DEFORESTATION IN INDIA AND CLIMATE CHANGE

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ABSTRACT

There are two processes going simultaneously one is deforestation and second is climate change and both are interrelated with each other. The quantum of deforestation is high and highly undesirable. There are various estimates of deforestation in India. From the regional analysis carried out, it can be seen that the overall net rate of deforestation was relatively high in the North East region (–0.90 to –5.29) and Deccan Peninsula (–0.19 to –3.2) followed by the Western Ghats. The rate of deforestation is unabated in the North-Eastern part of the country, hill areas and most importantly the losses are more from the VDF and MDF. Out of the 29 states and 7 union territories (UT) 24 states and 4 UTs have shown decline in forest cover as shown in the Table-2 and there is a huge decline in MDF and it is to the tune of (-) 3913 sq km (here only losses have been added up).There has been a decline in very dense forest (VDF) also to the tune of (-) 201 sq km and so has open forest to the level of (-) 690 sq km. Forests, like other ecosystems, are affected by climate change. Forests also influence climate, absorbing CO2 from the atmosphere and storing carbon in wood, leaves, litter, roots, and soil. The carbon is released back into the atmosphere when forests are cleared or burnt. By acting as sinks, forests are considered to moderate global climate change Deforestation is linked with decrease rate of precipitation, rise in temperature and extreme weather conditions in India

KEY WORDS: Climate Change, Deforestation, Forest, Forest Cover, Carbon Sequestration, Diversion of forest land, Forest Conservation Act, 1980, Indian Forest Act, 1927, Sanctuary and National Park,

INTRODUCTION

India has a total land area of 329 million hectares of which around 23.4%, that is, 76.87 million hectares (Mha), is classified as the forestland with tree cover. More than 40% of the country's forests are degraded and under stocked; subsequently there is a large potential of REDD+ activities in the country. Forests, like other ecosystems, are affected by climate change. Forests also influence climate, absorbing CO2 from the atmosphere and storing carbon in wood, leaves, litter, roots, and soil. The carbon is released back into the atmosphere when forests are cleared or burnt. By acting as sinks, forests are considered to moderate global climate change (J.Kishwan 2012). Natural forests are more resilient to climate change and disturbances than plantations because of their genetic, taxonomic, and functional biodiversity. This resilience includes regeneration after fire, resistance to and recovery from pests and diseases, and adaptation to changes in radiation, temperature, and water availability (including those resulting from global climate change).While the genetic and taxonomic composition of forest ecosystems changes over time, natural forests will continue to take up and store carbon as long as there is adequate water and solar radiation for photosynthesis (Vandana Sharma and Smita Chaudhry 2013). Forest, particularly in the tropical countries are receiving increasing attention due to a number of reasons such as deforestation and its contribution to global CO2 emissions, leading to climate change and loss of biodiversity and ecosystem services. In the global context, there is also an increasing realization on the need for periodic assessment and monitoring of the state of forests and biodiversity, flow of ecosystem services, rates of deforestation, factors driving deforestation and forest carbon stock changes. India, along with Brazil, Indonesia and South Africa, is one of the leading tropical countries periodically monitoring and reporting the state of forests as well as area under forests, using the latest remote sensing techniques. The Forest Survey of India (FSI) is the designated agency to periodically monitor and report the changes in area under forests (N. H. Ravindranath, I. K. Murthy et al 2014). FSI has already published state of Indian Forest Report in 2015 which shows some of the disturbing element in the area of forest loss which will come up in the discussion in later part of this article. In recent history of Indian forest, large-scale destruction of the forests began with the British who wished to utilize the timber and the natural resources for the expansion and continuation of the empire. An idea of the commercial onslaught on India's forests by the British has been pieced together by Gadgil and Guha (1992). Quoting from a number of sources, they show how the British navy's need for durable timber was increasingly being met from India from teak (*Tectona grandis)* forests. Vast tracks of forest were chopped to create the vast railway network that criss- crosses India today. The main aim was the fast, cheap and efficient transport of inexpensive raw materials to the ports from the hinterlands of the country for export to Britain's industries and to ensure the fast movement of security forces to maintain the hold over the empire. For instance, between 1869 and 1885, over 6,500,000 deodar Cedrus deodara sleepers were extracted from the Yamuna Valley forests in the Himalayas, which in turn were necessitated because the supply of teak and sal (*Shorea robusta)* from peninsular India was getting exhausted. Wood for railway sleepers and as fuel for powering the locomotives facilitated the expansion of both the

railways and the British Empire. The other major cause of deforestation immediately after independence was agricultural expansion, often state-sponsored. Much of the rich moist deciduous forests of the humid Terai region in northern Uttar Pradesh for example were cleared to provide land to immigrants from the newly created Pakistan. Most of the woodland once covering the Indo-Gangetic plains was also gradually converted to fields or grazing lands (Subramanium and Sasidharan, 1993). Indeed between 1951 and 1980, according to the Forest Survey of India (1987), over 26.20 lakh hectares (26,200 sq.kms) of forest was converted for agriculture purposes all over India. (Kothari, 1993) Human activities such as fuel consumption and land-use change are the main causes of an increase in the atmospheric carbon dioxide concentration, which is generally recognized as a factor of climate change and global warming(FAO 2014).The Stern Review highlighted that forest conservation, afforestation, reforestation, and sustainable forest management can provide up to 25% of emission reductions needed to effectively combat climate change and that curbing deforestation has the potential to offer significant emission reductions fairly quickly in a highly cost-effective manner(Nicholas Stern 2006). Reducing emissions from deforestation and forest degradation (REDD+) is a mechanism for providing financial rewards to countries that reduce carbon emissions caused by the loss and degradation of their forests. In concept, REDD resembles other Payment for Environmental Services (PES) programs, however, REDD emphasizes a reduction in deforestation and degradation rates from expected levels, also known as avoided deforestation and degradation(H. J. Albers and E. J. Z. Robinson 2013).

DEFINITION OF FOREST IN INDIA:

The definition of Forest is as diverse as its diversity in terms of types, species composition, goods and services it provides, etc. Forest types differ widely, determined by factors including latitude, temperature, rainfall patterns, soil composition and human activity. How a forest is defined also depends on who is defining. A legal definition is different from an ecological definition. A recent study of the various definitions of forests (Lund 2012) found that more than 800 different definitions for forests and wooded areas were in use round the world – with some countries adopting several such definitions at the same time. The definition of forest has direct linkages with the level of deforestation in India. We cannot quantify the level of deforestation unless we are sure about what forest is and how we define deforestation.

DEFINITION OF FORESTS IN INDIAN CONTEXT:

There is no definition of the word **"Forest"** in two important national acts of forests i.e. Indian Forest Act 1927, and Forest Conservation Act 1980. However a local Forest Act in Meghalaya namely **"The United Khasi & Jaintia Hills Autonomous District (Management and Control of Forests) Act 1958"** has a definition of forest, for the purpose of management of forests of that locality, the section 2 (f) of which says, "**Forest" means and shall be deemed to be a forest, if in the area there are reasonable no. trees, say, not less than twenty five per acre reserved or any other forest produce growing on such area, which have been or are capable of being exploited for purposes of business or trade.** The **Hon'ble Supreme Court of India in its order dated 12.12.1996 in WP No. 202/95,**

has defined the words "Forest", and "Forest land" occurring in section 2 of F.C Act as below.

"The word, "forest" must be understood according to its dictionary meaning. This description covers all statutorily recognized forests, whether designated as reserved, protected or otherwise for the purpose of Section 2(i) of the Forest Conservation Act. The term "forest land", occurring in Section 2, will not only include "forest" as understood in the dictionary sense, but also any area recorded as forest in the Government record irrespective of the ownership.

After the above definition/ interpretation of words, "Forest" and "Forest Land" by the Hon'ble Apex Court, the Sec. 2 (d) of The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, defined the "Forest Land" on similar lines and the same is as follows. "Forest land" means land of any description falling with in any area and includes unclassified forests, undemarcated forests, existing or deemed forests, protected forests, reserved forests, Sanctuaries and National parks. The above stated definitions are legal definitions of forest for the purposes of interpreting the term "forest land" occurring in the concerned Acts. India is yet to evolve a comprehensive definition of the word "Forest". However for the purpose of CDM Forest in pursuance of the "Kyoto Protocol" India has come up with a definition as per the threshold limits fixed by UNFCCC for different parameters, according to which, "A forest is a land area of at least 0.05 ha, with a minimum tree crown cover of 15%, and tree height of at least 2 m" (Nophea Sasaki and Francis E. Putz 2009) As per the India State of Forest Report 2011, Forest Area means, the area recorded as "Forest" in government records. The term "Forest Cover" includes "all lands with more than 1 Ha. area with tree canopy density of more than 10 % irrespective of ownership and legal status".

PROPOSED DEFINITION OF FORESTS AS MOVED BY GOVERNMENT OF INDIA (2016):

Following a 2006 order of the Supreme Court, all state governments were required to identify forests as per dictionary meaning of the word, apart from lands which were demarcated in records as forest. But this did not happen till very recently, forcing the apex court to reiterate the need for a clear definition of forest land from the Centre. After a lengthy process of consultations with the states, Ministry of Environment, Forest and Climate change gave in-principle clearance for the definition after which a draft notification has been prepared and is pending finalization as yet. This comes as an amended and partially-diluted version of the first definition which was drafted by the ministry in consultation with states in 2014. The new definition classifies states in two different ways. One is the states where cadastral surveys were completed before the FCA came in to being and land records were settled for the entire state, another is the states where this process was not completed and confusion remains over what is forest land. In the first category of states, the definition of forests covers not only areas recorded as forests but also those classified as forests under various state laws and land classification systems, such as chote jhad ke jungle, bani, oran, civil soyam land etc. Areas that are identified in state records by geographical features such as gair mumkin

pahar, ravines, nala etc. too would be considered as forests, with caveats for identifying healthy forest patches. This would cover areas like Aravallis where some forests still remain. Mangroves, alpine meadows and montane bamboo brakes would also get defined as forests. In the second category of states, apart from the areas identified through the process meant for the first category, more areas are to be brought under the ambit of forest laws. For this purpose, such states are further classified in two categories. In states where the forest cover as well as the recorded forest area is less than one-third of geographical area, land patches having 10 per cent crown density will also be defined as forests. This will be done only if 70 per cent of these patches have natural forests (not plantations). For areas that are not adjoining existing declared forests, this would be done only for plots bigger than five hectares. In states where either the forest cover or the already-demarcated forest land is above one-third of the geographical area, patches of lands that have more than 40 per cent crown density would additionally be designated as forest. Following the national forest policy, which recommends a higher forest cover in hill districts, the cut-off for identifying additional forests under the law has been kept at two-third of the geographical areas. The final definition marks some dilutions from the previous draft, which was circulated in 2014 after a meeting between states and Centre. In that definition, even scrub forests with densities lower than 10 per cent were to be protected in states with low forest cover. This has now been done away with. But to protect private plantation growers, it has been ensured that only large patches (upwards of five hectares), with more than 70 per cent natural forests, gets covered under the FCA. The draft notification makes it clear that where people have planted trees on their own the definition would not apply to ensure plantations are encouraged and the Green India Mission is not hobbled.

DEFINITION OF DEFORESTATION:

Deforestation is a very broad term, which consists of cutting of trees including repeated lopping, felling, and removal of forest litter, browsing, grazing and trampling of seedlings. It can also be defined as the removal or damage of vegetation in a forest to the extent that it no longer supports its natural flora and fauna. The rapid rate of deforestation in the tropics is a key driving force in the yearly increase of flood disasters. **Deforestation refers to the loss of tree cover; land that is permanently converted from forest to non-forest uses such as agricultural pasture, desert, and human settlement.** Deforestation is defined by **FAO as 'the conversion afforest to another land use or long-term reduction of the tree canopy cover below the minimum 10% threshold'.** Further, UNFCCC defines **deforestation as 'the direct human induced conversion of forested land to non-forested land' (**N. H. Ravindranath 2014). Here in the absence of data on forest conversion to non-forest uses, loss of canopy density of forests to below 10%, during the monitoring period, is considered as loss of forest area and potentially deforestation. The definition of forest varies across countries. In many countries, forest is typically defined as an area with substantially higher levels of canopy closure, for example, 30–40%

depending on age in Russia and 60% in South Africa. In Australia, forest is defined as a vegetation type dominated by woody species having a mature stand height exceeding 5 m, with an over storey canopy cover greater than 20%. In the classification of forests introduced by UNEP WCMC, all forest classes have a minimum threshold of 30%, except for the class including sparse trees and woodlands, for which canopy closure is from 10% to 30% (C. Sudhakar Reddy et al 2013) Forest degradation is yet another phenomenon and it primarily concerns the changes within the forest class which affect the forest stand, quality or site negatively. Reduction of the tree Canopy above the original threshold of 10 % is classified as forest degradation whereas the Forest decline can be defined as the two processes of deforestation and forest degradation, which have both common and specific drivers, and which may or may not be spatially and temporally interrelated and will differ between regions. Due to these definitions, activities such as logging often fall under the category of forest degradation and are therefore not included in the deforestation statistics provided by the FAO or by the Government of India. Therefore, the rates of forest degradation are remarkably higher than deforestation rates. It is of further interest to note that deforestation and forest degradation occur due to different driving forces and that deforestation does not necessarily follow degradation. In reality, the difference between deforestation and forest degradation is blurred and no data available on global as well as national level. Thus, while this study focuses on exploring deforestation, forest degradation is always closely intertwined. Tropical deforestation and degradation typically bring concrete socio-economic benefits for some, often accompanied with high societal costs/impacts for others. Impacts of tropical deforestation change over time and space, often with various scale levels involved (i.e. the effects of climate change are global, while the impacts of land use policies are merely local). The impacts are also closely linked to the climate and thus depend on how climate change evolves in the future. At the same time, tropical deforestation itself is also a determinant in climate change scenarios. Alternative policy responses to reduce deforestation and forest degradation will have varying socioeconomic impacts in different localities. Policies addressing deforestation and degradation will directly impact on land use choices. This impact will depend on a range of factors, including the characteristics of location-specific societal, environmental and economic factors driving current land use, and on the design of international climate policies addressing the issue (Uma Shanker Singh 2017).

DEFINITION OF TREE:

Definition of tree also becomes important when we discuss deforestation. The Delhi Tree Preservation Act, 1994 defines tree as any woody plant whose branches spring from and are supported upon a trunk or body and whose trunk or body is not less than five centimeters in diameter at a height of thirty cm from the ground level and is not less than one meter in height from the ground level. The Uttar Pradesh Protection of Trees in rural and hills area Act, 1976 also defines tree exactly in the same language and terminology. UP Tree Protection Act 1976 also defines Fell a Tree with its cognate meaning and expression which includes cutting, girdling, lopping, pollarding, or damaging a tree in any other manner. Indian Forest Act 1927 defines Tree as Palms, Bamboos, Stumps, Brushwood

and canes, since forest is on the concurrent list therefore; many amendments have been made at the state level which is not being mentioned.

QUANTUM OF DEFORESTATION IN INDIA:

Understanding of deforestation rates in various parts of India is far from complete due to selective studies across the country. The prime drivers of deforestation can be considered as shifting cultivation along with increasing demand for agricultural land, mining, quarrying, expansion of settlements, urbanization, dam construction, illegal logging, infrastructure development, forest fire and over-grazing. The spatial resolution is of interest because forest systems are sensitive to varying resolutions which are used to study ecological processes at different scales. Much research on forest cover change has been carried out using coarse spatial resolution imagery on 1: 1 M scale. The coarse-scale mapping of forest extent is difficult because each pixel may represent two or more land-cover classes. Some studies have shown that the extent of forest cover may be underestimated because of this problem, while other image classifications tend to overestimate forest extent. Visual corrections have a large impact on the results of automated land-cover classification and the final reviewed results for the tropics indicated that about 20% of the forest patch labels were improved. The visual refinement had a notable effect on estimates of forest area change for Southeast Asia, where the net rate of change in forest cover loss from 1990 to 2000 was assessed at 0.9% before and 1.6% after visual control65. The areas mapped as forests may be under various degree of degradation process, invisible from observations of IRS LISS III and Land sat satellite imagery. In this context, forest cover information at very high spatial resolution and scales is required to assess the impacts of forest cover change and degradation. The integration of both visible and invisible forest degradation based on very high resolution satellite data and field observations is necessary for effective conservation strategies. Consistency in definitions, and new methodologies and techniques for quantifying forest cover at global to regional level are likely to be a challenging area of research. A new national action plan is strongly recommended in the areas where large-scale deforestation and forest degradation have affected majority of forests, especially in NE India, parts of the Eastern Ghats and islands (C. Sudhakar Reddy 2013) Deforestation is a very important and serious issue not because we are losing carbon sink but we do not know how fast we are losing. The government of India does not publish the rate of deforestation or the level of deforestation at the country level. Two things are to be taken in to consideration before the issue of deforestation is discussed one is the definition of deforestation and secondly the definition of tree as discussed above.

FOREST COVER

The forest cover includes all lands which have a minimum area of one hectare and have a tree canopy density of 10% and above irrespective of ownership and legal status including orchards, palm ,bamboo etc. The forest area is different as defined earlier .The total recorded forest area in the country is 769,538 sq km which constitutes 23.41% of the total geographical area. The total forest cover of the country is estimated to be

TABLE-1 FOREST COVER OF INDIA

CLASS	AREA(sq km)	PERCENTAGE OF GEOGRAPHICAL AREA
FOREST COVER		
VDF	85904	2.61
MDF	315374	9.59
OF	300395	9.14
TOTAL FOREST COVER	701673	21.34
SCRUB	41362	1.26
NON FOREST	2544228	77.40
TOTAL GEOGRAPHICAL AREA	3287263	100.00

SOURCE- ISFR 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Change

701,673 sq km which comes to around 21.34% of the geographical area of the nation and the total tree cover of the country as per the assessment is estimated to be 92,572 sq km which constitutes 2.82% of the geographical area. If we add up both forests cover and tree cover of the country it comes to 24.16% of the total geographical area. There has been an estimated increase of 3,775 sq km in the forest cover of the country as compared to 2013 assessment (ISFR 2015). Out of the 29 states and 7 union territories (UT) 24 states and 4 UTs have shown decline in forest cover as shown in the Table-2 and there is a huge decline in MDF and it is to the tune of (-) 3913 sq km (here only losses have been added up).There has been a decline in very dense forest (VDF) also to the tune of (-) 201 sq km and so has open forest to the level of (-) 690 sq km. ISFR,(2015) calculates losses on the basis of gains, if the country gains 10 sq km and loses 6 sq km then it gains +6 sq km which is wrong in its totality. Forest ecosystem does not work like this, the deforestation in one dense forest triggers the declining trend in the entire ecosystem and remains unstoppable until very drastic measures are taken to contain it. In the hill states the losses are very dangerous and dreadful. If we study the Table-3 the losses in VDF, MDF and OF are (-) 177, (-) 1335 and (-) 326 square kilo meters respectively and mostly the reasons for the deforestation and degradation are shifting cultivation, illicit felling , biotic pressure and theft of timber etc.Table-4 also shows the level of deforestation at different altitudes in the country. The minimum losses (-62 sq km) have been in the altitude of above 4000 meter and maximum decline in the forest cover is estimated to be in the range of (-) 279 sq km in between the altitudinal range of 2000-3000 meter. The country needs to address the issue deforestation very seriously and the beginning has to be made by creating a database on deforestation, degradation of forest and decline in the forest ecosystem. We have to stop the diversion of forest land for political purposes and the data on the forest land should be made available in the public domain inviting public criticism so that corrective measures could be taken immediately if some wrong has been committed. We don't know yet as to what is the rate of deforestation at the national

level, the information system is completely opaque. As a country the information is not available with us as to what is the level of forest cover in the forest area and it needs immediate attention of the forest bureaucracy. Different studies have been carried out with the data available to find out the level of deforestation. In one of the study this has been found out that the current estimate of gross deforestation in India is quite low (–0.43%) for 2009–2011 compared to the global average of –0.6%. Even though considerable progress has been made in the protection of forests, gross deforestation rate continues as a focal hindrance. The deforestation studies carried out in various parts of India are found to be fragmentary and far from being comprehensive. From the regional analysis carried out, it can be seen that the overall net rate of deforestation was relatively high in the North East region (–0.90 to –5.29) and Deccan Peninsula (–0.19 to –3.2) followed by the Western Ghats. For precise estimation of gross and net deforestation, consistency in definitions, uniform methodology and new techniques for quantifying forest cover have been realized (C. Sudhakar Reddy& Kalloli Dutta 2013). Deforestation is not a new issue and has been going on ever since society took to agriculture and the process of forest degradation was hastened as the developmental activities got the precedence over sustainability of forest. With the ascent of Britishers vast tracks of forest were chopped to create the vast railway network, because the main aim was the fast, cheap and efficient transport of inexpensive raw materials to the ports from the hinterlands of the country for export to Britain's industries and to ensure the fast movement of security forces to maintain the hold over the empire.. The other major cause of deforestation immediately after independence was agricultural expansion, often state-sponsored. Much of the rich moist deciduous forests of the humid Terai region in northern Uttar Pradesh for example were cleared to provide land to immigrants from the newly created Pakistan. Most of the woodland once covering the Indo-Gangetic plains was also gradually converted to fields or grazing lands (Subramanium and Sasidharan, 1993).

TABLE-2 CHANGE IN FOREST COVER OF STATES/UTs (AREA IN km2)

STATES/UT	CHANGE IN FOREST COVER			
	VERY DENSE FOREST (VDF)	MODERATELY DENSE	OPEN FORESTS (OF)	TOTAL FORESTS
ANDHRA PRADESH	9	-70	128	67
ARUNACHAL PRADESH	-24	-113	64	-73
ASSAM	-3	-77	32	-48
BIHAR	1	-4	0	-3
CHANDIGARH	-1	-19	-15	-35
GOA	-1	-5	11	5
HARYANA	0	-1	-1	-2
JAMMU & KASHMIR	-79	55	474	450
JHARKHAND	1	-4	8	5
KARNATKA	4	-116	401	289
KERALA	-6	-100	1423	1317
MADHYA PRADESH	-3	-19	-38	-60
MAHARASHTRA	-8	-23	27	-4
MANIPUR	-1	-169	174	4
MEGHALAYA	0	-105	34	-71
MIZORAM	0	-42	-264	-306
NAGALAND	-2	-41	-35	-78
ODISHA	-19	172	-146	7
PUNJAB	0	-1	0	-1
SIKKIM	0	-1	0	-1
TELANGANA	29	-204	7	-168
TRIPURA	4	-32	-27	-55
UTTAR PRADESH	572	-490	30	112
UTTRAKHAND	-31	-509	272	-268
WEST BENGAL	-23	26	20	23
A&N ISLAND	1932	-1728	-164	40
DADAR&NAGAR	0	-34	27	-7
PUDUCHERRY	0	-6	11	5
GRAND TOTAL	-201	-3913	-690	

SOURCE- ISFR 2013 and 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Chang

Very Dense Forest	All lands with tree canopy density of 70% and above.
Moderately Dense Forest	All lands with tree canopy density of 40% and more but less than 70%.
Open Forest	All lands with tree canopy density of 10% and more but less than 40%.
Scrub	Degraded forest lands with canopy density less than 10%.

TABLE- 3 CHANGE IN FOREST COVER OF HILL STATESAREA IN km2

STATES/UT	CHANGE IN FOREST COVER			
	VERY DENSE FOREST	MODERATELY DENSE FORESTS	OPEN FORESTS	TOTAL FORESTS
ARUNACHAL PRADESH	-24	-113	64	-73
ASSAM	-3	-77	32	-48
HIMACHAL PRADESH	0	0	13	13
JAMMU & KASHMIR	-79	55	474	450
JHARKHAND	1	-4	8	5
KARNATKA	4	-116	401	289
KERALA	-6	-100	1423	1317
MAHARASHTRA	-8	-23	27	-4
MANIPUR	-1	-169	174	4
MEGHALAYA	0	-105	34	-71
MIZORAM	0	-42	-264	-306
NAGALAND	-2	-41	-35	-78
SIKKIM	0	-1	0	-1
TRIPURA	4	-32	-27	-55
UTTRAKHAND	-31	-509	272	-268
WEST BENGAL	-23	26	20	23
GRAND TOTAL	-177	-1335	-326	

SOURCE- ISFR 2013 and 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Change

SOURCE- ISFR 2013 and 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Change

TABLE- 4 CHANGE OF FOREST COVER IN ALTITUDE ZONES

Area in sq. km

ALTITUDE ZONE	VDF	MDF	OF	TOTAL	PERCENT TOTAL FOREST COVER	PERCENT OF GA OF ZONE	CHANGE WITH RESPECT TO ISFR,2013
0-500M	31892	154428	182024	368344	52.50	16.27	2342
500-1000m	21745	97171	79459	198375	28.27	32.75	1983
1000-2000m	14867	36536	24971	76374	10.88	65.38	-109
2000-3000m	14011	19013	7417	40441	5.76	70.37	-279
3000-4000m	3353	7934	5962	17249	2.46	28.36	-100
ABOVE 4000m	36	292	562	890	0.13	0.49	-62
TOTAL	85904	315374	300395	701673	100	21.34	3775

SOURCE- ISFR 2013 and 2015, Forest Survey of India, Ministry of Environment, Forest and Climate Change

Around 3000 B.C, nearly 80% of India was forested. Deforestation has occurred in the tropics throughout history. Growing population, widespread poverty, and limited employment opportunities in agricultural and industrial sector have resulted in heavy pressure on forests, primarily due to unsustainable extraction of fuel wood and over grazing resulting in forest degradation. Forest vegetation sequesters carbon while at the same time deforestation and degradation of standing forests leads to release of stored carbon. The total forest cover has been declining

globally. It stood at 3.95Mha or about 30% of the global land area in 2006. The gross deforestation rate is estimated to have declined between 2000 and 2005 compared to the decade of the 1990s, but it still amounted to a gross and net loss of 12.9 and 7.3Mha/year, respectively. Deforestation refers to conversion of area having forest cover to other uses, for example, croplands, pastures, or urban land. Degradation, on the other hand, refers to reduction in productivity and/or diversity of a forest due to unsustainable harvesting (removals exceeding replacements and changes in species composition), fire (except for fire-dependent forest systems), pests and diseases, removal of nutrients, and pollution or climate change (e.g., changes in productivity, total organic matter, and forest composition). In India, the forest cover is now relatively stable and, therefore, deforestation is not currently a significant issue in formulation of carbon sequestration policies (Vandana Sharma and Smita Chaudhry 2013). In a study on Deforestation and forest degradation in India and its implications for REDD+ N. H. Ravindranath and others (2012) worked out on the figures of state of forest reports of different years published by Forest Survey of India claimed that the significant annual deforestation of 100,400 ha, 63,650 ha and 99,850 ha for 2003–05, 2005–07 and 2007–09 respectively. It can be concluded that at the national level, India has been experiencing significant forest loss during the last few years, even though total area estimates as reported by FSI show a gain of 1.49 m ha during the period 2005– 2009. According to another estimate, if one subtracts plantations from total forest cover, India's native forests were actually declining at the rate of 0.8% to 3.5% per year for 2000–05.

DEFORESTATION IN WESTERN GHAT:

In a very crucial finding by collating data of forest cover by computing them on grids from 1920 till 2013 this has been found out that deforestation in the Western Ghats over a period of past nine decades has been huge. The classified forest cover maps for 1920, 1975, 1985, 1995, 2005 and 2013 indicates 95,446 (73.1%), 63,123 (48.4%), 62,286 (47.7%), 61,551 (47.2%), 61,511 (47.1%) and 61,511 km2 (47.1%) of the forest area, respectively. The rates of deforestation have been analyzed in different time phases, i.e., 1920–1975, 1975–1985, 1985–1995, 1995–2005 and 2005–2013.The grid cells of 1 km2 have been generated for time series analysis and describing spatial changes in forests. The net rate of deforestation was found to be 0.75 during 1920–1975, 0.13 during 1975–1985, 0.12 during 1985–1995 and 0.01 during 1995–2005. Overall forest loss in Western Ghats was estimated at 33,579 km2 (35.3% of the total forest) from 1920's to 2013. Land use change analysis indicates highest transformation of forest to plantations, followed by agriculture and degradation to scrub. The dominant forest type is tropical semi-evergreen which comprises 21,678 km2 (35.2%) of the total forest area of Western Ghats, followed by wet evergreen forest (30.6%), moist deciduous forest (24.8%) and dry deciduous forest (8.1%) in 2013. (C

Sudhakar Reddy etal2016).In yet another very similar study was carried out with a view to finding out deforestation in the state of Jharkhand in a span of last 80 years and interestingly the results were as similar as that of Western Ghats. Forest is always been a fundamental and central component of the environment anywhere in our country but unfortunately this sector has been neglected since very long. Deforestation is a reality which every forester likes to hide despite it is caused by various anthropogenic factors, forest fire and fragmentation of large contiguous forests. Deforestation represents a global issue mostly caused by human influence and the forest of Jharkhand, India is not an exception as they have also been witnessing large scale deforestation. In the study deforestation was found out using historical data for the year 1935 (Survey of India topographical maps of 1924– 1935) and for the year of 2015 with Landsat -8 datasets in Jharkhand, India. To achieve the objective, the analysis focused on grid (5km*5 km) based assessment to detect long term change. The grid based analysis revealed that forest percent in Jharkhand for the year 1935 and 2015 were roughly 49% and 23% respectively. The result shows 2596 forest grid for the year 1935 out of which 1372 forest grids were found present in the year 2015. 1224 forest grid (equivalent to 26% forest area) was lost during the span of 80 years (Firoz Ahmad and Laxmi Goparaju 2017). In India, human population has increased six-fold from 200 million to 1200 million that coupled with economic growth has resulted in significant land use and land cover (LULC) changes during 1880–2010. In a very interesting study on the forest matrix change in India by Hanqin Tian and others in 2014, it has been seen that results show a significant loss of forests (from89 million ha to 63 million ha) has occurred during the study period i.e. from 1880-2010. Interestingly, the deforestation rate was relatively greater under the British rule (1880–1950s) and early decades after independence, and then decreased after the 1980s due to government policies to protect the forests in the form of a stringent bill passed in the form of Forest conservation Act (1980) which slackened the process of transfer of forest land for non forestry purposes. In contrast to forests, cropland area has increased from 92 million ha to 140.1 million ha during 1880–2010. Greater cropland expansion has occurred during the 1950–1980s that coincided with the period of farm mechanization, electrification, and introduction of high yielding crop varieties as a result of government policies to achieve self-sufficiency in food production. The rate of urbanization was slower during 1880–1940 but significantly increased after the 1950s probably due to rapid increase in population and economic growth in India. Our study provides the most reliable estimations of historical LULC at regional scale in India. This is the first attempt to incorporate newly developed high-resolution remote sensing datasets and inventory archives to reconstruct the time series of LULC records for such a long period in India. The spatial and temporal information on LULC derived from this study could be used by ecosystem, hydrological,

and climate modeling as well as by policy makers for assessing the impacts of LULC on regional climate, water resources, and biogeochemical cycles in terrestrial ecosystems.

FOREST LAND TRANSFER IN INDIA IS ALSO DEFORESTATION AND FOREST DEGRADATION IN ITS WORST FORM:

The diversion of forest land for non forestry purposes is a kind of forest degradation and deforestation in its worst form. Soon after transfer of forest land, the vegetation over the land is destroyed land use gets changed permanently. The transfer of forest land has been consistently going on in our country at an undesirable pace despite a central theme of forest conservation should be the need of hour. The database for the deforestation and land transfer is also very difficult to be obtained from the central government; in fact record of deforestation is not maintained at Ministry of Environment, Forest and climate change (MOEF&CC). In pursuance of **Lok Sabha un starred question number 1508** on the transfer of forest land for non forestry projects the government of replied that during the last four years i.e. 2012, 2013, 2014 and 2015the Central Government has accorded approvals over 1,28,591 ha of forest land in 4,725 cases for public and private sector projects. Section-2 of the Forest (Conservation) Act, 1980 *inter-alia* provides that notwithstanding anything contained in any other law for the time being in force in a State, no State Government or other authority shall make, except with the prior approval of the Central Government, any order directing that any forest land or any portion thereof may be used for any non-forest purpose. Therefore, use of forest land for various development projects, including development projects in urban areas, requires prior approval of the Central Government under the Forest (Conservation) Act, 1980. The following table gives the details of land transferred in four years

TABLE-5 FOREST LAND TRANSFER IN INDIA (AREA IN HECTARE)

2012		2013		2014		2015		TOTAL LAND	
NO. OF CASES	LAND TRANSFERRED	NO. OF CASES	LAND TRANSFERRED	NO. OF CASES	LAND TRANSFERRED	NO. OF CASES	LAND TRANSFERRED	NO. OF CASES	LAND TRANSFERRED
1522	25218.63	1317	41716.92	783	35867.47	1103	25788.4	4725	128591.41

In yet another **Lok Sabha Starred Question No. 334,**the government replied that ever since forest conservation act came into being in 1980(October) till July 2016 a total of 897698.40 hectare of forest land has been diverted for non forestry purposes therefore, it comes to an average of **25000 hectare of forest land diverted every year**. **The government further adds that the forest land diverted has not caused ecological imbalance.** This is ironical that government in its reply says that diversion of forest land does not cause any ecological imbalance without any proper research or environmental impact assessment done. Tropical forests are disappearing at an alarming rate of 13.5 million hectare per year globally Kobayashi (2004). In India about 20% of the geographical area is under forest in which tropical forests contribute nearly 83% of the forest area. Almost half of the forest area is classified as degraded forest with poor population density and species abundance. Deforestation and forest degradation are widely recognized as major threats to environmental stability, economic prosperity and social welfare and also to perform the statutory function of biodiversity conservation and ecosystem services (Bajrang singh etal 2011).Deforestation has a direct linkage with carbon emission and climate change and this has been established in many studies. In a recent study titled "**Why is a solution to climate change, environmental degradation and the sustainability crisis eluding us?"** the author establishes that that fossil fuel (mainly coal, petroleum and natural gas) burning is the major cause for the present increase in atmospheric CO2. He further says that it is alarming that the rate at which the driver for the anthropogenic climate change is accelerating the global energy consumption rate (mainly from fossil fuels) has tripled in the last 50 years. Global CO2 emissions have increased by 65% since the early 1990s, when the Kyoto Protocol for CO2 emission reductions was signed (recall Kyoto Protocol was a failure and is now replaced by the 2015 Paris Agreement). The annual emission rate has increased more than fivefold since 1900 from less than 8 billion tones, **mostly from deforestation) to about 40 billion tonnes of CO2 today**. The modern anthropogenic climate change is unprecedented in the history of our planet such large rates of CO2 and temperature change on centennial timescales cannot be found in palaeo records (G. Bala 2017).

FOREST LAND DEGRADATION IS AN IMPORTANT FACTOR:

India supports approximately 16% of the world's human population and 20% of the world's livestock population on merely 2.5% of the world's geographical area. The steady growth of human as well as livestock population, the widespread incidence of poverty, and the current phase of economic and trade liberalisation, is exerting heavy pressures on India's limited land resources for competing uses in forestry, agriculture, pastures, human settlements and industries. This has led to very significant land degradation in the forest area, however, defining forest degradation is complex phenomenon and there is no standard internationally accepted definition of degradation. Over time, the definition of land degradation has become more complicated as the nature and scope of land degradation has expanded. Land degradation refers to **"a reduction in the capability of the land to support a particular use" (IPCC, 1995).** The IPCC Special Report on 'Methodological options to inventory emissions from direct-human induced degradation of forests and devegetation of other forest types' defines degradation as 'direct human-induced long-term loss Land includes not only the soil resource, but also the water, vegetation, landscape, and micro-climatic components of an ecosystem. **Land degradation also refers to "a temporary or permanent decline in the productive capacity of the land or its potential for environmental management" (FAO, 1995).** The climate and soil science literature has started estimation of the economic cost of land degradation in the early 1980s across the globe.

EXTENT OF LAND DEGRADATION IN INDIA:

The analysis based on the land degradation data reported in the Desertification and Land Degradation Atlas of India (ISRO, 2016) reveals that 96.40 Mha. area of the country is undergoing a process of land degradation (29.32 percent of the total geographic area of the country) during 2011-13, while during 2003-05 the area undergoing process of land degradation was 94.53 Mha (28.76 percent of the total geographic area of the country). Thus there is an increase of 1.87 Mha areas undergoing a process of land degradation (constituting 0.57 percent of the total geographic area of the country) during the time frame 2003-05 and 2011-13. Forest land recorded more degradation than any other land ecosystems in all regions of the country. The bulk of forest land conversion into agricultural land is the main reason for forest land degradation. The agricultural land cover is increased in many states from 2003-05 to 2011-2013 period. States like Uttar Pradesh, Odisha, Madhya Pradesh, Telangana, Assam, and Meghalaya`s agricultural land has been improved the land fertility due to land use change. As a country in India 797,576 ha of forest, 248,330 ha of grassland, and 64,431ha of cropland has been degraded over 8 years period.

VALUE OF ECOSYSTEM SERVICES:

Total economic values of cropland, grassland, and forest ecosystem biomes estimated through the meta-analysis of various India specific studies are given in **Table no.1.** Forest land ecosystem provides a large variety of services compared to the other two biomes and accordingly has higher Total Economic Value (TEV). The average TEV **values are ($/ha/year-2012) 7057, 4726 and 6344,** respectively for **forestland, grassland and cropland**. These estimated values fall within the range of global ecosystem service values (Pavan Sukhdev etal TEEB, 2010) and Robert Costanza et al (2014).The average global TEV values ($/ha/year-2012) are 7187, 5564, and 7435 forestlands, grassland, and cropland, respectively. In the case of forestland, the literature search yielded a significant number of studies that cover provisioning, regulating, supporting and cultural services provided by the forest ecosystem. However, there is a paucity of studies pertaining to provisioning, regulating and cultural services provided by the grasslands in India and also the regulatory services provided by the croplands. Further, the Indian studies on an average report lower value for different ecosystem services compared to those reported in other country studies. Independent of the reasons behind such undervaluation, this could lead to overall lower estimates for the cost of land degradation in an analysis based exclusively on the Indian Total Economic Values of ecosystem services. The annual rate of forest ecosystem degradation in India is 99,697 hectare which is very high from carbon emission point of view and this seems growing with the passage of time P. Dayakar (2017) **Government of India had decided to put a financial value on its forests therefore, set up a committee under the chair of Dr. Madhu Verma, a professor at the Indian Institute Of Forest Management (IIFM). The committee was asked to decide on the net present value (NPV) of forest land in case they had to be diverted for industrial or construction purposes. The committee after having worked out comprehensively reached to a conclusion that Indian forest is worth $1.7 trillion**.

TABLE 6: ANNUAL LAND USE COVER CHANGE IN INDIA: 2003-05 TO 2011-13 (AREA IN HECTARE)

STATES	FOREST	GRASSLAND	CROPLAND
ANDHRA PRADESH	258	-2797	11245
ARUNACHAL PRADESH	11759	895	00
ASSAM	127625	21793	-7001
BIHAR	-13565	1018	44989
CHATTISGARH	2188	-5141	16179
GOA	5870	00	-1
GUJRAT	69175	-13495	81221
HARYANA	897	2227	5127
HIMACHAL	94872	113477	33787
JAMMU AND	10179	62891	31468
JHARKHAND	71876	-2920	-476
KARNATAKA	10341	-3008	-15946
KERALA	8879	97	-917
MADHYA	2175	12099	-259
MAHARASHTRA	840	-8796	438172
MANIPUR	3205	-2309	00
MEGHALAY	20963	-96	-5230
MIZORAM	84731	464	675
NAGALAND	129036	11428	0
ODISHA	-7576	-26	-33143
PUNJAB	8027	8944	9102
RAJASTHAN	10039	-2404	-123036
SIKKIM	2963	-2849	0
TAMIL NADU	16960	189	0
TELANGANA	2481	131	-92989
TRIPURA	106495	4822	-2633
UTTAR PRADESH	8642	-2020	-360266
UTTRAKHAND	7290	53716	0
WEST BENGAL	951	0	34363
Total	797576	248330	64431

Source: India Space Research Organization (ISRO), 2016.

Ravindranath while finding out the extent of degradation in Indian forest found out that forest degradation during 2003–2009 presents a very mixed change matrix in the forest cover or degradation. As can be seen from biennial state of forest report from the year 2003-09, a net decrease in MDF by 140,900 ha is reported. At the same time, the area under VDF has increased only by 5100 ha. Thus bulk of the MDF has been converted to lower canopydensity classes such as OF and/or non-forest categories, indicating reduction in the tree crown density and the associated carbon stocks. During 2005–07, it can be found from the above reports that the area under MDF has declined by 93,600 ha, whereas VDF has increased by only 3,800 hectare and therefore, clearly indicating that MDF has been converted to low canopy density classes such as the OF and scrub, potentially leading to reduction in

carbon stocks. In the period 2007-9 there has been only a decrease in area under OF and gain in area under dense and moderately dense forests, and thus no degradation of forest is postulated (N. H. Ravindranath2012).

DEFORESTATION AND CLIMATE CHANGE:

A very crucial finding was obtained on the relationship of deforestation and the quantum of precipitation in India in study on effects of large-scale deforestation on precipitation in the monsoon regions-Remote versus local effects by N. Devaraju in 2015. In his paper, using idealized climate model simulations, the biogeophysical effects of large-scale deforestation on monsoon regions was investigated and it was found that the remote forcing from large-scale deforestation in the northern middle and high latitudes shifts the Intertropical Convergence Zone southward. This results in a significant decrease in precipitation in the Northern Hemisphere monsoon regions (East Asia, North America, North Africa, and South Asia) and moderate precipitation increases in the Southern Hemisphere monsoon regions (South Africa, South America, and Australia). The magnitude of the monsoonal precipitation changes depends on the location of deforestation, with remote effects showing a larger influence than local effects. The South Asian Monsoon region is affected the most, with 18% decline in precipitation over India. The results indicate that any comprehensive assessment of afforestation/ reforestation as climate change mitigation strategies should carefully evaluate the remote effects on monsoonal precipitation alongside the large local impacts on temperatures. In yet another study on the basis of simulation done with a view to establishing the relationship in between deforestation and desertification, water cycle and monsoon, this has been found that Impact of extensive desertification in northwest India, Himalayan glaciers depletion and tropical deforestation over Indian subcontinent and Southeast Asia, on Indian monsoon circulations, precipitation exist. In the research paper titled "Simulated Impact of Desertification and Deforestation on Indian Monsoon Rainfall and Surface Fluxes: RegCM4.0 Simulations", by changing vegetation types in the bats coupled - regCM4.0, the model impact of desertification and deforestation on Indian monsoons is investigated. By performing these sensitivity experiments (extended desertification, and tropical deforestation) it was found that over India, monsoon precipitation is significantly decreased at local and large scales. Decreased surface roughness length and increase in albedo because of desertification/deforestation in the model results in origination of anomalous westerly winds and subsidence, decreasing turbulent flow, decreasing rainfall over land and strengthening over the seas and consequently increases the temperature over land. Further, the hydrological and atmospheric water cycle gets weak because precipitation decreases. Thus any form of deforestation and desertification happening over tropical regions has a severe impact on Indian summer monsoon atmospheric

circulations and precipitation (Abhishek Lodh 2017) Deforestation not only makes an ecosystem vulnerable but also emits CO2 in the atmosphere which ultimately adds up to the overall concentration of green house gases in the ecosystem. Today eastern Himalayan forest is very fragile and in a state of degradation on account of excessive biotic pressure however, rainforest of North-East India in the Eastern Himalaya is so important that it forms a part of the Himalayan biodiversity hotspot with rich biodiversity accompanied with dense vegetation of trees, thus making rainforest ecosystems a major carbon sink. Despite the biological richness, forest degradation is a matter of serious concern in this region. Considering disturbance as a major factor, a study was carried out to assess the biomass and carbon allocation pattern in the different compartments of the rainforest by Anudip Gogoi in 2017.In his study the forest area where the study was to be carried out was stratified into least disturbed (LD), mildly disturbed (MD) and highly disturbed (HD) sites based on visual assumption, and later disturbance index of the sites were calculated. Vegetation analysis for various ecological indices was carried out. Biomass and carbon stock in different pools were estimated adopting suitable regression equations developed earlier for similar ecological regions. The total plant biomass showed a gradual decrease from LD to HD site and was 425.70 ± 29.71 Mg ha-1 in the LD site, followed by 236.08 ± 5.82 Mg ha-1 in the MD site and 127.38 ± 4.74 Mg ha-1 in the HD site. Amongst the different pools, aboveground biomass constituted the largest compartment in all the three sites for carbon stock and biomass. Tree density and basal area were highest in the LD sites. Soil organic Carbon (SOC) stock in 0 - 45 cm depth was also recorded maximum in the LD (72.48 ± 5.11 Mg C ha-1) followed by MD (40.13 ± 2.50 Mg C ha-1) and HD (32.38 ± 1.66 Mg C ha-1) sites. Total carbon stock was also found highest (306.61 ± 17.14 Mg C ha-1) in the LD site followed by 169.97 ± 2.59 Mg C ha-1 in the MD and 102.43 ± 3.18 Mg C ha-1 in HD site. Forest disturbance thus showed a significant inverse relation with carbon storage in all the pools. Therefore, it can be concluded that carbon sequestration in forest ecosystems was influenced by the anthropogenic disturbances in the present study.

GLOBAL EMISSION BY GAS:

At the global scale, the key greenhouse gases emitted by human activities are:

(1)CARBON DIOXIDE (CO2): Fossil fuel use is the primary source of CO2. CO2 can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture, and degradation of soils. Likewise, land can also remove CO2 from the atmosphere through reforestation, improvement of soils, and other activities.

(2)METHANE (CH4): Agricultural activities, waste management, energy use, and biomass burning all contribute to CH4 emissions.

(3)NITROUS OXIDE (N2O): Agricultural activities, such as fertilizer use, are the primary source of

N2O emissions. Fossil fuel combustion also generates N2O.

(4)FLOURIDE GASES (F-GASES): Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF6) (IPCC 2014).

GLOBAL EMISSION BY ECONOMIC SECTOR:

Global carbon emissions from fossil fuels have significantly increased since 1900. Since 1970, CO2 emissions have increased by about 90%, with emissions from fossil fuel combustion and industrial processes contributing about 78% of the total greenhouse gas emissions increase from 1970 to 2011. Agriculture, deforestation, and other land-use changes have been the second-largest contributors. Emissions of non-CO2 greenhouse gases have also increased significantly since 1900 (T.A Boden etal.2017) Global greenhouse gas emissions can also be broken down by the economic activities that lead to their production.

ELECTRICITY AND HEAT PRODUCTION (25% of 2010 global greenhouse gas emissions): The burning of coal, natural gas, and oil for electricity and heat is the largest single source of global greenhouse gas emissions.

INDUSTRY (21% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from industry primarily involve fossil fuels burned on site at facilities for energy. This sector also includes emissions from chemical, metallurgical, and mineral transformation processes not associated with energy consumption and emissions from waste management activities. (Note: Emissions from industrial electricity use are excluded and are instead covered in the Electricity and Heat Production sector.)

AGRICULTURE, FORESTRY AND OTHER LAND USE (24% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector come mostly from agriculture (cultivation of crops and livestock) and deforestation. This estimate does not include the CO2 that ecosystems remove from the atmosphere by sequestering carbon in biomass, dead organic matter, and soils, which offset approximately 20% of emissions from this sector.[2]

TRANSPORTATION (14% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector primarily involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.

BUILDINGS (6% of 2010 global greenhouse gas emissions): Greenhouse gas emissions from this sector arise from onsite energy generation and burning fuels for heat in buildings or cooking in homes. (Note: Emissions from electricity use in buildings are excluded and are instead covered in the Electricity and Heat Production sector.)

OTHER ENERGY (10% of 2010 global greenhouse gas emissions): This source of greenhouse gas emissions refers to all emissions from the Energy sector which is not directly associated with electricity or heat production,

such as fuel extraction, refining, processing, and transportation.

These data include CO2 emissions from fossil fuel combustion, as well as cement manufacturing and gas flaring. Together, these sources represent a large proportion of total global CO2 emissions. Emissions and sinks related to changes in land use are not included in these estimates. However, changes in land use can be important, estimates indicate that net global greenhouse gas emissions from agriculture, forestry, and other land use were over 8 billion metric tons of CO2 equivalent, or about 24% of total global greenhouse gas emissions. In areas such as the USA and Europe, changes in land use associated with human activities have the net effect of absorbing CO2, partially offsetting the emissions from deforestation in other regions.

RISING CO2 EMISSION TREND IN INDIA- A VISIBLE THREAT IN NEAR FUTURE:

During the week of April 6 to 12, 2015, average carbon dioxide (CO2) levels touched 404.02 parts per million (ppm), the highest-ever in recent human history and 15% above the levels. February, March and April of 2015 had monthly average CO2levels higher than 400 parts per million (ppm), the first time in recorded history all three months have reached such levels, according to the keystone Mauna Loa observatory in Hawaii, USA. These rising levels have growing relevance for India, as it struggles with a farm crisis brought on by uncertain rainfall, attributed increasingly to climate change. India is the world's third largest emitter of CO2, the chief greenhouse gas. A renewed push for industrialization will have to be balanced against further climate change. The 400 ppm mark is a milestone when it comes to CO2 levels in the atmosphere, and
the first day to record such levels was May 9, 2013. Currently [atmospheric] CO2 values are more than 100 ppm higher than at any time in the last one million years (and maybe higher than any time in the last 25 million years), but more disturbing than the magnitude of this change is the fact that the rate of CO2 accumulation in the atmosphere has been steadily increasing over the last few decades, meaning that future increases will happen faster. The rising CO2 levels have been linked by the UN's intergovernmental panel on climate change (IPCC), in a 2014 report, to rising ocean and land temperatures as well as rising sea levels over the past 35 years. As to how rising CO2 levels have affected or would affect India specifically, it is not clear. Claims in a 2007 IPCC report that the Himalayan glaciers would melt away in the near future. However, a series of studies have shown that unseasonal rain and erratic weather unsettling the Indian farmer and the nation's agriculture, economy and politics are no aberrations. India's stance at various conferences, including the Climate Change Conference in Lima in 2014, has been that it was unfair to demand emissions cuts from developing countries. The argument being that these economies were still growing compared to the developed world, and that such emission levels would be unavoidable if

they want to catch up. In a study carried out on the CO2 emission level in India by examining various data series this has been found that the long-term data series provides baseline information with an increasing trend in XCO2 over India for the period 2000–2015. With availability of space based OCO-2, similar increasing trend was observed at Cape Rama with mean XCO2 of 408 ppm. The increasing trend in XCO2 observed in India is comparable to the observed global mean CO2 growth rate of 2.15 ppm/yr over Mauna Loa, Hawaii, USA during the past decade. Besides, Earth System Research Laboratory, Global Monitoring Division, National Oceanic and Atmospheric Administration (NOAA) has also reported monthly average CO2 concentration of ~404 ppm measured at Mauna Loa observatory, Hawaii, indicating a global increase of atmospheric CO2 concentration during the recent period (Abha Chhabra and Ankit Gohel 2017) In a study titled "A threefold rise in widespread extreme rain events over central India" this has been found that the rain fury that lashed Maharashtra, West Bengal, Bihar and Assam in the month of July, August and September 2017, which displaced lives of lakhs of people, could be the new 'normal', according to study. Scientists have recorded a three-fold rise in such erratic rainfall over central India. The main reason is found to be rapid warming of the Arabian Sea. Due to excess warming, there is significant amount of moisture available in the atmosphere. This moisture then gets transported by strong surges of westerly winds over to the Indian mainland during the monsoon, resulting in widespread and heavy rainfall over central India. Human activities in the post-industrialization period have triggered an exponential rise in greenhouse gas emissions and pollutants. Frequency of events such as El Nino, the abnormal warming of central and east-central Pacific Ocean, are driving forces for the warming of Arabian Sea in recent decades The number of cyclones originating from the Arabian Sea has increased. Global economic losses from floods exceeded $30 billion per year in the past decade, with some of the largest losses linked to extreme rainfall events in Asia. Floods attributed to extreme rain events in India alone amounted to losses of about $3 billion per year, which is 10% of the global economic losses. The plains of central India are largely flood-prone; flash floods, landslides and torrential rains often kill thousands and displace millions of people as well as animals, underscoring the urgency in comprehending and predicting these events.

There have been 268 reported flooding events in India over 1950–2015 affecting about 825 million people, leaving 17 million homeless and killing 69,000 people (International Disaster Data Base). Many of these events which caused large loss of life, property and agriculture occurred across central India. Socioeconomic challenges continue to mount for half a billion residents of central India because of a decline in the total rainfall and a concurrent rise in the magnitude and frequency of extreme rainfall events. Alongside a weakening monsoon circulation, the locally available moisture and the frequency of moisture-laden depressions from the Bay of Bengal have

also declined. The study showed here that despite these negative trends, there is a threefold increase in widespread extreme rain events over central India during 1950–2015. The rise in these events is due to an increasing variability of the low-level monsoon westerlies over the Arabian Sea, driving surges of moisture supply, leading to extreme rainfall episodes across the entire central subcontinent. The homogeneity of these severe weather events and their association with the ocean temperatures underscores the potential predictability of these events by two-to-three weeks, which offers hope in mitigating their catastrophic impact on life, agriculture and property (M. K. Roxy 2017).

DISCUSSION:

Deforestation and degradation have been going on consistently in the Indian forest and we have not been able to stem the rot effectively, what we are doing is to replant those deforested and degraded forest area so as to claim that forest area has increased over a period of time and deforestation is compensated but the ecosystem does not work like this. A forest ecosystem is the basic ecologic unit in a particular forest that exists as "home" for a community of both native and introduced classified organisms. A forest ecosystem is named for the primary tree species that form the canopy. It is defined by all the collective living inhabitants of that forest ecosystem that co-exist together in symbiosis to create a unique ecology. In other words, a forest ecosystem is typically associated with land masses covered in trees and those trees are often classified by foresters into forest cover types .The forest ecosystem is just one of a number of unique ecosystems including prairies, deserts, Polar Regions and great oceans, smaller lakes, and rivers. We all know it takes a long time for cleared rainforests to regenerate, according to a study focusing on the Brazilian Atlantic forest, certain aspects can return surprisingly quickly within 65 years. But for the landscape to truly regain its native identity takes a lot longer up to 4000 years. Trees play a crucial role supporting life across the globe, producing oxygen and absorbing climate change-causing carbon dioxide. But, despite the plant's importance, humans have had little respect for the trees. World is home to more than 3 trillion trees. Humans throughout history have played a key role in determining the number of living trees, researchers note. People cut down 15 billion trees each year and the global tree count has fallen by 46% since the beginning of human civilization. Previous estimates, collected by satellite imaging, suggested that just over 400 billion trees live around the world. Trees occupy nearly every corner of the globe, but the study shows coverage is far from even and factors like moisture and warmth play a role in how many trees exist in a given area. Still, human activity is the greatest predictor of whether trees will survive in a given area. Losses are currently most dramatic in the tropical regions as land is cleared for agriculture and other commercial purposes, but they occur across the globe.The global extent and distribution of forest trees is central to our

understanding of the terrestrial biosphere. In a study on mapping tree density at a global level the number of trees available were found globally and the map revealed that the global number of trees is approximately 3.04 trillion, an order of magnitude higher than the previous estimate. Of these trees, approximately 1.30 trillion exist in tropical and subtropical forests, with 0.74 trillion in boreal regions and 0.66 trillion in temperate regions. Biome-level trends in tree density demonstrate the importance of climate and topography in controlling local tree densities at finer scales, as well as the overwhelming effect of humans across most of the world. Based on projected tree densities, it was estimated that over 15 billion trees are cut down each year, and the global number of trees has fallen by approximately 46% since the start of human civilization (T.W. Crowther etal.2015) In yet another study on estimating the carbon emission from different sources of forest in 74 countries, R.H. PearsonTimothy concluded that estimation of forest degradation emissions between 2005 and 2010 (across 74 developing countries) covering 2.2 billion hectares of forests. It was estimated annual emissions of 2.1 billion tons of carbon dioxide, of which 53% were derived from timber harvest, 30% from wood fuel harvest and 17% from forest fire. These percentages differed by region: timber harvest was as high as 69% in South and Central America and just 31% in Africa; wood fuel harvest was 35% in Asia, and just 10% in South and Central America; and fire ranged from 33% in Africa to only 5% in Asia. Of the total emissions from deforestation and forest degradation, forest degradation accounted for 25%. In 28 of the 74 countries, emissions from forest degradation exceeded those from deforestation. The following table gives us a crisp summary

TABLE-7 CARBON EMISSION FROM FORESTS

ACTIVITIES	ANNUAL EMISSION (GtCO2e/year)
DEGRADATION	2.06
TIMBER	1.09
WOODFUEL	0.62
FIRE	0.35
DEFORESTATION	6.22

SOURCE-R.H. PearsonTimothy etal 2017

The results of this study clearly demonstrate the importance of accounting greenhouse gases from forest degradation by human activities. The scale of emissions presented indicates that the exclusion of forest degradation from national and international GHG accounting is distorting. (R.H. PearsonTimothy etal 2017)

CONCLUSION:

India ranks 10th in the list of most forested nations in the world with 76.87 million ha of forest and tree cover. Like other forests of the world, our forests also provide critical ecosystem goods and services. However, the significant role of forests in carbon storage and sequestration has increased their importance manifold and brought them to the centre-stage of climate change mitigation strategies. India's forest and tree cover accounts for about 23.4% of the total geographical area of the country. Over the past decades, national policies of India aimed at conservation and sustainable management of forests have transformed India's forests into a net sink of CO2. From 1995 to 2005, carbon stocks stored in our forests have increased from 6244.78 to 6621.55 million tonnes (mt) registering an annual increment of 37.68 mt of carbon = 138.15 mt of CO2eq. This annual removal by forests is enough to neutralize 9.31% of our total annual emissions of 2000.The state of forest report 2015 also reveals that the Indian forest is increasing carbon stock over the last assessment but it is also a sad truth that the country is losing old forest ecosystem, the forest degradation is in different stages and there is an urgency to arrest this fall as fast as possible. The carbon sequestered by the Indian forest will still be adequate to dent our emissions even when these will be on the increase due to our accelerated development process. Estimates show that the continued removals by the forests would still be able to offset 6.53% and 4.87% of our projected annual emissions in 2010 and 2020 respectively. It is estimated that emissions in 2010 and 2020 will respectively be 45% and 95% higher than those in 2000.Therefore; this becomes imperative on our part to formulate a time based strategy to stop deforestation and bring it to zero deforestation level. We are losing precious forest very fast and an estimated 18 million acres (7.3 million hectares) of forest roughly the size of Panama are lost each year, according to the United Nations' Food and Agriculture Organization.

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