paudel, et al.,

2011). Therefore, all forest related documents including both legal papers and strategy works as well as research works should be made easily accessible to all in practicality also.

The description of proprietorship has been dissimilar in different authorized documents in Nepal. Though usually the manager of the resources has full rights to the products but there is huge confusion due to this difference of definition of ownership. As stated in the Forest Act (1993), community, government and private owners (including the one who takes forest on lease and individual can own the forest products (FAO, 1993). Forest certification and carbon certification is an important factor to develop forestry sector. The forest certification system is internationally accepted and acknowledged for the sustainable forest management. However, to earn profit from the carbon trading we require internationally reliable data and proper accounting of all forest related issues such as monitoring of biomass usage and revenue collected from forestry has not been done efficiently in Nepal due to different prevalent reasons like lacking behind technical aspect and corruption (Oli, 2009). As mentioned in section 4.2, revenue collected from forestry is not included properly in the GDP of the country, proper accounting of the revenue is important for providing databases to the interested parties to find their possibilities in participation by investment and other works in forestry. Clarity in the monetary transactions in forestry is necessity for further development of forestry and engaging investors in forestry sector.

10.2.3 Stock Protection and Sequestration Strategies

The policy from Nepal Government for forest stock protection and sequestration strategies would play crucial role for climate change mitigation and sustainable forest management. For climate change mitigation, one of the cost-effective methods is to prevent emissions from occurring which protects and enlarges the carbon stocks. Avoiding deforestation which would permanently convert forestland to other uses, reducing the impact of catastrophic disturbances such as forest fire, and delaying the harvest of existing forest are some of the cost-effective methods for preventing emissions from occurring.

Sustainable forest management is one of the best ways for sequestration of additional CO₂ from the atmosphere. Countries like Finland, Sweden and Latvia exhibit a carbon sequestration potential that well exceeds net carbon emissions (Ellison, et al., 2011). Planting new forests, implementing stand management techniques which emphasizes

carbon sequestration, production and usage of durable wood products which remain sequestered while in use are some of the ways of carbon sequestration. However, harvesting mature forest and replacing them with fast-growing trees which would though increase the sequestration rate is not good climate change mitigation strategy (Maness, 2009).

10.2.4 EU forest policy implications

Sustainable forest management has been practiced since long back in Europe. The practice has also been included in FOREST EUROPE principle which is implicated by Member States' policies and promoted by the EU, specifically through the rural development policy. EU has prioritized in some specific areas for achieving the goal of sustainable forest management. One of the prioritized areas is supporting the rural and urban communities which provide equality to all. The European Commission focused on investments in developing forestry technologies; enhancing the division's contribution to the bio-economy; developing flexibility, environmental significance and mitigation ability of forest ecosystems; accomplishing nature and biodiversity aims; adaptation to climate change; protection of genetic resources; forest conservation and information; and making new woodland and agro-forestry systems (European Commission (EC), 2013).

Encouraging competitive market and more sustainable product of the forest-based industries, bio-energy and the wider green economy is the other sustainable forest management technique in EU and this also plays vital role as climate change mitigating measures (European Commission (EC), 2013). Competing low-cost producers of wood-based products is one of the strategies for forest-based industries in EU. EU's market is focused on production of better-quality wood-based products for EU itself as well as non-EU region.

Commercialization of forestry sector is one of the aspects to forest development in Europe. On the basis of estimation in Eurostat, direct employment in the EU-28 forest sectors which include wood production, pulp and paper and loggings accounted to 2.2 million in terms of income generation in 2013 and in 2012 roundwood production accounted to 425 million cubic meters. Moreover, total value of USD 262 billion was produced in the year 2012 while the budget was USD147 billion (Hetemäki, et al., 2014). Hence, forestry sector has played a huge role in Europe, and it has been source of income generation and employment. Also, EU's strategy includes being open to innovation by giving place

for new products to meet varying social demands (European Commission, 2018) . Though forestry sector is believed to be conservative, EU has been investing on research and adapting to changes in marketing method in forestry which is also an innovative approach in EU's forestry. Implementation of new practices in forestry is also innovation in forestry.

Nepal can learn from these techniques to promote the production of sustainable forest-based biomass and non-wood forest products which enable to create new jobs, diversify income in a low-carbon and green economy. Also, commitments have been made by EU and the member states to enhance sinks and reduce forest-related emissions by accounting, monitoring and reporting to LULUCF. Forest Management Plans (FMPs) or similar instruments based on principles of SFM are also prime instruments in delivering multiple goods and services in a balanced way for enhancing genetic diversity and protecting endangered genetic resources (European Commission, 2013).

The EU Commission and Member States should set up the Forest Information system, develop different modules, e.g. for fires and pests, forest and climate change, and forest and ecosystem services that contributes to forest statistics and information for better understanding of environmental and societal challenges faced by forest sector. The commission encourages on new and innovative forestry and added-value products. To improve coordination and implementation, the commission relies on EU Forest Communication Strategy developed by Standing Forestry Committee (SFC). Forum like SFM provides the platform for discussing forest-related issues and ensures the proper coordination and coherence of forest policies (European Commission (EC), 2013).

11 Conclusion

Biomass energy has a huge share of contribution in Nepalese day-to-day lives and forest. Despite the impact of its use is well-known to the community, traditional form of energy use, such as open fire for cooking has become a compulsion. The reasons behind this are socioeconomic factors as well as easy availability of biomass in rural areas. A huge share of biomass energy is contributed by forest biomass and on a brighter note, there are opportunities of improvement of traditional biomass usage which can be more efficient and more environment friendly. Efficient use of biomass can reduce the negative impacts of traditional biomass usage and create energy security.

Nepal has taken many approaches in the path of forest management. The policies of Sustainable Forest Management have been practiced in Nepal for a while, and Master Plan for the forestry sector is one of the important provisions for sustainable forest management in Nepal. Number of long-term objectives such as fulfilment of basic requirements for timber, fuelwood and forest products; conservation of ecosystems and natural resources, protection of land degradation due to soil erosion, floods, landslides, and desertification, contribution to the local and national economies by management of forest were addressed by MPFS. Also, short term objectives like promotion of people's participation, development of the legal framework for involving individuals, organizations for and reinforcement of administrative agendas for development, management and conservation of forests were addressed in MPFS. In terms of ownership of forest, community-based forest management has been the most effective practice in Nepalese forestry which enabled local participation for the use and utilization of forest and benefited by huge percentage.

Nepal has also been engaging in Afforestation Reforestation (AR) activities under the Clean Development Mechanism projects and has also taken initiatives to reduce emissions from deforestation and forest degradations under the REDD and REDD plus mechanism. All these three mechanisms; AR, REDD and REDD plus work on reduction of GHG emissions through carbon sequestration which is effective for combatting climate change through forestry and also strengthen economy from carbon trading. REDD plus also aims in prioritization of sustainable management, preservation and improvement of forest carbon stocks parallel to reducing emissions from deforestation and forest degradation. Though, many projects and mechanisms have been introduced and financial aids

have also been given by many align nations, Nepalese forestry has not been able to make considerable accomplishment to different factors such as lack of transparency, geographic and climatic variations, socioeconomic conditions and political instability.

EU approaches in Nepalese forestry have been studied in this paper. Feasibility study of EU's approaches in Nepalese forest sector has been studied. Forest sector in Nepal can improve by application of EU approaches such as innovation in forestry which includes implementation of new products to meet varying social demands. There is need of change the mindset of traditional forestry and adapt new techniques in forestry sector in Nepal. Similarly, Commercialization of forestry sector in EU has been supporting to many forests related industry like wood production, pulp and paper, and loggings and has been source of income generation and employment. Though, non- timber forest products are used for commercial purpose in Nepal, the commercialization scale is not so big and proper accounting has not been done for revenue from forest in GDP. Therefore, Nepalese forestry sector can learn about the marketing strategies and other factors related to improving commercialization in forestry from EU. Encouraging competitive market by competing low-cost producers and better-quality wood-based products, is one of the sustainable forest management practices in EU which is also worth notable for implementation in Nepalese forestry.

Nepal should set up proper forest information system, develop different modules, such as, forest and climate change, and forest and ecosystem services that contributes to forest statistics and information for better understanding of environmental and societal challenges faced by forest sector. Nepal should learn from EU for reducing forest related emissions by proper accounting, monitoring and reporting emissions occurring in managed lands assuming all anthropogenic emissions that is land-based approach and activities that are occurred on subsets of lands, land identification and tracking that is activity-based approach to reduce GHG emissions in cost-effective ways. The idea of sustainable forest management must be promoted more to create awareness in forestry sector in Nepal by coordinated effort of the government, stake-holders and forest-oriented community.

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