



Forest Resource Management for Global Warming and Climate Change Mitigation in India

KEYWORDS

Forest Resource, Global Warming, Green House Gases, Climate Change, Mitigation, Strategy

Dr. P.S. Kamble

Professor, Department of Economics, Shivaji University, Kolhapur INDIA

ABSTRACT

The major environmental problem the world economy as a whole has been facing is the problem of global warming and climate change. The gases that are most active at trapping this radiation heat energy are known as greenhouse gases or radioactive gases are carbon dioxide, water vapour, ozone, nitrous oxide, black carbon and halo-carbon contributing to the global warming. In the greenhouse gases carbon dioxide is prominent (65%) in contributing to global warming, which is followed by methane (31%) and nitrous oxide (4%) respectively. The emissions of GHGs are prominently contributed by the energy sector (61%), which is followed by industrial activities, agricultural etc. respectively. The statistical information reveals that developed countries have accumulated emissions of carbon dioxide prominently (75%) through energy consumption and the contribution of developing countries stands at 25%. The country wise analysis of carbon dioxide emission shows that the USA was in leading position (29%), which is followed by the countries like Germany (7%), China (8%), Japan (4%), India (2.4%) etc. so far as per capita accumulation of carbon dioxide is concerned. There is a great change in climate due to global warming because of green house gases like carbon dioxide emitted by the traditional sources of the energy. High GHG emissions are produced by energy sector out of total GHG emissions. Energy sector produces 58% GHG emissions in India. To control this serious problem there is great need for the forests resource management to facilitate decrease in global warming and mitigation of climate change. Forests play very significant role in the control of green house gases emissions, and thereby global warming and climate change, because trees have a quality of absorption of carbon dioxide and releasing of oxygen. Hence protection, plantation, preservation of trees through management of the forests is required and urgently needed. For environmental balance the area covered by the forests should be at least 33% of the total area. But except some countries, many countries could not increase their forest area at least up to 33 % also. The noteworthy countries in 2010 whose forest coverage was less than 33% are Australia : 19%, China : 22%, India: 23%, Pakistan : 2%, South Africa 5%, Sri Lanka 30%, U. K. 12%, U.S.A. 33%, Germany 32%, France 29%. Japan 68%. It is therefore the present study intends to assess forest management in India and suggests a suitable strategy for the forest resource management, which will help in controlling the emissions of the green house gas like carbon dioxide and in the control of global warming and climate change from the side of India.

1) INTRODUCTION:

We are suffering from the number of problems such as economic, social, political, religious, cultural and environmental. The major environmental problem the world economy as a whole has been facing is the problem of global warming and climate change. It is a problem being faced by all the countries comprising of developed countries as well as developing countries. Environment is the part and parcel of living things in general and human beings in particular. It is the quality of the environment that determines the survival of the living things coupled with human beings as well. But it is found that environment has been showing a continuous and rapid deterioration due to environmental pollution and degradation. The human activities along with natural activities are contributing to the degradation of environmental quality. Global warming is a major environmental problem the world as a whole has been facing, along with the countries like India. It is because of greenhouse effect being contributed by the emissions of greenhouse gases namely carbon dioxide, methane, water vapour, nitrous oxide, etc. The emissions of greenhouse gases are dominated by carbon dioxide, which is followed by methane prominently. The emissions of GHGs have been taking place because of the human activities like energy generation, agricultural, industrial activities dominantly. The problem of global warming is increasing day by day which has very bad consequences on the biosphere in general and living things like human beings, trees, animals, etc. in particular. This urgently demands to mitigate global warming. The gases that are most active at trapping this radiation heat energy are known as greenhouse gases or radioactive gases. They are carbon dioxide, water vapour, ozone, nitrous oxide, black carbon and halocarbon contributing to the global warming. In the greenhouse gases carbon dioxide is prominent (65%) in contributing to global

warming, which is followed by methane (31%) and nitrous oxide (4%) respectively. The emissions of GHGs are prominently contributed by the energy sector (61%), which is followed by industrial activities, agricultural etc. respectively. The statistical information reveals that developed countries have accumulated emissions of carbon dioxide prominently (75%) through energy consumption and the contribution of developing countries stands at 25%. The country wise analysis of carbon dioxide emission shows that the USA was in leading position (29%), which is followed by the countries like Germany (7%), China (8%), Japan (4%), India (2.4%) etc. so far as per capita accumulation of carbon dioxide is concerned. There is a great change in climate due to global warming which is due to green house gases like carbon dioxide emitted by the traditional sources of generation of the energy. High GHG emissions are produced by energy sector out of total GHG emissions. Energy sector produced 58% of GHG emissions in India. There is great impact on climate change of the global warming contributed by the green house gas emissions. To control this serious problem there is great need for the forests resource management to facilitate decrease in global warming and mitigation of climate change. Forests play very significant role in the control of green house gases emissions, and thereby global warming and climate change, because trees have a quality of absorption of carbon dioxide and releasing of oxygen. Hence protection, plantation, preservation of trees through management of the forests is required and urgently needed. Because for environmental balance the area covered by the forests should be at least 33% of the total area. But except some countries, many countries could not increase their forest area at least up to 33 % also. The noteworthy countries in 2010 whose forest coverage was less than 33% are Australia : 19%, China : 22%, India: 23%, Pakistan : 2%, South Africa 5%, Sri Lanka 30%, U. K. 12%,

U.S.A. 33%, Germany 32%, France 29%. Japan 68%. It is a fact that the developed countries are emitting green house gas like carbon dioxide very much higher than the developing countries, except Japan no any developed countries has fulfilled the minimum target of 33% ,so far area covered under the forests is covered. The same is the case of developing countries in the context of forest area covered. Now days, the contribution of the developing countries like China and India in the emissions of especially carbon dioxide has become a thing of concern for global warming and climate change mitigation. And their efforts to achieve minimum forest area coverage didn't achieve. Both are over populated countries, hence their attempts for increasing forest area is most welcomed. This demands to examine the forest management in the context of India. It is therefore the present study intends to assess forest management in India and suggest a suitable strategy for the forest resource management, which will help in controlling the emissions of the green house gas like carbon dioxide and in the control of global warming and climate change from the side of India.

II RESEARCH METHODOLOGY:

The present research study solely relies on the secondary data only comprising of time series and cross sectional as well. The necessary data are collected from the published sources like Indian's Initial National Communication on Climate Change, UNDP Human Development Reports, International Energy Annual, World Energy Outlook, United States Department of Environment, Reports of Ministry of Environment and Forests, IPCC Reports, Research Papers and articles. The data about the state of forests resource and its management attempts has been collected from the sources like Forest Survey of India, Reports of Ministry of Environment and Forests Government of India and all others. The period that present study covers is from 2001 to 2011, which is the latest period. The present study has made use of simple data analysis tools like ratio analysis, percentage increase to analyse the data. The study endeavours to analyse the problem of Global warming and Climate change. Also tries examine the relationship between Forests and Global warming and Climate change mitigation through Carbon dioxide emissions control. Then assesses the state of Forests resource and management in India, and on the basis of that reveals a suitable strategy for the management of the Forests resource in India, that will facilitate the control of Global warming and Climate change from the side of India.

III) PROBLEM OF GLOBAL WARMING AND CLIMATE CHANGE: AN ANALYSIS:

"Climate change" is an international environmental problem. Climate change is a change in the "average weather." (Reddy 2008) Climate refers to the weather over very long periods, while the weather is what we experience daily. It invariably refers to one component of changes expressed in the form of global warming. Climate change is closely associated with green house effects. Based on the position of Earth relative to the sun and characteristics of Earth's surface, the average temperature of Earth's surface should be - 18°C. However, the mean temperature is closer to + 15°C. Earth is warmed largely from trapping and reradiating of heat by gases in the atmosphere is called the "greenhouse effect." (Patrica, 2008) The gases that are most active at trapping this radiant heat energy are referred to as "greenhouse gases" or "radioactive gases." They are carbon dioxide (CO₂), water vapor; tropospheric ozone, methane (CH₄), Nitrous oxide (N₂O), black soot (black carbon) and Halocarbons are contributing to the climate change.

In 2007, the IPCC (Intergovernmental Panel on Climate Change) indicated that the global average temperature has increased by 0.76 degrees C (1.4 degrees F) when comparing current (2001-2005) average temperatures with those from 1850-1899, an increase that is unprecedented during the last 1000 years. Remember that these data reflect global means: warming has been more in some place and less in others. [e.

g. average Arctic temperatures have increased at about twice the global average rate over the past century (IPCC 2007)] .The linear warming trend over the past 50 years is nearly twice that is warming seems to be accelerating (IPCC, 2007).

According to the Government of India Initial National Communications (NATCOMI) 2004, at the national level, increase of 0.4 °C has been observed in surface air temperatures over the past century. A warming trend has been observed along the west coast, in central India, the interior peninsula, and northeastern India. However, cooling trends have been observed in north-west India and parts of south India. (Ritu 2008) While the observed monsoon rainfall at the all India level does not show any significant trend, regional monsoon variations have been recorded. A trend of increasing monsoon seasonal rainfall has been found along the west coast, northern Andhra Pradesh and north-western India (+ 10% to + 12% of the normal over the 100 years) while a trend of decreasing monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, north-eastern India, and some parts of Gujarat and Kerala (- 6% to - 8%) of the normal 100 years).

Climate change has a wide range and variety of impacts. According to the United Nations Intergovernmental Panel on Climate Change 2007 (IPCC), precipitation would increase at high latitudes and decrease in most sub-tropical land regions. Other likely manifestations of warming include increasing acidification of the ocean, melting of snow and sea ice, and an increase in the intensity of extreme events such as heat waves, droughts, floods and tropical cyclones. At higher temperatures, the probability of catastrophic climate changes would rise (for example, melting of the west Antarctic ice sheet or permafrost, a change in monsoon patterns in South Asia). (Natalia et al 2008) The three benchmark studies (Mendelsohn and others 2000; Nordhaus and Boyer 2000; and Tol 2002) and the review of the literature in the Stern review point to mean GDP losses between 0% and 3% world GDP for a 3° C warming (from 1990-2000 levels).

According to the NATCOMI the impacts of climate change on Indian economy consist of, sea level rise has been observed to increase by 0.4 - 2 mm/year along the Gulf of Kutch and the coast of West Bengal. However, relative decrease along the Karnataka coast has also been observed. Changes in key climate variables, namely temperature precipitation, and humidity, may have significant long-term implications for the quality and quantity of water. The most significant changes are likely to occur in the glacier fed river systems, due to the melting of the Himalayan glaciers. Changes are likely in the long term lean-season water flows of large snow and glacier fed river systems of the Brahmaputra, the Ganga and the Indus. A decline in total runs off for all river basins, except Narmada and Tapi. A decline in run off by more than two thirds is projected for the Sabarmati and Luni basins. Concentration of droughts is projected in Gujarat and Rajasthan, which are already drought prone, and in Orissa, which is currently flood prone. Wheat production for the country as whole may decline after 2020 and rice production may be adversely impacted in the eastern states. Boundary changes in the growth of crops are also expected. Studies by the Indian Agricultural Research Institute (IARI) indicate the possibility of a loss of 4-5 million tonnes in annual wheat production with every 1°C rise in temperature. Small changes in temperature and rainfall have significant effects on the quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants, and basmati rice. Other impacts on agricultural and related sectors include lower yields from dairy cattle and decline in fresh breeding, migration, and harvests. Changes in climate may alter the distribution of important sector species (for example, malarial mosquitoes) and may increase the spread of such diseases to new areas. An increase of 3.8 ° C in temperature and a 7% increase in humidity by 2050 over present levels is projected to lead to the transmission windows being open for all 12 months in a states in India. Heavily popu-

lated regions such as coastal areas are exposed to climatic extremes and large falls in new areas in arid and semi arid zones, of which nearly two-thirds are drought prone large areas in Rajasthan, Andhra Pradesh, Gujarat and Maharashtra and comparatively small areas in Karnataka, Orissa, Madhya Pradesh, Tamil Nadu, Bihar, West Bengal and Uttar Pradesh are frequented by drought. About 40 million hectares of land is flood-prone including most of the river basins in the north and the north-eastern belt affecting about 20 million people on an average each year. A mean sea level rise of 15-38 cm is projected along India's coast by the mid 21st century and of 46-59 cm by 2100. A projected increase in the intensity of tropical cyclones by 15% poses a threat to the heavily populated coastal zones (GOI, 2004). India's NATCOM I projects an increase in the area under xeric shrub lands and xeric woodlands in central India, replacing dry savanna in these regions. A study by Indian Institute of Science concludes that in 2085, between 68% and 77% of the forested grids in India are likely to experience shift in forest types depending upon climate change scenarios.

The problem of climate change is very closely associated with the green house gases and effects. The foregoing analysis has adequately revealed that the problem is important because of its bad impacts on Indian economy. The study of sources of green house gas emissions enables us in understanding the areas of green house gases. The necessary data is presented in Table 1 below. Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, fresh water supply, health etc. (Sathaye et al., 2006)

Table 1: Sources of Green House Gas (GHG) Emissions in India

Sr. No.	Source of GHG	% share
1	Energy	61
2	Agriculture	28
3	Industrial Processes	08
4	Wastes	02
5	Land Use Changes	01
	Total	100

Source: India's Initial National Communications on Climate Change, 2004.

India is a large developing country with nearly 700 million rural populations directly depending on climate sensitive sectors and natural resources for their subsistence and livelihoods. It is observed from the data in Table 1 that energy and agriculture are the major contributors to green house gases and thereby to the problem of climate change, which is followed by industrial processes. Thus, it is the energy sector, which is mainly responsible for the problem of climate change in India.

It is a fact that the green house gases namely carbon dioxide, methane, nitrous oxide, water vapour, halo carbons and black carbons are responsible for green house effects and thereby climate change. The research studies show that the major gases contributing to climate change are carbon dioxide (CO₂), methane (CH₄) and Nitrous oxide (N₂O). This demands to study the relative shares of these prominent gases in total emissions in India. Table 2 presents the necessary data concerning that. It is estimated that 16 million tonnes of carbon dioxide are emitted into the atmosphere every 24 hours worldwide. (Amie, 2007)

Table 2: Relative Green House Gases (GHG) Emissions

Sr. No.	GHG	% Share
1	Carbon dioxide (CO ₂)	65
2	Methane (CH ₄)	31
3	Nitrous oxide (N ₂ O)	04

Source: Sumana Bhattacharya, NATCOM, PMC

It is revealed that the carbon dioxide is a prominent green

house emitted in India, and contributing significantly to the problem of climate change with 65% share in green house gas emissions. It is followed by methane and nitrous oxide respectively.

Climate change is a global phenomenon being contributed by many countries and their groups through emissions of green house gases. It is necessary to identify the place of India in green house gas emissions and thereby relative contribution to the problem of climate change. On a global basis, it is estimated that RE (Renewable Energy) accounted for 12.9% of the total 492 Exajoules (EJ) of primary energy supply in 2008. The largest RE contributor was biomass (10.2%), with the majority (roughly 60%) being traditional biomass used in cooking and heating applications in developing countries but with rapidly increasing use of modern biomass as well. Hydropower represented 2.3%, whereas other RE sources accounted for 0.4%. In 2008, RE contributed approximately 19% of global electricity supply (16% hydropower, 3% other RE) and biofuels contributed 2% of global road transport fuel supply. Traditional biomass (17%), modern biomass (8%), solar thermal and geothermal energy (2%) together fuelled 27% of the total global demand for heat. The contribution of RE to primary energy supply varies substantially by country and region (IPCC 2012). Table 3 represents the necessary data about that.

Table 3: Per Capita and accumulated emissions of Carbon dioxide (Co₂) through Energy Consumption

Country/ Group	Per capita emissions of Co ₂ in 2004 (tonnes)	Total accumulated emissions of Co ₂ during 1840-2004 as % of world total	Per capita accumulated emissions of Co ₂ during 1850-2004 tonnes	Per capita in 2005 (US \$)
China	3.8	8.1	68.9	6757
India	1.2	2.3	23.3	3452
Japan	9.9	3.9	334.2	31267
USA	20.6	29.4	1105.4	41890
Germany	9.8	7.2	962.8	29461
Spain	7.6	0.9	237.9	27169
Developing Countries	2.4	24.9	53.9	5282
Developed Countries	13.3	75.1	843.0	33082

Source: UNDP, Human Development Report, 2007.

It is observed that developed countries have contributed substantially to the carbon dioxide emissions in the atmosphere than the developing countries. Their efforts to achieve rapid and all round economic development are responsible for greater emissions of carbon dioxide and thereby to the problem of climate change. On the contrary, developing countries contribution to this problem is considerable, but not significant one. A country wise analysis of carbon dioxide emissions reveals that the developed countries namely USA, Germany were the significant contributors to the emissions of carbon dioxide, which was followed by the developing country like China. India's relative contribution to carbon dioxide emissions and thereby to the problem of climate change is considerable, but not significant one.

As the climate change is a serious international problem, hence its control through reductions in green house gas emissions is of vital important. It is a fact that the countries of the world have been attempting for adaptations to the climate change. The efforts in that direction and their results in carbon dioxide emissions are shown in Table 4.

Table 4 : Share in Global Carbon dioxide (Co₂) Emissions (%)

Countries	1990	2003
United States	23.04	23.06
China	10.41	14.07
Russia	9.67	6.38
Japan	4.54	4.79

India	2.63	4.07
Germany	4.24	3.35
Canada	2.19	2.39
United Kingdom	2.76	2.24
Italy	1.91	1.85
France	1.80	1.63
Rest of World	38.61	36.17

Source: United States Department of Environment.

It is observed that, Russia, Germany, England and France are developed countries, which have succeeded in reducing carbon dioxide emissions during the period from 1990 to 2003. The USA has not succeeded in reducing its relative higher share in the carbon dioxide emissions. Likewise, Canada, Japan also could not succeed in the emissions control of carbon dioxide. It is noteworthy that China's emissions of carbon dioxide have been rose significantly during the same period. Even though, India's carbon dioxide emissions are lower, they have increased considerably. As per the latest data for 2009, the carbon dioxide emissions of China was 7710.50 lakh tones, which was followed was 5424.53 lakh tones by USA, 1602.12 lakh tones by India, 1572.07 lakh tones by Russia and 1097.96 lakh tones by Japan respectively.

It is agreed worldwide that, energy sector is dominantly contributing to the green house gas emissions and thereby to the problem of climate change. In energy sector, primary energy generated from fossil fuels, coals mainly facilitates increased carbon dioxide emissions and thereby to the climate change. The necessary data relating to consumption of primary energy is presented in Table 5 below.

Table 5: Consumption of Primary Energy (Millions of tonnes of oil equivalent)

Country	1990	2005	2030	Increase during 1990-2005	Increase during 2005-2030
World	8755 (100%)	11429 (100%)	17721 (100%)	2674 (100%)	6292 (100%)
OECD	4518 (51.6%)	5542 (48.5%)	6800 (38.4%)	1024 (38.3%)	1258 (20%)
China	874 (10%)	1742 (15.2%)	3819 (21.6%)	868 (32.5%)	2077 (33%)
India	320 (3.7%)	537 (4.7%)	1299 (7.3%)	217 (8.1%)	762 (12.1%)
China + India	1194 (13.6%)	2279 (19.9%)	5118 (28.9%)	1085 (40.6%)	2839 (45.1%)

Source: International Energy Agency (EIA), World Energy Outlook, 2007

It is observed that OECD countries (Organisation for Economic Cooperation and Development) have a major share in the consumption of primary energy in the world during 1990 to 2030. It has been declining, but still it is prominent one. The relative consumption shares of primary energy of China and India are significant one, and they are increasing. The growth in China's share is rapid one. It is primary energy that emits green house gases especially carbon dioxide and contributes to the problem of climate change. Hence, its place or relative position in India is necessary to assess. Table 6 below gives the data concerning that.

Table 6: Energy Sources in India (in 2004)

Sr. No.	Source	% share
1	Biomass/Waste	38
2	Coal	33
3	Oil	22
4	Gas	04
5	Hydro	01
6	Nuclear	0.84
7	Solar/Wind/Other	0.03
8	Geo Thermal	0.00

Source: International Energy Agency, 2006.

It is observed that coal, biomass/waste, oil is the sources of primary energy in India, which stood at 93% in 2004, are basically higher green house gases emitting energy. The sources of eco-friendly energy are gas, hydro, nuclear, solar, wind, other and geo thermal contribute only 7% share in the generation of energy. Thus, there are only meager attempts, have been undertaken to exploit and harvest eco-friendly energy.

After the energy sector, agriculture is an important source of green house gas emissions in India. Therefore, the study of various sectors or constituents of agriculture, which contribute to the climate change, is necessary to study. The necessary data is given in Table 7 below.

Table 7: Sectors of Indian Agriculture Contributing to Climate Change

Sr. No.	Sector of Agriculture	% share
1	Enteric fermentation	59
2	Rice cultivation	23
3	Emission from soils	12
4	Manure management	05
5	Crop residues	01
	Total	100

Source: India's Initial National Communications on Climate Change, 2004.

It is observed that enteric fermentation and rice cultivation are the major sectors, which contribute to the climate change in India, especially from agriculture sector, which is followed by emissions from soils.

IV) ROLE OF FORESTS IN GLOBAL WARMING AND CLIMATE CHANGE MITIGATION:

Growing trees and plants take up atmospheric carbon dioxide (CO₂) through photosynthesis and store it as carbon in biomass (living trunks, branches, leaves and roots), necromass (deadwood and litter), and soils. Some of this carbon finds its way to the rivers and oceans. Some gets buried underground in the sediments and as fossil fuels such as coal, oil and gas. CO₂ is in turn released into the atmosphere through plant and animal respiration and decomposition, soil respiration, burning of fossil fuels for energy and industrial activities, and through deforestation and forest degradation.

Forests have the potential to contribute to climate change through their influence on the global carbon cycle. They store large quantities of carbon in vegetation and soil, exchange carbon with the atmosphere through photosynthesis and respiration, release carbon into the atmosphere when they are disturbed, become atmospheric carbon sinks during regrowth after disturbance and can be managed (locally) to alter their role in the carbon cycle. Recent studies suggest that the local management of forests for carbon conservation and sequestration could mitigate emissions of carbon dioxide by an amount equivalent to 11 to 15 percent of fossil fuel emissions over the same period. The importance of forests for such goods and services as wood products, fuel, and conservation of soil and water resources, recreation and biological diversity has been recognized for a long time. Now, forests are also being recognized as playing important roles in global biogeochemical cycles, particularly the global carbon cycle. The global carbon cycle is important for its role in regulating the concentration of carbon dioxide (CO₂), an important greenhouse gas, in the atmosphere. The increasing concentration of CO₂ in the atmosphere contributes to global warming and, thus, to climate change. Major pools of carbon are the atmosphere, fossil fuels, oceans and the terrestrial biota and soils. Carbon is exchanged between these pools and the atmosphere as CO₂ by: burning fossil fuels; net primary production and respiration of the biota, soils and

other forms of dead organic matter; deforestation, forestation and regrowth of vegetation after disturbance; and diffusion with the oceans. (S. Brown, 1995)

At present forests cover is just over 4 billion hectares or roughly 31% of the earth's surface and sequester (absorb or remove from the atmosphere) and store large quantities of carbon. Forest ecosystems are estimated to store about 650 billion tonnes of carbon (44% in biomass, 11% in necromass and 45% in soils) and absorb 8.5 billion tonnes of CO₂ per year from the atmosphere. However, deforestation (conversion to other land use) and forest degradation in the tropics through logging, fire and other anthropogenic disturbance results in substantial CO₂ emissions. The UN's Intergovernmental Panel on Climate Change (IPCC), using 1980s and 1990s-era forest surveys and satellite data, estimated that deforestation was responsible for around 17% of total annual global GHG emissions. Using updated data (reduced deforestation and increased fossil fuel use in recent years), Guido van der Werf and colleagues scaled down the estimate to about 12% though allowing for a wide range of 6-17%. Winrock International's ongoing study using LIDAR remote sensing data and field inventories suggests a much lower rate of around 8% for 2000 to 2005, with a possible range of 5-12%¹⁴. Forest (Unna Chokkalingam, 2011)

Estimates of forest contribution to GHG emissions and their potential role in mitigating (reducing) global warming vary widely because of incomplete country data, the complexity of monitoring forest cover and condition, the wide diversity of methods used, as well as changing land use and emissions patterns. However, even at 8-12% contribution, forests still remain a significant source of global warming. Forests and the role they play and could play have become increasingly important in discussions and negotiations to mitigate climate change.

Climate change mitigation via forests is possible through Forest carbon stocks could be potentially conserved and enhanced through a wide range of activities such as: Planting and/or regenerating trees on barren or non-forested land, in degraded forests, and in agricultural and urban landscapes. This includes concepts such as afforestation, reforestation, forestation, forest rehabilitation, forest restoration, agroforestry, urban forestry and enrichment planting. Conserving existing forests and avoiding their degradation or conversion to alternative land use. This includes concepts such as avoided deforestation, Reducing Emissions from Deforestation and Forest Degradation (REDD), and conservation of forest carbon stocks, Improved or sustainable forest management using options such as reduced impact logging (RIL), longer rotations, mixed ages and species, Managing harvested wood products, Soil (including peatland) conservation and rehabilitation, Use of forestry products for bioenergy to replace fossil fuel use, Tree species improvement to increase biomass productivity and carbon sequestration. (Unna Chokkalingam, 2011)

V) STATE OF FORESTS AND FOREST MANAGEMENT IN INDIA:

The problem of global warming and climate change is a global or international problem. It is a fact that forests as a natural resource plays a very vital role in the control of accumulation of a major green house gas Carbon dioxide. Hence it is essential to examine the state of forest area in the world as a whole. It is at least 33% of total geographical area should be forest cover area for the environmental balance and qualitative environment.

Table 8: Forest Area in Top Ten Countries in 2010

Countries	Area (in Million Hectares)	% to Total
Russian Federation	809	20.05
Brazil	519	12.86
Canada	310	7.68

USA	304	7.53
China	206	5.10
Democratic Republic of the Congo	154	3.81
Australia	149	3.69
Indonesia	94	2.33
Sudan	69	1.71
India	68	1.68
Total World	4033	100

Source: GFRA 2010

It observed that not a single country in World has succeeded in achieving the goal of at least 33% forest area of the total geographical area. Only the efforts of the Russian Federation are appreciable. The developed as well as undeveloped countries are very much lagging in materialising the forest area necessary for environmental balance. India is also in the same direction and level. This demands an urgent need and rigorous and honest attempts to increase the area under the forest, which will enable mitigating global warming and climate change coupled with environmental balance and qualitative environment that promotes the well being of the society as a whole.

As the present study is mainly related to India in the context of the problem of global warming and climate change by taking into consideration the importance of the forests a natural resource, it is necessary to assess the state of forest resources in India. The data relating to the forest resources in India is being provided by the Forest Survey of India and the Ministry of Environment and Forests. The area recorded as forest in the Government records is known as forest area. It is also referred to as recorded forest area. Forest cover means all lands, more than one hectare area with a canopy density of more than 10 % irrespective of ownership and legal status. Such lands may not necessarily be a recorded forest area. It also includes orchards, bamboo and palm. The forest cover is classified as i) very dense forest, ii) moderately dense forest and iii) open forest. All lands with a forest cover having a tree canopy density of 40% and above are known as dense forest. Moderately dense forest refers to all lands with forest cover with a tree canopy density between 40 to 70 %. Lands with forest cover having a tree canopy density of 70 % & above are called as very dense forest. All lands with a tree canopy density between 10 to 40 % are known as open forest. Scrub is degraded forest lands a tree canopy density of less than 10 %. The data in table below depicts the state of forests and forest cover in India.

Table 9: Forest Cover of India 2011

Class	Area (Km ²)	% of Geographical Area
Forest Cover		
a)Very Dense Forest	83471	2.54
b)Moderately Dense Forest	320736	9.76
c) Open Forest	287820	8.75
Total Forest Cover	692027	21.05
Tree Cover	90844	2.76
Total Forest and Tree Cover	782871	23.81
Scrub	42177	1.28
Non -forest	2553059	77.67
Total Geographical Area	3287263	100

Source: India State of Forest Report 2011, Forest Survey of India

It is revealed that total forest cover excluding tree cover in India was 21.05 % of total geographical area. It is less than 33% necessary for environmental balance and environmental quality and consequently for the control of global warming and climate change. Even the tree cover is considered the total forest cover does not arrive at 33%. It is a thing of concern in the era of global warming and climate change. The note worthy thing is that a major forest cover comprises of the moderately dense forest and open forest. This clearly poses

the need and urgency for increasing the forest cover in India. The total forest cover in 1990 was 63939 (1000 hectares), which increased to 65390 in 2000, 67709 in 2005 and 68434 in 2010. The annual growth rate of area under forests stood at just 0.22% during 1990-2000, 0.70% during 2000-2005 and 0.21% during 2005 -2010 is a thing of serious concern.

India is a country with number of states and union territories. Hence it is also necessary to examine the scenario of the forests across the states in India. This enables us to know whether the states are attempting rigorously and honestly for increasing forest area necessary for environmental balance, coupled with control of global warming and climate change. It also enables in suggesting an appropriate strategy for forests resource management for India. The present state of forests in India, across the states and also trends in forest area with changing of time, i.e. during 2009 to 2011, is given in table below.

Table 10: Forest Area in States and UTs in India (Area in km²) (2009- 2011)

State / UT	Geo. Area (GA)	Total Forest in ISFR 2009 Area	2011 Assessment				Real Change from 2009 to 2011
			Very Dense Forest	Moderate Dense Forest	Open Forest	Total Forest	
Andhra Pradesh	275069	45102	850	26242	19297	46389	-281
Arunachal Pradesh	83743	67353	20868	31519	15023	67410	-7.4
Assam	78438	27692	1444	11404	14825	27673	-19
Bihar	94163	6804	231	3280	3334	6845	41
Chhattisgad	135191	55870	4163	34911	16600	55674	-4
Delhi	1483	177	7	49	120	176	0
Goa	3702	2151	543	585	1091	2219	7
Gujrat	196022	14620	376	5231	9012	14619	-1
Haryana	44212	1594	27	457	1124	1608	14
Himalachal Pradesh	55673	14668	3224	6381	5074	14679	11
Jammu & Kashmir	222236	22686	1440	8760	9639	22539	2
Jharkand	79714	22894	2590	9917	10470	22977	83
Karnataka	191791	36190	1777	20179	14238	36194	4
Kerala	38863	17324	1442	9394	6464	17300	-24
Madhya Pradesh	308245	77700	6640	34986	36074	77700	0
Maharashtra	307713	50650	8736	20815	21095	50646	-4
Manipur	22327	17280	730	6151	10209	17090	-190
Meghalaya	22429	17321	433	9775	7067	17275	-46
Mizoram	21081	19240	134	6086	12897	19117	-66
Nagaland	16579	13464	1293	4931	7094	13318	-146
Orissa	155707	48885	7060	21366	20477	48903	48
Punjab	50362	1664	0	736	1028	1764	100
Rajasthan	342239	16036	72	4448	11567	16087	51
Sikkim	7096	3357	500	2161	698	3359	2
Tamil Nadu	130058	23338	2948	10321	10356	23625	74
Tripura	10486	8073	109	4686	3182	7977	-8
Uttar Pradesh	240928	14341	1626	4559	8153	14338	-3
Uttarakhand	53483	24495	4762	14167	5567	24496	1
West Bengal	88752	12994	2984	4846	5365	12995	1
A&N Islands	8249	6662	3761	2416	547	6724	62
Chandigarh	114	17	1	10	6	17	0
Dadra & Ngaraveli	491	211	0	114	97	211	0
Daman & Diu	112	6	0	.62	5.53	6	0
Lakshadeep	32	26	0	17.18	9.88	27	1
Poudcherry	480	50	0	35.37	14.69	50	0
Total	3287263	690899	83471	320701	287820	692027	337

Source: India State of Forest Report 2011, Forest Survey of India

It is a fact that, there is a need for increasing area under forest cover in India for environmental balance, environmental quality, and more importantly for the control of global warming and climate change through reducing carbon dioxide emissions. But it is observed that India has failed in arriving at the 33% area under forest cover. Besides during

2009 to 2011, there is fall in forest area by 337 km² area, which stands at 0.05%. The scenario of change in forest area during the period into consideration across the states is not satisfactory, and it differs from the state to state. There are only a few states in which the area under forests has been increased, that are also different across the states. The states that have increased their forest area are Punjab, Tamil Nadu, Rajasthan, Jharkhand, Assam, Bihar, Andaman & Nicobar Islands considerably. There are some states who have registered a very meager growth in rise in forest area, which is

a thing of concern. Surprisingly, there are number of states in India in which a significant fall in forest area is found. They are Andhra Pradesh, Manipur, Arunachal Pradesh, Nagaland, Meghalaya, Mizoram and others, is a more serious thing to be noted. It is also observed that not a single state in India has succeeded in achieving a forest area required for the environmental balance and environmental quality. The responsible reasons for such trends in India as well as across the states are, in Andhra Pradesh management interventions like harvesting of short rotation crops followed by new regeneration/ plantations, forest clearances in some encroached areas led to the trend of a fall in area under the forests. In Andaman and Nicobar Islands recovery of coastal vegetation in Tsunami affected areas, shelterbelt plantations and increase in mangrove cover contributed to increase their forest cover. The forest cover in Arunachal Pradesh has declined due to shifting of cultivation and biotic pressure. In Assam the de-

crease in forest area is due to illicit felling, encroachments in surgency affected areas and shifting of cultivation practices in the state. The enhanced plantation activity outside forest areas in recent times contributed towards increase in forest cover in Bihar. The submergence of forest areas in catchments of the dams led to a slight fall in area under forest. In Manipur, Meghalaya, Mizoram and Nagaland the decrease in forest area is due to shortening of shifting cultivation cycle and biotic pressure. The main reason for the increase in forest cover in Orissa is due to effective protection the JFM committees and regeneration of shifting cultivation areas. In Punjab the growth of young plantations carried out under externally aided project and agro-forestry activities helped to enhance the forest area in the state. The states of Rajasthan and Tamil Nadu carried out regeneration in forest areas and extensive plantation activities in and outside forests were re-

sponsible for increasing their forest areas. (India State of Forest Report 2011) The minus growth in the area under the forest indicates deforestation for the India as a whole, as well as in the context of some states in India. One of the causes causing the fall in area under the forest is forest fire incidences, their number was 26187 in 2008-09, which increased to 30892 in 2009-10 which stood at 13898 in 2010-11.

Management of terrestrial carbon sinks are of paramount importance to contain and arrest the carbon dioxide from the atmosphere as it is the main green house gas (GHG) attributed to global warming. The forests play very significant role in the dynamics of global carbon cycle. In order to assist policy makers on climate change related issues, it is desirable to have a periodical account of carbon stocks in forests and changes in the stocks to assess contribution of forests in sequestration of atmospheric carbon. The estimate on carbon stock stored in India's forest for the year 1995 and 2005 has been given in ISFR 2009. These estimates were based on a study conducted by Indian Council of Forestry Research and Education. The estimates were based on forest and tree cover and generated by using biomass expansion factor for different pools. The FSI has estimated carbon stock for 1994 and 2004 in respect of Forest Land Remaining Forest Land and Land Converted into Forest Land in 2010 in the ISFR 2011. The 'Good Practices Guidance' (GPG) developed by Inter-governmental Panel on Climate Change (IPCC) is universally accepted source book for concepts, definitions, pools, methods, default values, various equations etc, for preparing account of forest carbon stocks(FCS). The data about the change in carbon stock from forest in India is presented in Table below.

Table 11: Change in Carbon Stock from Forest Land Remaining Forest Land including Land Converted to Forest Land in 1994 and 2004 (Million Tonnes)

Component	Carbon Stock in Forest Land in 1994 (MtC)	Carbon Stock in Forest Land remaining Forest Land in 2004(MtC)	Net Change in Carbon Stock in forest land remaining Forest Land(MtC)	Annual change in Carbon stock in forest land remaining Forest Land during 1994-2004(MtC)	Carbon stock change from land converted to forest land in 2004(MtC)	Annual change in Carbon stock in land converted to forest land during 1994-2004(MtC)
Above Ground Biomass	1784	1983	199	19.9	118	11.8 (31%)
Below Ground	563	626	63	6.3	37	3.7 (10%)
Dead Wood	19	24	5	0.5	1	0.1
Litter	104	114	10	1.0	7	0.7
Soil	3601	3542	-59	-5.9	211	21.1(56 %)
Total	6071	6288	217	21.7	375	37.5 (100)

Source: India State of Forest Report 2011, Forest Survey of India

The data in table reveals that carbon stock from forest land remaining forest land including land converted to forest land during 1994 to 2004 stood at 37.5 million tonnes. In 2004 the emissions of carbon dioxide only from energy sector was 1380 million tonnes. And as per the data for 2009 the carbon dioxide emissions of India was 1602.12 lakh tonnes. This reveals the need for a vital role of the forests in carbon sequestration in India in the era of global warming and climate change. During 1994 to 2004 the carbon stock by the forests was dominated by the soil (56%), which is followed by above ground biomass (31%), below ground (10%) respectively. The contributions of other components in the stock of carbon dioxide stock are meager and hence insignificant.

It is very much essential to take a review of the present forests resource management activities in India. It comprises of ; Survey & Utilization Division of Ministry of Environment and Forests deals with the matter related to Forest Survey of India, Dehradun, Andaman & Nicobar Forest & Plantation

Development Corporation Ltd., Port Blair, Export & Import of wood and wood products, Forest Certification, Sustainable Forest Management, Non-Timber Forest Products (NTFP) Management, International Tropical Timber Organization etc. Besides the above, there is a plan scheme in SU Division - 'Strengthening of Forestry Division' under its administrative control. Forest Survey of India (FSI) is a subordinate office of the Ministry of Environment & Forests, Government of India and is responsible for the national forest resource assessment. Forest Fire Monitoring is an ongoing service, which started in November 2005. Under the service, forest fire data generated by MODIS satellite system is overlaid on the forest cover map made by interpretation of satellite images. (Ministry of Environment and Forests, 2010-11) Biomass Study was conducted as a part of National Communication-II (NATCOM-II). Carbon Estimation work is being conducted under NATCOM-II in collaboration with NFDMC Unit of FSI. For India, Forest Survey of India is the nodal agency for compilation and sending the country' data to FAO. The Central Empowered Committee (CEC) of Hon'ble Supreme Court on India assigned the task of mapping the mining areas of Aravali hills of Haryana to the Forest Survey of India. Under the

scheme Survey and Utilization of the Forest Resources, the approved outlay for 11th Plan period is 28.60 Crore. Forest Certification has emerged as a voluntary market-driven mechanism in support of Sustainable Forest Management (SFM). Certification and Eco-labeling are the new mantras to enhance the product positioning for a premium price on one hand and ensuring better forest management practices on the other hand. The Ministry constituted an Expert/Advisory/Working Group with an aim to support the implementation of an integrated National Forestry Database Management System (NFDMS) in a comprehensive manner including strengthening of the technological, institutional and human capabilities to ensure continuing and effective dissemination and use of forest statistics. A Committee was constituted under the Chairmanship of Inspector General of Forests (NAEB), Ministry of Environment & Forests for evolving a mechanism for Minimum Support Price to the collectors of NTFPs. The Division deals with the formulation of guidelines and directions for domestic and international trade in forest produce and the necessary regulation of export and import of forest produce as per the Foreign Trade Policy as well as the applied Tariff rates. Committed to the goal of achieving Sustainable Forest Management, a National Task Force was constituted in November, 1999 by Government of India as Bhopal-India process. This recognized eight Criteria & 43 Indicators. The National set of C&I was refined in the year 2005 based on field experiences. Thereafter 8 Criteria & 37 Indicators have been adopted during the year 2008 for monitoring the directions of change at National level. Andaman & Nicobar Islands Forest and Plantation Development Corporation Limited (ANIFPDCL) is a Government of India Public Sector Undertaking, created in 1977 with the broad objectives of development and managing forestry plantations on the Islands. (Ministry of Environment and Forests, 2010-11)

VI) A STRATEGY FOR FOREST RESOURCE MANAGEMENT IN INDIA:

It is necessary to evolve a suitable forests resource management strategy for India in the era of global warming and climate change for their mitigation. It is because the foregoing analysis clearly and adequately reveals that the contribution of India to the problem of global warming and climate change is considerable especially after the China. Hence it is the forests resource has an ability and potentiality to control emissions of carbon dioxide and thereby the control of the intensity of global warming and climate change.

It is a fact that, it is very much essential to increase forest cover area for the more or less all the countries with some exceptions for environmental balance, environmental quality, more importantly the mitigation of the global warming and climate change. But as the present paper is concerning the India, the strategy for the forests resource management would be relating to India only. The government of India should prepare and implement a target based programme of increasing forest area in the country and it should be incorporated as an objective of the economic plan in India. A continuous review of the state of forests in India should be carried out annually and it should provide the data and the state with regards to the forests in India. The present data relating to the state of forest as well as carbon dioxide absorbed is not up to date to the extent required. The attempts should be made to control the use of nontraditional energy source like fuel wood as well as use of alternative materials for wood and wood products especially in the construction activities. There is a wide disparity in the forest area across the states in India. Every state should attempt to achieve the goal of at least 33% forest area of the total geographical area. Deforestation should be totally banned in India; it should be permitted wherever there is a natural need of the area. The Union government of India with the due participation of both the State and Local governments should introduce and implement a programme "Forests Resource for Global Warming and Climate Change Mitigation" by creating a separate fund of Rs. 100 crore for a five year plan. It is urgent need of the hour to prepare and

implement an appropriate Land Utilisation Policy for the Indian nation as a whole, which will make a specific area to be left as forest area by taking in to consideration the state of the forests that enable to enhance the area under the forests at national level as well as across the states in India. The active participation of the people in the activity of promoting forests can be an effective measure on improving the state of the forests resources in the country. For this, people should be given economic incentives like tax exemptions, rebates, subsidies. A forestation programme for creating carbon credits should be introduced and enforced that will increase the area under the forests in India. The corporate sector in India should be involved in the activity of forestation programme to increase forests that will help in the control of carbon emissions, global warming and climate change as well. This will be Environmental responsibility of the corporate sector in India, and it will be obligatory. The Forests Commission like that of Finance Commission should be appointed after every five years, that will examine the state of forests and the problems there in and it will give recommendations to the Union government of India to be implemented by the Union as well as State governments in the country. The local governments should attempt for developing urban and rural forests in the areas available in their jurisdictions for this it can be an item of expenditure, which has the benefits like the control of carbon dioxide, global warming and climate change for qualitative environment. Forest development should be an economic activity in both the Union and State plans in India. It should be made obligatory to the landlords to undertake some land under the forests that can be helpful in promoting forest area in especially rural India. On the banks of oceans and rivers also it should be made compulsory to develop forests up to some area that will promote forest area as well as protect from the natural calamities like floods, Tsunami and others. The working of the Joint Forest Management Committees should be made active and effective for protection and enhancement of the forest cover area in India, for which economic incentives such as financial assistance, Land cultivation, forest products etc, should be given to the concerned. The active involvement of the Government of India is necessary for the marketing of the carbon credits and profit making price for them can be useful in promoting the forests area and its proper management. The knowledge and awareness about the forests, their protection, and conservation should be created and promoted among the people through colleges, educational institutions and universities as well, which is helpful in the proper management of the forests in India. The research studies relating to forests, their proper management and role in the control of carbon dioxide emissions should be carried out in the universities, colleges and research institutes should be promoted by providing financial support, which will provide inputs for policy making relating to forests area increase, management and global warming and climate change mitigation.

VII) CONCLUDING REMARKS:

Forests are a very valuable natural resource. It can play a very vital role in controlling the emissions of the carbon dioxide, which is a prominent green house gas contributing to the problem of green house effect, global warming and climate change. It is very much essential to control these environmental problems, because they have very bad impacts on the various spheres of the environment, especially the human beings. In this backdrop the present research paper is a little bit attempts to deal with forests, their management and mitigation of the global warming and climate change. Forests and global warming and climate change is a very vast issue with wider scope and multiple facets. Hence there is a lot of scope in undertaking the number of the research studies on this topic in the form of research projects, dissertations, theses and research papers. Moreover, these studies should have the primary data base, which was not endeavoured in the present study due to some constrains, but it is essential. In this direction the number of studies can be carried out, which will touch upon more or all the aspects of the topic

necessary for dealing with the problem of global warming and climate change through the forests as a very valuable natural resource.

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