



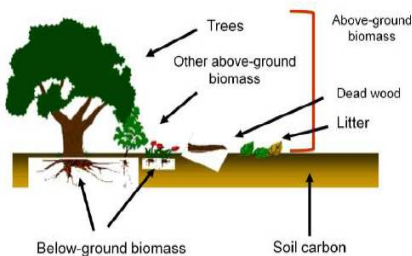
FSI TECHNICAL INFORMATION SERIES

Volume I No. 3 2019

INDIA'S NATIONALLY DETERMINED CONTRIBUTION OF CREATING AN ADDITIONAL CARBON SINK OF 2.5 TO 3 BILLION TONNES OF CO₂ EQ THROUGH ADDITIONAL FOREST & TREE COVER : POSSIBILITIES, SCALE AND COSTS FOR FORMULATING STRATEGY

■ Possible carbon pools

- Above-ground biomass
- Below-ground biomass
- Dead wood
- Litter
- Soil carbon



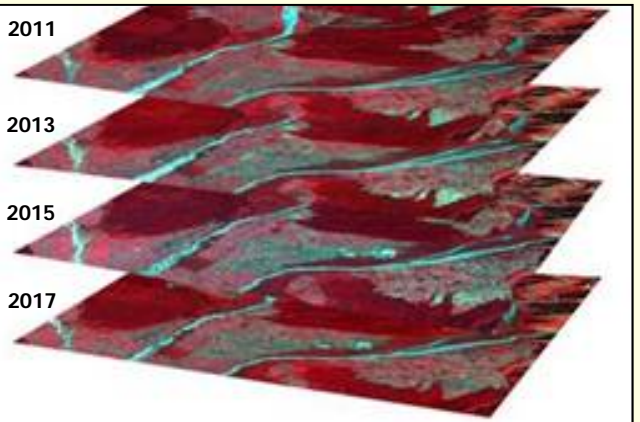
(IPCC, 2003)

2011

2013

2015

2017



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India's Nationally Determined Contribution of Creating an Additional Carbon Sink of 2.5 to 3 billion tonnes of CO₂ eq through Additional Forest & Tree Cover: Possibilities, Scale & Costs for Formulating Strategy

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Abbreviations

ANR	Assisted National Regeneration
CAFRI	Central Agroforestry Research Institute
CAMPA	Compensatory Afforestation Fund Management & Planning Authority
CBDR	Common But Differentiated Responsibilities
COP	Conference of Parties
DoLR	Department of Land Resources
EF	Emission Factor
FSI	Forest Survey of India
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIM	Green India Mission
IFS	Integrated Farming System
IPCC	Intergovernmental Panel on Climate Change
ISFR	India State of Forest Report
IWMP	Integrated Water Management Programme
MDF	Moderately Dense Forest
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Scheme
MIDH	Mission for Integrated Development of Horticulture
MoEFCC	Ministry of Environment, Forest and Climate Change
NAP	National Afforestation Programme
NAP	National Agro-forestry Policy
NBM	National Bamboo Mission
NDC	Nationally Determined Contribution
NF	Non Forest
NFP	National Forest Policy
NGHM	National Green Highway Mission
NH	National Highway
NHAI	National Highway Authority of India
NMCG	National Mission for Clean Ganga
NMSA	National Mission for Sustainable Agriculture
NP	National Parks
NTFP	Non-Timber Forest Products
OF	Open Forest
PF	Protected Forest
PIB	Press Information Bureau
RF	Reserved Forest
RF	Removal Factor
RFA	Recorded Forest Area
SH	State Highway
SMAF	Sub-Mission on Agro-forestry
SMC	Soil & Moisture Conservation
TGA	Total Geographical Area
TOF	Trees Outside Forest
UNFCCC	United Nations Framework Convention on Climate Change
VDF	Very Dense Forest

India's Nationally Determined Contribution (NDC) of Creating an Additional Carbon Sink of 2.5 to 3 billion tonnes of CO₂ eq through Additional Forest & Tree Cover: Possibilities, Scale and Costs for Formulating Strategy

Abstract

Countries across the globe have committed to create a new international climate agreement by the conclusion of the UNFCCC COP21 held in Paris in December 2015. In preparation, countries have agreed to publicly outline what post-2020 climate actions they intend to take under a new international agreement, known as their Nationally Determined Contributions (NDCs). India too has submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC in October 2015 which outlines the post-2020 climate actions the country intends to take under a new international agreement. One of the commitments made by India is creating an additional carbon Sink of 2.5 to 3.0 billion tonnes CO₂ eq through additional forest & tree cover by 2030. Achieving this ambitious target requires a well planned strategy taking in to consideration all possible interventions within the forests and all other available lands.

With an objective of analyzing implications of the above INDC target in terms of actions on the ground, associated cost and carbon numbers etc, FSI has recently undertaken a detailed exercise for exploring the possibilities. The study follows a bottom-up approach wherein computations of each State have been done according to the States' circumstances and available lands and using State, forest type and physiographic zone specific emission/removal factors and cost norms. The results of this exercise may provide important inputs in formulating a realistic strategy to achieve the INDC target.

Trend of carbon sink through forest & tree cover analysed in the study provides an understanding of the implications of the NDC target vis-a-vis creation of additional carbon sink by different activities of restoration of forests and tree plantations. The study reveals that if the NDC target is not above the BAU level then the increase in carbon sink by 2030 to the target level may be achieved by just sustaining the existing policies and programmes of conservation and afforestation.

India's Nationally Determined Contribution (NDC) of Creating an Additional Carbon Sink of 2.5 to 3 billion tonnes of CO₂ eq through Additional Forest & Tree Cover: Possibilities, Scale and Costs for Formulating Strategy

1. Introduction

Countries across the globe have committed to create a new international climate agreement by the conclusion of the U.N. Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP21) in Paris in December 2015. In preparation, countries have agreed to publicly outline what post-2020 climate actions they intend to take under a new international agreement, known as their Intended Nationally Determined Contributions (INDCs). The INDCs will largely determine whether the world achieves an ambitious 2015 agreement and is put on a path toward a low-carbon, climate-resilient future 'by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius'¹

The INDCs submitted by all major emitters indicate the cumulative emissions of the world between 2012 and 2030 would be in the range of 700 to 800 Gt of CO₂. According to the latest report of the Intergovernmental Panel on Climate Change (IPCC), to meet the 2°C temperature increase target, the world has an emission budget of only 1,000 billion tonnes of CO₂ till 2100. The world will consume most of this budget by 2030, leaving a small space for developing countries in Asia and Africa to grow in the future.

India too has submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC in October 2015² which outlines the post-2020 climate actions the country intends to take under a new international agreement.

Salient features of India's INDC

- To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation.

¹ Paris Agreement, UNFCCC (2015)

² India's Intended Nationally Determined Contribution: Working Towards Climate Justice (2015), MoEF&CC, Gol

- To adopt a climate-friendly and a cleaner path than the one followed hitherto by others at corresponding level of economic development.
- To reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030, with the help of transfer of technology and low cost international finance, including from Green Climate Fund.
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO₂ equivalent through additional forest and tree cover by 2030.
- To better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management.
- To mobilize domestic and new and additional funds from developed countries to implement the above mitigation and adaptation actions in view of the resource required and the resource gap.
- To build capacities, create domestic framework and international architecture for quick diffusion of cutting edge climate technology in India and for joint collaborative R&D for such future technologies.

As seen above, India's INDC centers around its policies and programmes on promotion of clean energy, especially renewable energy, enhancement of energy efficiency, development of less carbon intensive and resilient urban centres, promotion of waste to wealth, safe, smart and sustainable green transportation network, abatement of pollution and India's efforts to enhance carbon sink through creation of additional forest and tree cover. India has accepted the huge impact that climate change is exerting and will exert on different sectors of its economy and has agreed to enhance investments to adapt in vulnerable sectors like agriculture, water resources, coastal regions, and health and disaster management. India's INDC reflects its development challenges, aspirations of large numbers of poor people and the realities of climate change.

India has also reiterated its need for international finance and technology support to meet its climate goals. In this regard, it has said it would require at least USD2.5 trillion (at 2014-15 prices) to meet its climate change

actions between now and 2030. India's INDC is fair and is quite ambitious, specifically on renewable energy and forestry³.

There are three quantified targets in the India's NDC; the first one related to emission intensity of GDP, second about the contribution of renewable energy in the overall installed power and the third about achieving additional carbon sink of 2.5 billion to 3.0 billion tonnes through additional forest and tree cover by 2030. The present study focuses on the third target specified in quantity.

An attempt has been made first to understand the magnitude and scale of actions required to achieve the target and then what are the possibilities of implementation while looking at the availability of land for different activities. The study is based on calculations on time series data on forest cover, its past and projected changes i.e flux, stratification of changes (activity data) in terms of forest types, emission and removal factors for each forest type and land use and land cover area figures. The figures used in the study are largely from the primary data reported by FSI in ISFRs. Data on land availability under different categories have been taken from different credible sources. Analysis of trend of carbon in India's forest & tree cover vis-à-vis NDC target helps in understanding implication of increasing carbon sink through forest & tree cover with respect to baseline⁴. The study based on best possible data presents different scenarios and magnitude of actions required for achieving the NDC target for creating additional carbon sink through additional forest and tree cover in the country. The study may be found useful in providing inputs for drawing a comprehensive strategy to achieve the NDC target in terms of possible interventions, potential carbon sink in respect of each intervention and cost involved in implementation.

2. Existing Framework of Policies, Acts & Rules and Programmes for increasing Carbon Sink through Forest and Tree Cover in the Country: The Business as Usual (BAU) Scenario

Forest and tree cover in India has shown a gradual and steady trend of increase in the last one and a half decades which is evident from Fig 1.

³ India's NDC, Center for Science & Environment, New Delhi (2015)

⁴ Accounting for baseline targets in NDCs: Issues and options for guidance, OECD, IEA (2018)

India is among the few countries in the world to achieve the positive trend of forest cover increase. This is even more creditable for the country that forest & tree cover has increased despite large dependence of the tribal people and other villagers living in the forest fringe villages for their day-to-day needs of fuel wood, fodder, small timber and NTFPs. This could be possible because of high priority accorded to conservation by the National and State governments in the country which is reflected in a strong framework of Policies, Acts & Rules and programmes to ensure conservation of forests and biodiversity, enhance green cover and participation of people in the conservation activities while protecting rights of forest dependent communities.

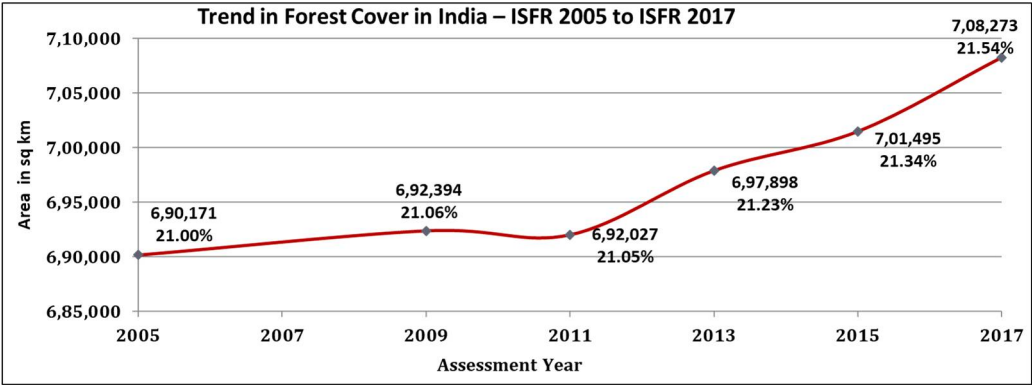


Fig 1

An overview of policies, legal instruments and programmes which provide enabling conditions in India for achieving sustained growth of forest & tree cover in the country are presented in the following sub sections.

2.1 Indian Forest Act, 1927

This is the country-wide Act to consolidate the law relating to forests, the transit of forest produce and the duty leviable on timber and other forest-produce. Proper implementation of the provisions of this Act is capable of ensuring conservation of biodiversity of the natural forests as also enhancing the quality and extent of the forest and tree cover in the country, which in turn, contribute to achievement of NDCs.

2.2 Wildlife protection Act, 1972

As this Act provides for the protection of wild animals, birds and plants and for matters connected therewith or ancillary or incidental thereto, it perfectly synergises with NDC targets of increasing forest and tree cover by conservation of biodiversity and non-conversion of natural forests into plantations.

2.3 National Forest Policy, 1988

The principal aim of National Forest Policy (NFP), 1988 is to ensure environmental stability and maintenance of ecological balance. The policy aims for maintaining one third of the country's geographical area under forest and tree cover and calls for massive afforestation and social forestry programmes with people's participation for increasing the forest and tree cover in the country.

The objectives of NFP synergise with India's NDC commitments of climate change mitigation through forestry sector. More the area under forest, more the mitigation it will provide. The National Forest Policy (1988) is presently under revision. The overall objective and goal of the draft National Forest Policy (2018) is to safeguard the ecological and livelihood security of people, of the present and future generations, based on sustainable management of forests for the flow of ecosystem services. In order to achieve the national goal for eco-security, the country should have a minimum of one-third of the total land area under forest and tree cover. The draft National Forest Policy (2019) also lays emphasis on integrating climate change mitigation and adaptation measures in forest management by increasing forest and tree cover so that the impacts of the climate change are minimised. Under the draft policy strategic actions especially sustainable forest management will be taken to strengthen forest-based climate change mitigation and adaptation.

2.4 Forest Conservation Act, 1980

The Forest (Conservation) Act, 1980 is one of the most effective legislations contributing to reduction in diversion of forest lands for non forestry purposes. This was enacted to reduce indiscriminate diversion of forest lands for non-forestry purposes, and to help regulate and control the land use changes in forests. The Act empowers the Union Government to allow the diversion of forest for non-forestry use in a rational manner after detailed scrutiny and ensuring compensatory afforestation.

With the enactment of this act, the deforestation and conversion of forest lands to non-forest use has been drastically reduced. The pace of diversion of forest land for non-forest purposes was around 1,60,000 hectares per annum from 1951 to 1976. It comes down drastically to 32,000 ha annually (MoEFCC, 2016) during 1980-2011 after the implementation of this Act. Being an Act for regulating diversion of forest land for non-forestry purposes, and to strike a balance between

conservation and development, it will help to achieve NDC targets in the country by supporting conservation and improvement of natural forests.

2.5 Central and State sponsored Schemes

Afforestation is cross-sectoral activity taken up under various Central and State Government schemes viz National Afforestation Programme, Green India Mission and CAMPA (Ministry of Environment, Forest and Climate Change), National Bamboo Mission and Integrated Development of Horticulture (Ministry of Agriculture and Farmers' welfare), Mahatma Gandhi National Rural Employment Guarantee Scheme and Integrated Water Management Programme (Ministry of Rural Development), Catchment Area Rehabilitation under Namam Ganga Scheme (Ministry of Water Resources) etc. There are externally aided projects operational in forestry sector in various states. Apart from central assistance, most of the states allocate funds for afforestation activities in their annual budget. In XI plan period (2007-08 to 2011-12) as per figures compiled by MoEF&CC an estimated 4.2 million hectare area was afforested with an investment of Rs 8500 crores. National Afforestation Programme (NAP) of MoEF&CC which targets degraded lands contributed about 20% of this total afforestation with an investment of about Rs 1,665 crores. An account of various recent initiatives and policy measures having significant activity of afforestation and reforestation is given below:

2.5.1 Green India Mission (GIM)

GIM is one of the eight Missions under the National Action Plan on Climate Change (NAPCC) envisaging a holistic view of greening and focuses on multiple ecosystem services, especially, biodiversity, water, biomass, preserving mangroves, wetlands, critical habitats etc. One of the key differences of this Mission with conventional afforestation program relates to Mission's emphasis on the landscape approach. Landscapes as large contiguous areas of forest and non-forest land provide unique opportunity to address the issues in a holistic manner. While the contiguous area of forests provides opportunity for improving the quality of the forest cover; the non-forest areas provide opportunity for increasing the forest cover.

In order to address these issues effectively, GIM adopts an integrated approach using inter-sectoral convergence that treats forests and non-forest public lands as well as private lands simultaneously and seeks for convergence with related missions and schemes such as MGNREGS, Compensatory Afforestation Management and Planning Authority

(CAMPA), National Afforestation Program (NAP), National Rural Livelihood Mission (NRLM), Integrated Watershed Management Program (IWMP).

GIM aims to increase the forest/tree cover to the extent of 5 million hectare (mha) and improving quality of forest/tree cover of another 5 mha of forest/ non forest lands, and increasing forest based livelihood income of about 3 million households. GIM is a Centrally Sponsored Scheme with Central Share of 90% for NE and Special category States while 75% for rest of India

2.5.2 National Afforestation Programme (NAP)

To increase and conserve forest land, National Afforestation Programme, a Centrally Sponsored Scheme has been implemented since 2000-02. The aim is regeneration of degraded forests and adjoining area through people's participation. The scheme is implemented through a decentralized mechanism of State Forest Development Agency (SFDA) at State level, Forest Development Agency (FDA) at Forest Division Level and Joint Forest management Committees (JFMCs) at Village level. An amount of Rs 3778.65 crore has been released to the States to treat an area of 21.78 lakh hectares since inception of this programme in 2000-01 till 2017-18.

2.5.3 CAMPA

A Compensatory Afforestation Fund has been created and is being managed by Adhoc Compensatory Afforestation Fund Management & Planning Authority (CAMPA). The money received from user agencies towards compensatory afforestation, additional compensatory afforestation, penal compensatory afforestation, catchment area treatment plant etc., in lieu of forest land diversion for various non-forestry activities/projects, is deposited in this Fund. Sizeable amount of fund is available under the Compensatory Afforestation Fund for undertaking artificial regeneration (plantations), assisted natural regeneration, and protection of forest, wildlife protection and other activities and for matters connected therewith or incidental thereto as per extant guidelines.

2.5.4 MGNREGA

MGNREGA provides guaranteed employment to rural households creating productive assets of prescribed quality and durability, thus addressing the economic security of the backward sections in the rural sector. It also emphasizes on afforestation, tree plantation and horticulture

in common and forest lands, road margins, canal bunds, tank foreshores and coastal belts, improvement of livelihoods through horticulture, sericulture, plantation and farm forestry, development of fallow or wastelands of households and water conservation through water harvesting structures, watershed management, de-silting of water bodies and irrigation works. Under MGNREGA, all the wages will be met as a 100% central grant and the material component will be shared on 75:25 ratios between the Centre and State Governments

2.5.5 Green Highway Policy, 2015

Loss of vegetation is one of the inevitable consequences of Highway Development. It is the responsibility of the highway development agencies to offset this loss by way of following the approach of Corridor Development & Management. The objectives of this policy are:

- a) To evolve a policy frame work for plantation along National Highway
- b) To reduce the impacts of air pollution and dust as trees and shrubs are known to be natural sink for air pollutants;
- c) To provide much needed shade on glaring hot roads during summer;
- d) To reduce the impact of ever increasing noise pollution caused due to increase in number of vehicles;
- e) To arrest soil erosion at the embankment slopes;
- f) Prevention of glare from the headlight of incoming vehicles;
- g) Moderating the effect of wind and incoming radiation;
- h) Employment to local people;
- i) Augmenting in maintaining biodiversity

This policy provides for selection of tree species for roadside plantation, plantation patterns and transplantation, role of local bodies, financial arrangement, monitoring, audit etc.

2.5.6 Policy for enhancement of Urban Greens

Population growth and high densities in cities adversely impact natural and environmental resources. Today biggest challenge for urban development is not only to ensure greening of cities and towns but also to maintain and strengthen the existing green cover. Urban greening is an integrated approach to planting, care and management of all vegetation in cities, towns, townships and informal settlements in urban and peri-urban areas.

Urban Green Guidelines, 2014 act as a model for States and Cities particularly the State Town Planning Departments, Urban Development

Authorities and Urban Local Bodies who are responsible for managing and preserving urban greens.

2.5.7 National Agro-forestry Policy and Sub-Mission on Agro-forestry (SMAF)

Agro-forestry is known to have the potential to mitigate the climate change effects through microclimate moderation, conservation of natural resources and creation of additional source of livelihood and income opportunities. In order to make agriculture less vulnerable to climatic aberrations, Government of India formulated the National Agro-forestry Policy in 2014. The policy recommends for setting up of a Mission or Board to address development of agro-forestry sector in an organised manner. The Sub-Mission on Agro-forestry (SMAF) under NMSA is an initiative to this end. The aim of the submission is to expand the tree coverage on farmland in complementary with agricultural crops.

SMAF has objectives like expanding tree plantation in complementary and integrated manner with crops and livestock, ensuring availability of quality planting material like seeds, seedlings, clones, hybrids, improved varieties, etc, popularising various Agro-forestry practices/models suitable to different agro ecological regions and land use conditions etc.

2.5.8 National Bamboo Mission

Bamboo is a versatile group of plants which is capable of providing ecological, economic and livelihood security to the people. India has the highest area (13.96 million ha) under bamboo and is the second richest country, after China, in terms of bamboo diversity with 136 species (125 indigenous and 11 exotic). Bamboo is an important species of forest ecosystem. The National Bamboo Mission (NBM) was launched as a Centrally Sponsored Scheme in 2006-07 and was subsumed under Mission for Integrated Development of Horticulture (MIDH) during 2014-15 and continued till 2015-16. Later this mission is restructured for holistic development of bamboo sector.

The main objective of this mission is to increase area under bamboo plantation in non forest government land and private lands to supplement farmers 'income and contribute towards resilience to climate change as well as availability of quality raw material requirement of industries, to improve post-harvest management, to promote product development and to promote skill development.

2.5.9 National Mission for Sustainable Agriculture

National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

Under NMSA, Rainfed Area development aims at promoting integrated farming system (IFS) with emphasis on multi-cropping, rotational cropping, inter-cropping, mixed-cropping practices with allied activities like horticulture, livestock, fishery, agroforestry, apiculture, conservation/promotion of NTFPs etc. to enable farmers not only in maximizing the farm returns for sustaining livelihood, but also to mitigate the impacts of drought, flood or other extreme weather events.

2.6 State Funded schemes

In addition to the above, State and UT Governments have their own afforestation and reforestation programmes. State specific schemes are formulated according to the States' circumstances for which financial resources are provided from the respective State's budget. Almost every State has activities under social forestry which largely focuses on tree planting in areas outside forests.

3. Data, Methodology and Scope of the Study

The study follows a bottom up approach wherein the state specific circumstances in terms of forest cover and its changes in the last ten years, forest types, land use and land cover, availability of culturable wasteland and other available lands including lands in linear geometry i.e. along roads, railways, canals, possible expansion under agro-forestry systems and urban spaces have been taken in to consideration. For enhancement of carbon sink two broad activities i.e improvement of natural forests and tree planting on other available lands, have been taken in to account. Forest improvement and tree planting activities on different land types for enhancing forest and tree cover have been identified in 10 activities shown in the Table 1 which can be part of the strategy for achieving the NDC target. Forest type and Physiographic zone specific emission/removal factors have been used for calculating increase in carbon sink for each State separately. Removal and Emission factors for all possible changes in canopy density classes for each Forest Type are given in Annexure IV & V respectively. The emission/removal factors have been derived from the forest inventory sample plots data of FSI.

Aggregation of all the States and UTs gives the national level figures of carbon stock increase, area brought under forest & tree cover. Method of estimating carbon enhancement confirms to the IPCC Good Practices Guidance (GPG) 2003. The study thus presents the possibilities and potentials in respect of each State and the country as a whole.

While calculating increase in carbon sink size from the different activities considered in the study, care has been taken to account for different growth stages of plantations while using removal factors. Suitable discounting for young plantations and also for early stages of restoration of natural forests has been done in carbon calculations.

Physiographic zone specific removal factors for plantations raised under different activities have been used. For this, removal factors of TOF for all the 14 Physiographic zones were derived from the TOF inventory sample plot data afresh, the same is given at Annexure VI. All the States have been categorised in one of the Physiographic zone on the basis of predominance and removal factors of the corresponding physiographic zone has been used for the tree plantations under different activities.

Land use land cover area figures and statistics of other lands have been taken from different credible sources which are given in the Table 2. Area figures of forest cover and forest cover change for different years used in the analysis are from India State of Forest Reports (ISFR) of different years.

Study of this nature, which is about possibilities, projections and different scenarios for achieving the INDC target is bound to use certain estimates, presumptions and scenarios. Presumptions and estimates used in drawing the projections are based on expert consultation wherein a conscious attempt has been made to be practical and close to realism and with slight leaning towards conservative projections. All such presumptions and estimates are summarised in the Annexure II.

Costs for restoration of natural forests and raising tree plantations have been calculated using cost norms being followed under CAMPA by the MoEF&CC. There are 5 models of cost norms for raising plantations for different regions according to the annual rainfall in the document of CAMPA norms. Accordingly, a suitable cost norm model was selected for each State according to the average annual rainfall of the State. Maintenance of plantations up to 3 years has been included in the cost for all the activities except for afforestation on culturable waste lands where

considering the difficult nature of such lands, it has been covered up to the 4th year.

In the study, first possibilities of improving forests categorised as recorded forest areas which are largely under the control of State Forest Departments have been explored. Recorded forest areas constitute about 72% of India's forest cover. These forests are largely natural forests which are managed for conservation and sustainable yield under scientifically prepared Working Plans. About 42% of India's forest cover is in open forest category with canopy density between 10% to 40%. There is significant scope of increasing carbon sink in this segment of forest cover by improving stocking of trees. Similarly, quality of forest cover can be improved through interventions such as assisted natural regeneration (ANR), soil & water conservation, enrichment planting for improving canopy density from other lower categories like OF to MDF, MDF to VDF, scrub to OF and NF to OF to increase forest carbon. Apart from increasing carbon sink, restoration of forests and changing their canopy density category will lead to widespread benefits of ecosystem services. For estimating possible forest carbon increase in recorded forest areas, a State wise calculation of possible improvements has been done. Forest cover mapping provides information of all such patches where forest cover has been impaired as well as those patches where forests have improved. This information is presented in change matrix for each State in ISFRs⁵ which is basically a statement of flux of forest cover change. For assessing potential of creating additional carbon sink by improving natural forests for each State, following two activities have been identified

- (i) improving all such forests which have impaired and moved to lower category of canopy density in the last three biennial cycles (i.e. 6 years) of forest cover mapping.
- (ii) improving open forests (of vintage more than 6 years) to moderately dense forests.

Change Matrix given in ISFRs have been used to assess area available for restoration of existing forests in the above two activities for creating additional carbon sink.

Tree planting on all other possible lands is the other broad approach for increasing carbon sink. Availability of land for any land use is scarce, there are competing sectors seeking more and more lands. Food security

⁵ FSI (2017), India State of Forest Report 2017

for the growing population is the first priority and therefore land under agriculture should be preserved. Possible lands for tree planting could be culturable wastelands, linear plantations along roads, railways, rivers & canals, urban spaces and agro-forestry. Area figures for available lands under each of these categories have been taken from credible sources. Table 2 gives sources of area figures for all the activities considered in this study for increasing carbon sink through additional forest & tree cover.

The activities which may be included in the Strategy for creating additional carbon sink of 2.5 to 3.0 billion tonnes through additional forest & tree Cover by 2030 can be broadly outlined as follows

- A Improvement / Restoration of Natural Forests
 - Improving forests which have lost canopy density in the last few years
 - Improving open forests of longer vintage
- B Tree planting on culturable wastelands & other available lands in villages
- C Tree planting along
 - Roads (National Highways, State Highways and Other Roads)
 - Railway lines including Railway Siding
 - Rivers & Canals
- D Greening of Urban Spaces
- E Agro-forestry

Based on the above, following ten possible activities have been considered in this analysis (Table 1). The potential area which may be available for each activity is given in the following Table 3.

Table 1: Activities Considered in the Study for Increasing Carbon Sink through additional Forest & Tree Cover

SI No	Activities	Description
1	Restoration of Impaired Forests	Restoration of forests impaired in the last 6 years like VDF changing to MDF, MDF changing to OF and likewise there would be other possible impaired forests in terms of canopy density. All such changes are mapped by FSI and their area figures are presented in change matrix. Being of relatively recent degradation, it is possible to restore these impaired forests by silvicultural operations like ANR, soil & moisture conservation, enrichment planting etc to a great extent. Three scenarios (@ 50, 60, 70 % of their total area in the last 6 years have been considered.
2	Restoration of Open Forests	Apart from the above, there is significant chunk of open forests which are in existence since last several years i.e older than at least 6 years. It may be relatively difficult to improve these forests to next higher class i.e. MDF because of the fact they have remained OF for so long and defied the natural restoration process. Three scenarios of restoring Open Forests of more than 6 years vintage to MDF (@ 10, 20, 30 Percent of Area respectively have been considered in this study
3	Afforestation on Wastelands	Three scenarios of plantations on Culturable Wastelands (@ 10, 20, 30 percent of available area respectively have been considered.
4	Agro-forestry	Creation of additional Agro-forestry Plantations on 10, 15 and 20 % of the existing area under agro-forestry respectively have been considered as three scenarios.
5	Green Corridor along NH & SH	Planting of trees on both sides of National Highways and State Highways in 50 m wide strips in each side forming Green Corridor would lead to significant increase in carbon sink. Three scenarios @ 30, 40 and 50 % of Corridor Area respectively have been considered.
6	Plantations along Other Roads	Plantations along Other Roads in strips of width 10m on both sides have been taken in to consideration, three scenarios @ 20, 30 and 40 % of the total strip area respectively have been considered.
7	Plantations along Railways	Plantations along Railway tracks in strips of width 10 m on both sides with three scenarios (@ 10%, 20% and 30 % of the total strip area respectively have been considered
8	Plantations on Railway Sidings	Indian Railways has significant land area for siding of goods, tree planting around such lands can be undertaken to increase carbon sink. Plantations around Railway Sidings over entire area has been considered.
9	Plantations along Rivers and Canals	Plantations along important rivers and canals in strip width of 20m on both sides has been taken in to calculations. Three scenarios @ 10, 20 and 30 % of total strip area respectively have been considered.
10	Urban Green Spaces	Expanding Urban Green Spaces including avenue plantations, parks etc in three scenarios @ 2.5, 5 and 7.5 % of Urban Areas in the country respectively have been considered

Table 2: Data Sources for the Study

SI No.	Activities	Sources of Area Figures
1	Restoration of Forests impaired in the last 6 years (@ 50, 60, 70 % of area respectively)	India State of Forest Report (2011, 2013, 2015, 2017), Forest Survey of India
2	Restoring Open Forests of more than 6 years old to MDF (@ 10, 20, 30 Percent of Area respectively)	India State of Forest Report (2011, 2013, 2015, 2017), Forest Survey of India
3	Plantations on Culturable Wastelands (@ 10, 20, 30 Percent of Area respectively)	Statistical Year Book of India (2017), under Ministry of Statistics and Programme Implementation
4	Agroforestry Plantations (@ 10, 15, 20 % of existing area under agroforestry respectively)	A Country Level Assessment of Area under Agroforestry and its Carbon Sequestration Potential by National Innovations in Climate Resilient Agriculture (NICRA), Central Agroforestry Research Institute (ICAR), (2017)
5	Green Corridor along National and State Highways (@ 30, 40 and 50 % of Corridor Area respectively)	1. Transport Research Wing, Ministry of Road Transport and Highways (2015) and Statistical Year Book of India (2017) , under Ministry of Statistics and Programme Implementation 2. Planning for Green Corridor (Plantation) Development Along Highway , NHAI (2015)
6	Plantations along Other Roads (@ 20, 30, 40 % of Area respectively)	Transport Research Wing, Ministry of Road Transport and Highways (2015) and Statistical Year Book of India (2017), under Ministry of Statistics and Programme Implementation
7	Plantations along Railway Tracks (@ 10%, 20% and 30 % Area respectively)	1. Plantation of Trees along Highways/Railways tracks , Press Information Bureau Government of India Ministry of Environment, Forest and Climate Change (2018) 2. Procedure for issue of 'NOC' for construction of government and private buildings on land adjoining railway boundary , Ministry of Railway, Government of India (2015)
8	Plantations around Railway Sidings (Entire Area)	Inventorization of Railway Sidings and Guidelines for their Environment Management , Central Pollution Control Board (2015)
9	Plantation along Important Canals (@ 10, 20 and 30 % Area respectively)	Department of Animal Husbandry, Dairying & Fisheries, M/o Agriculture (2013)
10	Expanding Urban Green Spaces and Avenue Plantations (2.5 and 5% of Urban Area respectively)	Census of India (2011)

Table 3: Potential Area Available for Different Activities

SI No.	Activities	Area in million ha
1	Restoration of Forests impaired in the last 6 years	13.7
2	Restoring Open Forests of more than 6 years vintage to MDF	18.9
3	Plantations on Culturable Wastelands	12.5
4	Agro-forestry Plantations	13.7
5	Green Corridor along National and State	1.40
6	Plantations along Other Roads	2.89
7	Plantations along Railway Tracks	0.07
8	Plantations around Railway Sidings	0.01
9	Plantation along Important Rivers and Canals	0.39
10	Expanding Urban Green Spaces and Avenue Plantations	12.2
Total Area		75.8

4. Trend of Carbon Stock in Forest & Tree Cover in India vis-a-vis NDC Target

FSI has assessed carbon stock in India's forests four times so far in the year 2004 and then biennially since 2011 i.e 2011, 2013 and 2015. The following table gives the assessment in different years.

Table 4: Forest Carbon Assessment done by FSI in different Years

SI No	Year	Forest Carbon (in million tonnes)
1	2004	6663
2	2011	6941
3	2013	7044
4	2015	7083

The above estimates of carbon stock corresponds to forest cover assessed by FSI and reported in ISFRs in different years, which includes all tree patches of size 1 ha or more within the recorded forest areas and outside. The above estimates do not include carbon stock in 'tree cover' which is also assessed by FSI regularly and reported in ISFRs. Tree cover which is assessed through sampling based design constitute all trees occurring in patch sizes smaller than 1 ha. Since the INDC target mentions 'forest & tree cover', it is desirable to generate an estimate for the carbon stock in forest & tree cover of the country and its trend. The following Table 5 gives derived estimates for carbon stock in 'forest & tree cover' of India in different years in which carbon factor for TOF has been used.

Table 5: Derivation of Carbon in Forest & Tree Cover of India

SI No	Year	Forest Cover (sq km)	Forest Carbon in Forest Cover (million tonnes)	Tree Cover (sq km)	Carbon in Tree Cover (million tonnes)	Forest Carbon from Forest & Tree Cover (million tonnes)	Forest Carbon from Forest & Tree Cover CO ₂ eq (billion tonnes)
1	2004	677,088	6,663	91,663	958	7,621	27.97
2	2011	697,898	6,941	91,266	953	7,894	28.97
3	2013	701,495	7,044	92,572	967	8,011	29.40
4	2015	708,273	7,083	93,815	980	8,063	29.59

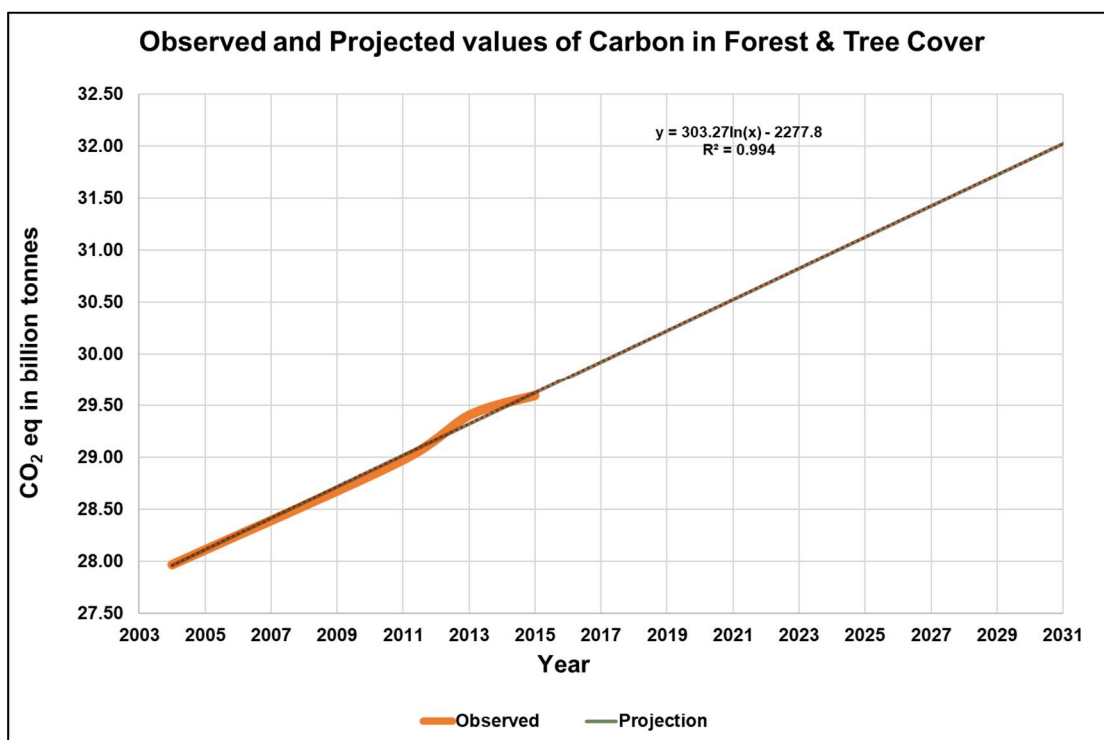


Fig 2

It is seen from the above table that like forest and tree cover, trend of carbon stock also shows a steady increase in the last fifteen years. For drawing projection of forest carbon trend from the last four assessments, regression equations using linear, logarithmic and exponential functions were developed. Table 6 shows the projection of carbon stock in Forest & Tree cover of India in billion tonnes CO₂ eq up to the year 2030. Though all the three regression equations show good fit, the logarithmic equation shows the highest R^2 value of the three and therefore it has been chosen for the purpose of drawing projections of forest carbon in this study (Fig 2).

Table 6: Projection of Carbon in Forest & Tree Cover

SI No	Year	Observed	Projection of Carbon in Forest & Tree Cover billion tonnes CO2 eq		
			Linear	Log	Exponential
			$y = 0.1563x - 285.55, R^2 = 0.992$	$y = 303.2\ln(x) - 2277, R^2 = 0.994$	$y = 0.0005e^{0.0055x}, R^2 = 0.992$
1	2004	27.97	27.87	27.96	27.97
2	2011	28.97	28.93	29.02	29.01
3	2013	29.40	29.23	29.32	29.32
4	2015	29.59	29.53	29.62	29.63
5	2017		29.84	29.93	29.94
6	2019		30.14	30.23	30.26
7	2021		30.44	30.53	30.58
8	2023		30.74	30.83	30.90
9	2025		31.04	31.13	31.23
10	2027		31.34	31.43	31.56
11	2029		31.65	31.72	31.89
12	2031		31.95	32.02	32.23

Fig 2 shows the trend of projected values of carbon stock in forest & tree cover of India in CO2 eq. This trend reflects business as usual (BAU) scenario i.e. the increase in carbon stock which is happening in the normal circumstances with the existing framework of policies and programmes. This also means a trend, which is observed without implementing additional measures per se for increasing forest carbon sink. It is seen in the Table 7 that the carbon stock in forest & tree cover of India which was 28.12 billion tonne CO2 eq in 2005 would become 31.87 billion tonne CO2 eq in 2030 showing an increase of 3.75 billion tonne CO2 eq in 25 years.

It is important to understand the correct meaning of the NDC target in relation to forest & tree cover. The phrase used in the NDC document is

‘to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030’

A careful reading of the above statement raises following questions

- (i) what is the significance of word ‘additional’ figuring twice in the statement?
- (ii) what is the base year from which additional 2.5 to 3.0 billion tonnes CO2 eq carbon sink is to be measured?

- from 2005 (the same base year as mentioned in GDP emission intensity target) or
- from 2015 (year of Paris accord) or
- from 2020 (year from which actions committed in NDC are to be implemented)

(iii) whether the target 2.5 to 3.0 billion tonnes CO₂ eq is above the business as usual (BAU) scenario?

The following Table gives projected values of carbon in India's forest & tree cover in different (possible) baseline years and the corresponding NDC targets.

Table 7: Projection of NDC targets in different (indicative) baseline years

Year	Projection of Carbon in Forest & Tree Cover in BAU Scenario (billion tonnes CO ₂ eq)	Plus 2.5 billion tonnes	Plus 3.0 billion tonnes	Difference from the Projected Value in 2030	
				2.5 billion tonnes	3.0 billion tonnes
2005	28.12	30.62	31.12	-1.25	-0.75
2015	29.62	32.12	32.62	0.25	0.75
2020	30.53	33.03	33.53	1.16	1.66
2030	31.87				

There could be two interpretations of the NDC target

Interpretation I - achieving additional carbon sink of 2.5 to 3.0 billion tonnes CO₂ eq from the level of baseline year, in BAU and meeting only the shortfall by additional forest & tree cover.

Interpretation II – achieving additional carbon sink of 2.5 to 3.0 billion tonnes CO₂ eq above the level, which is projected for 2030 in BAU from the level of baseline year

Presuming the baseline year as 2005, the NDC target in respect of additional carbon sink through additional forest & tree cover would be as follows.

Table 8: NDC target under different interpretations

Baseline Year	NDC Target			
	Interpretation I		Interpretation II	
	2.5 bn tn CO2 eq	3.0 bn tn CO2 eq	2.5 bn tn CO2 eq	3.0 bn tn CO2 eq
2005	30.62	31.12	34.37	34.87

* bn tn – billion tonnes

Thus according to Interpretation I the target would be between 30.62 and 31.12 billion tonnes and according to interpretation 2 it would be between 34.37 and 34.87 billion tonnes.

5. Results & Discussion

Trend of carbon in forest & tree cover based on the past assessments vis-a-vis India's NDC target depicted in the Table 8 and Fig 2 provide an understanding of implications of the NDC target vis-a-vis trend of carbon sink increase and the level it will be able to reach by 2030 in BAU scenario.

It is important to have clarity on the baseline year and correct interpretation of the NDC target; that whether the additional carbon sink 2.5 to 3.0 billion tonnes is above the BAU scenario or the same can be achieved in the normal BAU course. MoEF&CC should issue clarification on these two critical questions without which strategy for achieving the NDC target cannot be developed.

Table 7 shows that if the NDC target is not above the BAU level then the increase in carbon sink by 2030 to the target level can be achieved by just sustaining the existing policies and programmes (BAU). However if the NDC target is interpreted otherwise then concerted programmes of forest restoration and tree planting on all available lands will have to be launched from 2020 onwards. The table given below shows three indicative scenarios of increasing carbon sink size by 2030 along with the cost for each scenario.

Table 9: Indicative scenarios of increasing the carbon sink size by 2030

Scenario 1			Scenario 2			Scenario 3		
Increase in Carbon Sink CO ₂ eq (billion tonnes)	Resulting increase in Area of Forest & Tree Cover (million ha)	Cost (in lakh crores INR)	Increase in Carbon Sink CO ₂ eq (billion tonnes)	Resulting increase in Area of Forest & Tree Cover (million ha)	Cost (in lakh crores INR)	Increase in Carbon Sink CO ₂ eq (billion tonnes)	Resulting increase in Area of Forest & Tree Cover (million ha)	Cost (in lakh crores INR)
1.63	12.73 (2.38% of GA)	1.14	2.51	18.71 (3.43% of GA)	1.92	3.39	24.69 (4.49% of GA)	2.46

Table 10 presents a summary of the results of this study. It is seen that the largest potential of creating additional carbon sink lies in restoration of forests which have impaired in the last 15 to 20 years. The two activities of restoration of natural forests contribute up to 60% of the total carbon sink which can be achieved by 2030 (fig 3).

Table 10: Potential Increase in Carbon Sink and Forest Cover

Activities	Scenario 1			Scenario 2			Scenario 3		
	CO ₂ eq (billion tonnes)	Area (Ha)	% Gain in Forest Cover (w.r.t. TGA)	CO ₂ eq (billion tonnes)	Area (Ha)	% Gain in Forest Cover (w.r.t. TGA)	CO ₂ eq (billion tonnes)	Area (Ha)	% Gain in Forest Cover (w.r.t. TGA)
Restoration of impaired Forests	0.68	68,71,341	1.17	0.82	82,45,609	1.40	0.95	96,19,877	1.63
Restoration of Open Forests	0.31	18,89,989	0.00	0.63	37,79,978	0.00	0.94	56,69,967	0.00
Afforestation on Wastelands	0.19	12,46,948	0.38	0.38	24,93,896	0.76	0.56	37,40,844	1.14
Agroforestry	0.15	13,73,200	0.42	0.23	20,59,800	0.63	0.31	27,46,400	0.84
Green Corridor	0.14	4,20,000	0.13	0.18	5,60,000	0.17	0.23	7,00,000	0.21
Plantations along Other Roads	0.075	5,78,909	0.18	0.11	8,68,363	0.26	0.15	11,57,817	0.35
Plantations along Railways	0.00084	6,669	0.002	0.0017	13,337	0.0041	0.0025	20,006	0.0061
Plantations on Railway Sidings	0.0012	5,154	0.0016	0.0012	5,154	0.0016	0.0012	5,154	0.0016
Plantations along Rivers and Canals	0.0098	39,042	0.012	0.02	78,084	0.024	0.029	1,17,126	0.036
Urban Green Spaces	0.073	3,04,799	0.093	0.15	6,09,599	0.19	0.22	9,14,398	0.28
Total National Level CO₂ eq (Bt) upto year 2030	1.63	1,27,36,051	2.38	2.51	1,87,13,821	3.43	3.39	2,46,91,590	4.49

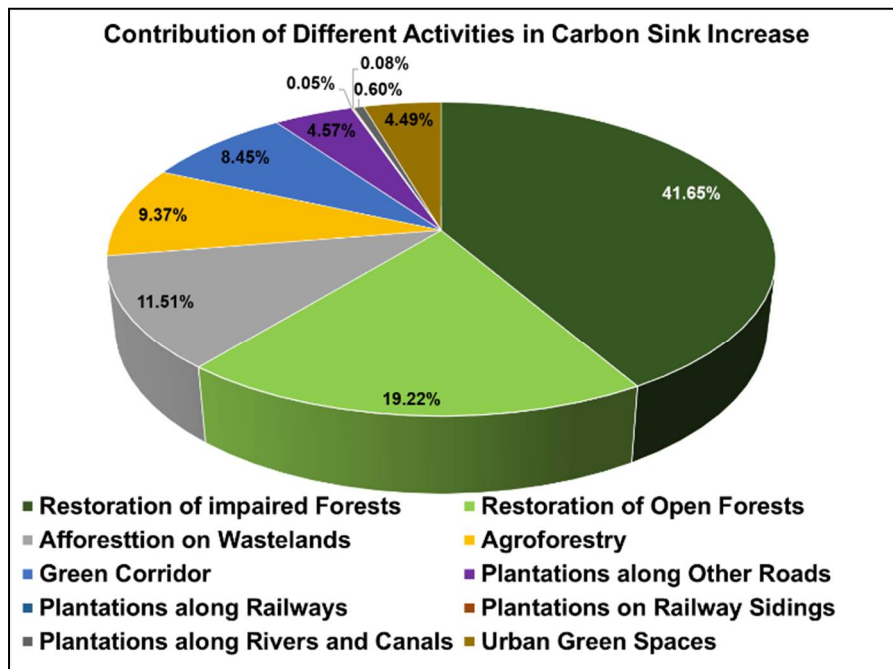


Fig 3

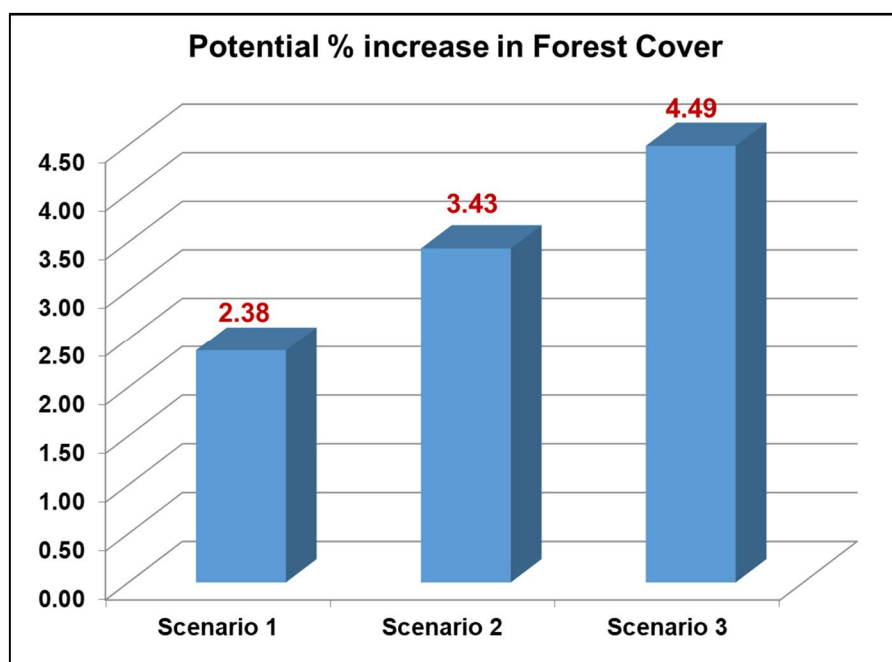


Fig 4

The 10 activities which could be part of the strategy for enhancing forest and tree cover in the country for additional carbon sink would be implemented over an area of 75 million hectare which is 23% of the country's geographical area, would lead to wide spread greening in the country with a positive contribution in enhancing ecology, biodiversity and environment in general.

The Table 10 and Fig 4 show that under the 3 scenarios analysed in this paper, the forest and tree cover in the country would increase by 2.38%, 3.43% & 4.49% respectively. Thus, while achieving the INDC goal, the country will be closer to the national policy goal of 33% of the country's geographical area under forest & tree cover in the next 11 years.

Figure 3 shows contribution of different activities in creating additional carbon sink during the period 2020 to 2030. It is seen that the restoration of natural forests covered in the first two activities offer maximum potential which contribute 41.65% and 19.22% respectively. Contribution of other activities though is much lesser but they are also important as the first two activities may not be able to generate carbon sink to fully achieve the NDC target. Moreover other activities are also important in creating wide spread greening on available lands for ecological benefits in widespread manner.

Table 11 shows unit cost of creating additional sink in terms of INR per ton CO₂ eq by implementing different activities. It is seen that the restoration of natural forests is the least cost option (Fig 5). The tree planting based activities show higher unit cost as it involves creation of new plantations and also tending operations in the next 3 to 4 years. Extension of agro- forestry is another low cost option than tree plantations, but it has limited scope for extension.

Annexure VIII shows cost of implementing different activities in each State/UT for achieving potential carbon sink in the three scenarios by 2030.

Annexures VI & VII present removal factors (RFs) and emission factors (EFs) for all possible activity data within the forest cover. RF and EF values for all the forest type groups are given in the above Annexure. These RFs and EFs have been computed from the large number of sample plot data of national forest inventory (NFI). RFs and EFs have also been computed for different Physiographic Zones of the Country which is given in Annexure VII.

Table 11: Unit Cost and Carbon Sink per unit Area for different Activities

Sl No	Activities for Increasing Forest & Tree Cover	Cost (in INR per tonne CO2 eq)	Additional Sink (in tonne CO2 eq per ha)
1	Restoration of Impaired Forests	329	98.88
2	Restoration of Open Forests	193	165.91
3	Afforestation on Wastelands	2,373	150.59
4	Agroforestry	243	111.30
5	Green Corridor along NH & SH	853	328.19
6	Plantations along Other Roads	2,134	128.88
7	Plantations along Railways	2,179	126.41
8	Plantations on Railway Sidings	1,153	239.04
9	Plantations along Rivers and Canals	1,093	250.19
10	Urban Green Spaces	1,137	240.27

Annexure VII presents State & UT wise potential of the additional carbon sink, possible area for implementing different activities and cost involved in implementation. The top ten states with high potential of carbon sink are given in the Table 12.

Table 12: Top Ten States in respect of Potential Carbon Sink

S.No	State	Total Potential Carbon Sink (in million tonnes CO2 eq)		
		Scenario1	Scenario2	Scenario3
1	Maharashtra	185.82	307.71	412.30
2	Karnataka	112.95	162.09	199.25
3	Rajasthan	90.73	149.87	202.34
4	Uttar Pradesh	104.91	148.31	177.69
5	Madhya Pradesh	87.16	142.35	178.57
6	Andhra Pradesh	100.42	140.64	164.23
7	Tamil Nadu	102.39	136.38	147.87
8	Jammu & Kashmir	98.04	124.23	148.20
9	Manipur	70.53	105.57	140.38
10	Chhattisgarh	57.97	105.18	145.25

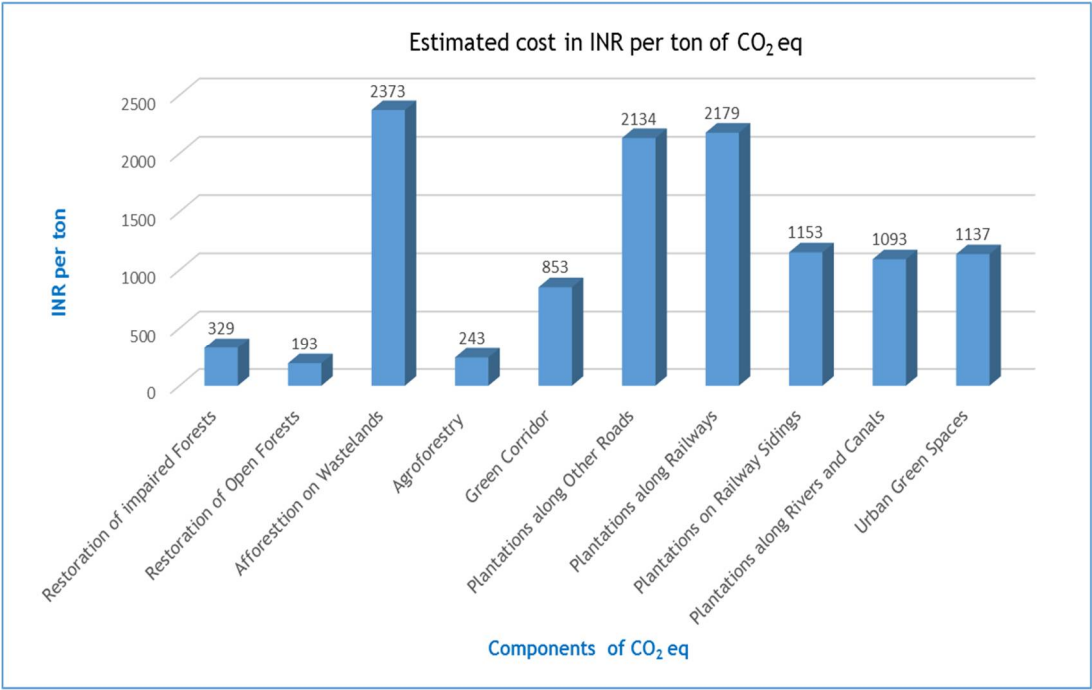


Fig 5

6 Conclusions

NDC target of creating additional carbon sink through additional forest & tree cover may be seen as an opportunity to enhance forestry sector in the country. Targeted approach of improving natural forests and creating tree plantations in widespread manner along with a strong framework of monitoring, reporting and verification (MRV) may go a long way in strengthening ecosystems for greater flow of ecosystem services. Improved silvicultural practices and soil & water conservation measures in restoration of natural forests deserve important place in the strategy.

The study reveals the scale of activities and cost implications for formulating an effective and practical strategy. Capacity building of Forest Department personnel and other stake holders in MRV and forest carbon measurement is a necessary requirement for ensuring success of implementation.

It is important to have clarity on the baseline year and correct interpretation of the NDC target; that whether the additional carbon sink 2.5 to 3.0 billion tonnes is above the BAU scenario or the same can be achieved in the normal BAU course. MoEF&CC should issue clarification on these two critical questions without which strategy for achieving the NDC target cannot be developed.

To achieve any short fall between projection and the target, additional sink by implementing different activities for which carbon, area and cost etc have been analysed in the study.

Acknowledgement

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References

- (i) Accounting for baseline targets in NDCs: Issues and options for guidance, OECD, IEA (2018)
- (ii) Bhattacharya A.K. (2015), Planning for Green Corridor, (Plantation) Development Along Highway, National Highway Authority of India.
- (iii) Central Pollution Control Board (2015), Inventorization of Railway Sidings and Guidelines for their Environment Management.
- (iv) Forest Survey of India (2011), India State of Forest Report.
- (v) Forest Survey of India (2013), India State of Forest Report.
- (vi) Forest Survey of India (2015), India State of Forest Report.
- (vii) Forest Survey of India (2017), India State of Forest Report.
- (viii) Land Use Statistics of India (2017), Ministry of Agriculture and farmer's welfare.
- (ix) Newaj R, Rizvi R.H., Chaturvedi O.P., Alam B., Prasad R., Kumar D.& Handa A.K. (2017), A Country Level Assesment of Area under Agroforestry and its Carbon Sequestration Potential by National Innovations in Climate Resilient Agriculture (NICRA), Central Agroforestry Research Institute (ICAR).
- (x) Press Information Bureau (2018), Plantation of Trees along Highways/Railways tracks, Ministry of Environment, Forest and Climate Change, Government of India.
- (xi) Procedure for issue of 'NOC' for construction of government and private buildings on land adjoining railway boundary (2015), Ministry of Railway, Government of India.
- (xii) State-wise Inland Water Resources in the Country (2013), Department of Animal Husbandry, Dairying & Fisheries, M/o Agriculture.
- (xiii) Statistical Year Book of India (2017), under Ministry of Statistics and Programme Implementation.
- (xiv) Total and Surfaced Road Lengths of India (2015), Transport Research Wing, Ministry of Road Transport and Highways
- (xv) Wastelands Atlas of India (2011), Department of Land Resources, Ministry of Rural Development, Government of India and National Remote Sensing Centre, Indian Space Research Organisation, Dept. of Space, Govt. of India

ANNEXURES

Three Scenarios Considered in the Study

SI No	Activities of Increasing Forest & Tree Cover	Description	Scenario 1	Scenario 2	Scenario 3
			Area in Percentage		
1	Restoration of Impaired Forests	Restoration of Forests impaired in the last 6 years (@ 50, 60, 70 % of area respectively)	50%	60%	70%
2	Restoration of Open Forests	Restoring Open Forests of more than 6 years old to MDF (@ 10, 20, 30 Percent of Area respectively)	10%	20%	30%
3	Afforestation on Wastelands	Plantations on Culturable Wastelands (@ 10, 20, 30 Percent of Area respectively)	10%	20%	30%
4	Agroforestry	Agroforestry Plantations (@ 10, 20, 30 % of existing area under agroforestry respectively)	10%	15%	20%
5	Green Corridor along NH & SH	Green Corridor along National and State Highways (@ 30, 40 and 50 % of Corridor Area respectively)	30%	40%	50%
6	Plantations along Other Roads	Plantations along Other Roads (@ 20, 30, 40 % of Area respectively)	20%	30%	40%
7	Plantations along Railways	Plantations along Railway Tracks (@ 10%, 20% and 30 % Area respectively)	10%	20%	30%
8	Plantations on Railway Sidings	Plantations around Railway Sidings (Entire Area)	100%	100%	100%
9	Plantations along Rivers and Canals	Plantation along Important Canals (@ 10, 20 and 30 % Area respectively)	10%	20%	30%
10	Urban Green Spaces	Expanding Urban Green Spaces and Avenue Plantations (2.5, 5 and 7.5 % of Urban Area respectively)	2.5%	5.0%	7.5%

Set of Estimates, Presumptions & Norms Adopted in the Study

SI No	Activities	Set of Estimates, Presumptions & Norms
1	Restoration of impaired Forests	<ul style="list-style-type: none"> (i) The average rate of degradation observed during ISFR 2011 to 2017 has been assumed to be the same during the period 2019 to 2030. (ii) The area of VDF and MDF degraded to NF will be restored to OF only. The area figures have been calculated only for recorded forest area. (iii) For calculation of the carbon estimates, the forest cover has been distributed to forest type groups and corresponding removal factors has been used. (iv) The removal factors have been multiplied by an adjusting factor 0.773 to take into account the actual carbon sequestration. (v) Since entire area can not be restored, only three possible scenario @ 50, 60, 70 % has been taken for calculation of carbon estimates. (vi) Restoration cost has been taken as Rs. 32500/- per ha (from the draft strategy document of the MoEF & CC)
2	Restoration of Open Forests	<ul style="list-style-type: none"> (i) The area of open forest state wise as given in ISFR 2017 duly adjusted for the area of open forest taken in activity 1 has been taken for calculation. (ii) The area so obtained has been distributed into different forest type groups and corresponding removal factors have been used for the calculation. (iii) The removal factors have been multiplied by an adjusting factor 0.773 to take into account the actual carbon sequestration. (iv) Since entire area can not be restored, only three possible scenario @ 50, 60, 70 % has been taken for calculation of carbon estimates. (v) Restoration cost has been taken as Rs. 32500/- per ha (from the draft strategy document of the MoEF & CC)
3	Afforestation on Wastelands	<ul style="list-style-type: none"> (i) The area of culturable wastelands has been taken from land use statistics of Ministry of Agriculture for the year 2017. Since plantations may not be possible in the entire culturable wastelands, only three scenario @ of 10, 20, 30 has been taken for carbon stock calculation. (ii) The carbon stock figures and removal factors used for calculation of carbon has been reduced to 25 % considering the low productivity of the wastelands. (iii) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. in wasteland, it has been assumed that the plantation will reach upto MDF only. (iv) It has been assumed the NF will convert to OF in 4 years and OF will convert to MDF in next 3 years. (v) Cost has been estimated as per the model of CAMPA (2016).It has also been assumed that for afforestation in wastelands, one year plantation and 4 years post plantation operational cost will be required i.e. extra one year operational cost has been assumed.
4	Agroforestry	<ul style="list-style-type: none"> (i) Since the scope of plantation in Agroforestry is limited, three scenario @ 10, 15 and 20 % has been considered. (ii) It has been assumed that the NF will convert to OF in 4 years due to linear and dispersed pattern of Agroforestry. (iii) State wise dominant physiography has been identified and

SI No	Activities	Set of Estimates, Presumptions & Norms
		<p>accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here it has been assumed that that the planation will form only OF.</p> <p>(iv) The cost of plantation has been taken as Rs. 27000/- per ha which includes only the cost of seedlings. No pre-planting cost has been taken for agroforestry.</p>
5	Green Corridor	<p>(i) The area under green corridors of 1,40,000 Km National Highways (As per NDC Mandate, 2015) has been taken @ of 30, 40, 50 % for the calculation of the carbon.</p> <p>(ii) The width of the plantation has been taken as 50 m each side of the NH and SH (total width of 100 m, As per NHAI document, 2015)</p> <p>(iii) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here it has been assumed that the plantation will convert to VDF after 8 years.</p> <p>(iv) It has been assumed that after 4 years of plantation it will become open forest. The OF will get converted into MDF after three years and MDF will become VDF after 2 years.</p> <p>(v) Considered linear nature of Highways (ignoring curves) in calculating the area.</p> <p>(vi) Cost norm has been calculated from NHAI document i.e. Rs 2,80,000 per Ha.</p>
6	Plantations along Other Roads	<p>(i) The width of the plantation along other roads has been taken as 5 m in each side due to proximity of built up area, cultivation lands etc beside other roads.</p> <p>(ii) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here, OF factor has been used.</p> <p>(iii) Considered linear nature of Other Roads (ignoring curves) in calculating the area.</p> <p>(iv) The newly planted forest become OF in 4 years.</p> <p>(v) Three possible scenario have been considered @ 20, 30, 40 percent of available area.</p> <p>(vi) Cost has been estimated as per the model of CAMPA (2016).</p>
7	Plantations along Railways	<p>(i) The width of the plantation along railway line has been taken as 5 m in each side.</p> <p>(ii) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here it has been assumed that the planation will form only OF.</p> <p>(iii) The planation will convert to OF after 4 years.</p> <p>(iv) Considered linear nature of Railway Tracks (ignoring curves) in calculating the area.</p> <p>(v) Plantation achievement has been projected @ 10, 20, 30 percent of available area along railway tracks.</p> <p>(vi) Cost estimated as per rainfall based climatic model of CAMPA (2016)</p>
8	Plantations on Railway Sidings	<p>(i) Planting trees in 15m each side (15+15=30m width) of total 859 railway sidings in India as per CPCB recommendation (2015).</p> <p>(ii) From Google Earth it was found that average length of each railway siding is 2Km. Therefore, 859 railway sidings is having the length = $859 \times 8 = 1718$ Km.</p> <p>(iii) The siding length has been distributed to all relevant states as per railway length.</p> <p>(iv) Considered linear nature of Railway Sidings during rectangular area calculation.</p> <p>(v) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and</p>

SI No	Activities	Set of Estimates, Presumptions & Norms
		VDF have been calculated. Here, OF and MDF factors have been used. (vi) It has been assumed that after 4 years of plantation will form OF which will convert to MDF after 3 years. (vii) 100% area wise achievement has been projected.viii. Cost has been estimated as per the model of CAMPA (2016).
9	Plantations along Rivers and Canals	(i) The width of the plantation along rivers and canals has been taken as 10 m each side. (ii) The plantation length has been found by interpreting High Resolution Google Earth Images along important canals. It was found that atleast 10 m plantation in each side is visible properly. (iii) Considered linear nature of Canals during rectangular area calculation. (iv) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here, OF and MDF factors have been used. (v) Plantation achievement has been projected @ 10, 20, 30 percent of available area along important canals. (vi) Cost has been estimated as per the model of CAMPA (2016).
10	Urban Green Spaces	(i) Considering lack of space in urban areas, three scenario @ 2.5, 5 and 7.5 % of available Urban Spaces has been considered for afforestation. (ii) State wise dominant physiography has been identified and accordingly the respective factors for generation of OF, MDF and VDF have been calculated. Here, OF and MDF factors have been used. (iii) Cost has been estimated as per the model of CAMPA (2016).

Annexure III

Potential Area for different Activities

Sl No	States/UTs	Restoration of impaired Forests (area in ha)			Restoration of Open Forests (area in ha)		
		Scenario1 (50%)	Scenario2 (60%)	Scenario3 (70%)	Scenario1 (10%)	Scenario2 (20%)	Scenario3 (30%)
1	Andhra Pradesh	408,000	489,600	571,200	97,300	194,600	291,900
2	Arunachal Pradesh	93,450	112,140	130,830	109,165	218,330	327,495
3	Assam	269,850	323,820	377,790	103,944	207,888	311,832
4	Bihar	25,050	30,060	35,070	22,760	45,519	68,279
5	Chhattisgarh	23,550	28,260	32,970	121,249	242,497	363,746
6	Goa	5,250	6,300	7,350	5,804	11,607	17,411
7	Gujarat	10,200	12,240	14,280	56,115	112,230	168,345
8	Haryana	41,850	50,220	58,590	2,887	5,774	8,660
9	Himachal Pradesh	57,000	68,400	79,800	27,328	54,656	81,984
10	Jammu & Kashmir	702,000	842,400	982,800	49,757	99,514	149,270
11	Jharkhand	37,800	45,360	52,920	57,585	115,170	172,754
12	Karnataka	693,600	832,320	971,040	64,957	129,915	194,872
13	Kerala	228,450	274,140	319,830	35,764	71,529	107,293
14	Madhya Pradesh	99,450	119,340	139,230	298,410	596,820	895,230
15	Maharashtra	438,000	525,600	613,200	136,882	273,764	410,645
16	Manipur	281,550	337,860	394,170	83,980	167,961	251,941
17	Meghalaya	123,150	147,780	172,410	61,782	123,565	185,347
18	Mizoram	142,650	171,180	199,710	114,295	228,589	342,884
19	Nagaland	141,750	170,100	198,450	46,102	92,204	138,306
20	Orissa	161,400	193,680	225,960	149,593	299,186	448,778
21	Punjab	28,050	33,660	39,270	3,740	7,480	11,220
22	Rajasthan	336,150	403,380	470,610	55,819	111,638	167,458
23	Sikkim	13,350	16,020	18,690	3,626	7,252	10,877
24	Tamil Nadu	798,300	957,960	1,117,620	60,909	121,819	182,728
25	Telangana	429,900	515,880	601,860	0	0	0
26	Tripura	136,350	163,620	190,890	10,973	21,945	32,918
27	Uttar Pradesh	526,500	631,800	737,100	39,773	79,546	119,320
28	Uttarakhand	403,050	483,660	564,270	33,645	67,289	100,934
29	West Bengal	159,150	190,980	222,810	33,335	66,670	100,005
30	A. & N. Islands	41,400	49,680	57,960	1,883	3,765	5,648
31	Chandigarh	0	0	0	14	28	42
32	D. & N. Haveli	9,300	11,160	13,020	551	1,102	1,653
33	Daman and Diu	252	302	353	0	0	0
34	Delhi	2,313	2,776	3,238	64	128	191
35	Lakshadweep	225	270	315	0	0	0
36	Puducherry	3,051	3,661	4,271	0	0	0
	Total	6,871,341	8,245,609	9,619,877	1,889,989	3,779,978	5,669,967

to be cont.

S. No	States/UTs	Afforestation on Wastelands (area in ha)			Agroforestry (area in ha)		
		Scenario1 (10%)	Scenario2 (20%)	Scenario 3 (30%)	Scenario1 (10%)	Scenario 2 (15%)	Scenario3 (20%)
1	Andhra Pradesh	39,141	78,281	117,422	117,500	176,250	235,000
2	Arunachal Pradesh	6,246	12,493	18,739	1,800	2,700	3,600
3	Assam	14,198	28,396	42,595	25,900	38,850	51,800
4	Bihar	4,467	8,934	13,402	75,600	113,400	151,200
5	Chhattisgarh	35,074	70,148	105,222	60,100	90,150	120,200
6	Goa	5,253	10,507	15,760	900	1,350	1,800
7	Gujarat	196,000	392,000	588,000	81,300	121,950	162,600
8	Haryana	1,703	3,406	5,110	33,600	50,400	67,200
9	Himachal Pradesh	12,167	24,333	36,500	3,300	4,950	6,600
10	Jammu & Kashmir	13,939	27,877	41,816	8,800	13,200	17,600
11	Jharkhand	35,287	70,574	105,861	29,300	43,950	58,600
12	Karnataka	40,943	81,886	122,830	92,400	138,600	184,800
13	Kerala	10,068	20,135	30,203	8,600	12,900	17,200
14	Madhya Pradesh	101,032	202,064	303,095	117,200	175,800	234,400
15	Maharashtra	91,870	183,740	275,610	160,700	241,050	321,400
16	Manipur	74	148	222	2,200	3,300	4,400
17	Meghalaya	38,959	77,918	116,876	1,800	2,700	3,600
18	Mizoram	744	1,487	2,231	400	600	800
19	Nagaland	6,842	13,684	20,527	500	750	1,000
20	Orissa	55,000	110,000	165,000	56,500	84,750	113,000
21	Punjab	6,904	13,807	20,711	41,300	61,950	82,600
22	Rajasthan	403,816	807,631	1,211,447	155,100	232,650	310,200
23	Sikkim	420	840	1,260	700	1,050	1,400
24	Tamil Nadu	32,520	65,039	97,559	65,000	97,500	130,000
25	Telangana	18,251	36,502	54,753	0	0	0
26	Tripura	302	604	906	2,600	3,900	5,200
27	Uttar Pradesh	40,532	81,063	121,595	186,400	279,600	372,800
28	Uttarakhand	31,698	63,397	95,095	7,100	10,650	14,200
29	West Bengal	1,694	3,389	5,083	36,000	54,000	72,000
30	A. & N. Islands	309	619	928	0	0	0
31	Chandigarh	0	0	0	0	0	0
32	D. & N. Haveli	46	92	138	0	0	0
33	Daman and Diu	6	11	17	0	0	0
34	Delhi	989	1,979	2,968	500	750	1,000
35	Lakshadweep	0	0	0	0	0	0
36	Puducherry	455	911	1,366	100	150	200
	Total	1,246,948	2,493,896	3,740,844	1,373,200	2,059,800	2,746,400

to be cont.

S. No	States/UTs	Green Corridor (area in ha)			Plantations along Other Roads (area in ha)		
		Scenario1 (30%)	Scenario2 (40%)	Scenario3 (50%)	Scenario1 (20%)	Scenario2 (30%)	Scenario3 (40%)
1	Andhra Pradesh	17,673	23,564	29,455	22,239	33,359	44,478
2	Arunachal Pradesh	3,981	5,308	6,636	2,511	3,767	5,022
3	Assam	10,003	13,338	16,672	10,753	16,130	21,506
4	Bihar	14,460	19,280	24,100	19,826	29,739	39,652
5	Chhattisgarh	11,808	15,744	19,680	13,024	19,536	26,048
6	Goa	857	1,143	1,429	1,883	2,825	3,767
7	Gujarat	36,420	48,560	60,700	28,078	42,117	56,156
8	Haryana	7,026	9,369	11,711	7,491	11,237	14,983
9	Himachal Pradesh	6,229	8,306	10,382	7,214	10,822	14,429
10	Jammu & Kashmir	4,316	5,754	7,193	3,805	5,708	7,610
11	Jharkhand	6,321	8,429	10,536	4,644	6,966	9,288
12	Karnataka	41,434	55,246	69,057	38,119	57,179	76,239
13	Kerala	9,747	12,996	16,244	26,670	40,005	53,340
14	Madhya Pradesh	25,536	34,048	42,560	43,386	65,079	86,772
15	Maharashtra	74,767	99,689	124,611	84,998	127,497	169,996
16	Manipur	3,899	5,199	6,498	2,178	3,267	4,356
17	Meghalaya	3,097	4,130	5,162	1,413	2,120	2,827
18	Mizoram	2,527	3,369	4,212	1,137	1,705	2,273
19	Nagaland	2,926	3,902	4,877	3,208	4,812	6,416
20	Orissa	13,869	18,492	23,115	47,656	71,484	95,312
21	Punjab	5,342	7,123	8,904	18,090	27,134	36,179
22	Rajasthan	29,828	39,770	49,713	35,192	52,787	70,383
23	Sikkim	1,600	2,134	2,667	963	1,445	1,926
24	Tamil Nadu	26,550	35,400	44,250	38,661	57,992	77,323
25	Telangana	8,604	11,473	14,341	11,911	17,867	23,823
26	Tripura	3,097	4,130	5,162	3,417	5,125	6,834
27	Uttar Pradesh	25,390	33,853	42,317	68,125	102,187	136,250
28	Uttarakhand	10,422	13,895	17,369	5,437	8,155	10,874
29	West Bengal	10,468	13,957	17,446	20,776	31,164	41,552
30	A. & N. Islands	966	1,289	1,611	130	194	259
31	Chandigarh	315	420	525	546	819	1,092
32	D. & N. Haveli	116	154	193	158	237	316
33	Daman and Diu	35	46	58	64	95	127
34	Delhi	127	169	211	4,660	6,990	9,320
35	Lakshadweep	0	0	0	43	64	86
36	Puducherry	242	323	404	502	753	1,004
	Total	420,000	560,000	700,000	578,909	868,363	1,157,817

to be cont.

SI NO	States/UTs	Plantations along Railway (area in ha)			Plantations on Railway Sidings (area in ha)
		Scenario1 (10%)	Scenario2 (20%)	Scenario3 (30%)	
1	Andhra Pradesh	370	741	1,111	286.21
2	Arunachal Pradesh	1	2	4	0.90
3	Assam	244	489	733	188.78
4	Bihar	373	746	1,119	288.32
5	Chhattisgarh	121	243	364	93.74
6	Goa	7	14	21	5.36
7	Gujarat	526	1,052	1,578	406.41
8	Haryana	171	342	513	132.20
9	Himachal Pradesh	30	59	89	22.90
10	Jammu & Kashmir	30	60	89	23.05
11	Jharkhand	239	479	718	185.06
12	Karnataka	328	656	984	253.60
13	Kerala	105	209	314	80.79
14	Madhya Pradesh	500	1,000	1,500	386.43
15	Maharashtra	575	1,149	1,724	444.04
16	Manipur	0	0	0	0.10
17	Meghalaya	1	2	3	0.68
18	Mizoram	0	0	0	0.12
19	Nagaland	1	2	3	0.86
20	Orissa	257	514	772	198.79
21	Punjab	227	454	681	175.38
22	Rajasthan	589	1,179	1,768	455.45
23	Sikkim	0	0	0	0.00
24	Tamil Nadu	403	805	1,208	311.24
25	Telangana	174	347	521	134.22
26	Tripura	19	39	58	14.88
27	Uttar Pradesh	908	1,815	2,723	701.56
28	Uttarakhand	34	68	102	26.26
29	West Bengal	414	827	1,241	319.59
30	A. & N. Islands	0	0	0	0
31	Chandigarh	2	3	5	1.21
32	D. & N. Haveli	0	0	0	0
33	Daman and Diu	0	0	0	0
34	Delhi	18	37	55	14.16
35	Lakshadweep	0	0	0	0.00
36	Puducherry	2	4	7	1.71
	Total	6,669	13,337	20,006	5154.00

to be cont.

SI NO	States/UTs	Plantation along river & Canals (area in ha)			Urban Green Spaces (area in ha)		
		Scenario 1 (10%)	Scenario 2 (20%)	Scenario 3 (30%)	Scenario 1 (2.5%)	Scenario2 (5%)	Scenario3 (7.5%)
1	Andhra Pradesh	39,042	78,084	117,126	19,636	39,273	58,909
2	Arunachal Pradesh				0	0	0
3	Assam				3,150	6,299	9,449
4	Bihar				5,812	11,624	17,435
5	Chhattisgarh				8,119	16,239	24,358
6	Goa				1,946	3,893	5,839
7	Gujarat				18,329	36,658	54,987
8	Haryana				4,940	9,880	14,821
9	Himachal Pradesh				678	1,357	2,035
10	Jammu & Kashmir				3,099	6,198	9,296
11	Jharkhand				5,629	11,257	16,886
12	Karnataka				14,980	29,960	44,940
13	Kerala				18,997	37,994	56,991
14	Madhya Pradesh				19,366	38,732	58,098
15	Maharashtra				22,802	45,603	68,405
16	Manipur				451	901	1,352
17	Meghalaya				707	1,414	2,122
18	Mizoram				2,165	4,330	6,495
19	Nagaland				0	0	0
20	Orissa				57,427	114,855	172,282
21	Punjab				6,287	12,573	18,860
22	Rajasthan				16,645	33,291	49,936
23	Sikkim				96	191	287
24	Tamil Nadu				34,089	68,178	102,267
25	Telangana				0	0	0
26	Tripura				980	1,959	2,939
27	Uttar Pradesh				19,503	39,006	58,508
28	Uttarakhand				2,255	4,510	6,764
29	West Bengal				12,783	25,566	38,349
30	A. & N. Islands				95	190	285
31	Chandigarh				274	548	821
32	D. & N. Haveli				114	229	343
33	Daman and Diu				121	243	364
34	Delhi				2,885	5,770	8,656
35	Lakshadweep				53	107	160
36	Pudducherry				386	773	1,159
	Total	39,042	78,084	117,126	304,799	609,599	58,909

to be cont.

Removal Factors for Natural Forests

SI No	Forest type groups	MDF-VDF	OF-VDF	Scrub-VDF	NF-VDF	OF-MDF	Scrub-MDF	NF-MDF	Scrub-OF	NF-OF	NF-Scrub
1	Tropical Wet Evergreen Forests	-46.00	-96.38	-172.34	-181.84	-50.38	-126.34	-135.84	-75.96	-85.46	-9.50
2	Tropical Semi-Evergreen Forests	-85.09	-144.02	-191.88	-197.87	-58.93	-106.79	-112.78	-47.86	-53.85	-5.98
3	Tropical Moist Deciduous Forests	-26.92	-56.43	-110.09	-116.79	-29.51	-83.17	-89.87	-53.66	-60.36	-6.71
4	Littoral and Swamp Forests	-60.30	-124.43	-166.31	-171.55	-64.13	-106.01	-111.25	-41.88	-47.12	-5.24
5	Tropical Dry Deciduous Forests	-17.59	-104.82	-143.52	-148.35	-87.23	-125.93	-130.76	-38.70	-43.53	-4.84
6	Tropical Thorn Forests	-0.17	-21.09	-42.81	-45.53	-20.92	-42.64	-45.36	-21.72	-24.44	-2.72
7	Tropical Dry Evergreen Forests	-67.75	-96.41	-146.38	-152.62	-28.66	-78.63	-84.87	-49.97	-56.21	-6.25
8	Subtropical Broadleaved Hill Forest	-49.42	-74.72	-149.61	-158.97	-25.30	-100.19	-109.55	-74.89	-84.25	-9.36
9	Subtropical Pine Forests	-54.58	-78.73	-141.92	-149.82	-24.15	-87.34	-95.24	-63.19	-71.09	-7.90
10	Subtropical Dry Evergreen Forest	-42.16	-98.72	-175.18	-184.73	-56.56	-133.02	-142.57	-76.46	-86.01	-9.56
11	Montane Wet Temperate Forests	-35.14	-75.17	-132.27	-139.41	-40.03	-97.13	-104.27	-57.10	-64.24	-7.14
12	Himalayan Moist Temperate Forest	-33.52	-86.85	-160.83	-170.07	-53.33	-127.31	-136.55	-73.98	-83.22	-9.25
13	Himalayan Dry Temperate Forests	-101.85	-152.19	-224.91	-234.00	-50.34	-123.06	-132.15	-72.72	-81.81	-9.09
14	Sub-Alpine Forests	-83.58	-117.94	-186.21	-194.75	-34.36	-102.63	-111.17	-68.27	-76.81	-8.53
15	Moist Alpine Scrubs	-38.16	-71.92	-130.30	-137.60	-33.76	-92.14	-99.44	-58.38	-65.68	-7.30
16	Dry Alpine Scrub	-68.78	-126.59	-179.25	-185.83	-57.81	-110.47	-117.05	-52.66	-59.24	-6.58
17	Plantation/TOF	-26.34	-83.43	-40.01	-140.00	-57.09	-13.67	-113.66	43.42	-56.57	-99.99

Emission Factors for Natural Forests

SI No	Forest type groups	VDF-MDF	VDF-OF	VDF-scrub	VDF-NF	MDF-OF	MDF-Scrub	MDF-NF	OF-Scrub	OF-NF	Scrub-NF
1	Tropical Wet Evergreen Forests	46.00	96.38	172.34	181.84	50.38	126.34	135.84	75.96	85.46	9.50
2	Tropical Semi-Evergreen Forests	85.09	144.02	191.88	197.87	58.93	106.79	112.78	47.86	53.85	5.98
3	Tropical Moist Deciduous Forests	26.92	56.43	110.09	116.79	29.51	83.17	89.87	53.66	60.36	6.71
4	Littoral and Swamp Forests	60.30	124.43	166.31	171.55	64.13	106.01	111.25	41.88	47.12	5.24
5	Tropical Dry Deciduous Forests	17.59	104.82	143.52	148.35	87.23	125.93	130.76	38.70	43.53	4.84
6	Tropical Thorn Forests	0.17	21.09	42.81	45.53	20.92	42.64	45.36	21.72	24.44	2.72
7	Tropical Dry Evergreen Forests	67.75	96.41	146.38	152.62	28.66	78.63	84.87	49.97	56.21	6.25
8	Subtropical Broadleaved Hill Forest	49.42	74.72	149.61	158.97	25.30	100.19	109.55	74.89	84.25	9.36
9	Subtropical Pine Forests	54.58	78.73	141.92	149.82	24.15	87.34	95.24	63.19	71.09	7.90
10	Subtropical Dry Evergreen Forest	42.16	98.72	175.18	184.73	56.56	133.02	142.57	76.46	86.01	9.56
11	Montane Wet Temperate Forests	35.14	75.17	132.27	139.41	40.03	97.13	104.27	57.10	64.24	7.14
12	Himalayan Moist Temperate Forest	33.52	86.85	160.83	170.07	53.33	127.31	136.55	73.98	83.22	9.25
13	Himalayan Dry Temperate Forests	101.85	152.19	224.91	234.00	50.34	123.06	132.15	72.72	81.81	9.09
14	Sub-Alpine Forests	83.58	117.94	186.21	194.75	34.36	102.63	111.17	68.27	76.81	8.53
15	Moist Alpine Scrubs	38.16	71.92	130.30	137.60	33.76	92.14	99.44	58.38	65.68	7.30
16	Dry Alpine Scrub	68.78	126.59	179.25	185.83	57.81	110.47	117.05	52.66	59.24	6.58
17	Plantation/ TOF	26.34	83.43	40.01	140.00	57.09	13.67	113.66	-43.42	56.57	99.99

Physiographic Zone wise Removal Factors of TOF

S. No	Physiographic Zones	VDF-MDF	VDF-OF	MDF-OF
1	Western Himalayas	-69.27	-111.37	-42.10
2	Eastern Himalayas	-64.81	-115.50	-50.69
3	North East Ranges	-45.67	-85.89	-40.22
4	Northern Plains	-115.49	-173.37	-57.88
5	Eastern Plains	-53.76	-98.98	-45.21
6	Western Plains	-64.93	-84.01	-19.08
7	Central Highlands	-86.08	-84.47	1.62
8	North Deccan	-65.96	-89.81	-23.85
9	East Deccan	-71.45	-121.70	-50.25
10	South Deccan	-32.55	-49.39	-16.84
11	Western Ghats	-10.09	-112.51	-102.41
12	Eastern Ghats	-76.38	-80.76	-4.38
13	West Coast	-47.41	-80.35	-32.93
14	East Coast	-26.45	-77.86	-51.41

Potential Increase in Carbon Sink for different Activities in million tonnes CO2 eq

SI No	States/UTs	Restoration of Forests impaired in the last 6 years			Restoring Open Forests of more than 6 years old to MDF		
		Scenario1 (50%)	Scenario2 (60%)	Scenario3 (70%)	Scenario1 (10%)	Scenario2 (20%)	Scenario3 (30%)
1	Andhra Pradesh	54.14	64.96	75.79	0.68	1.36	2.05
2	Arunachal Pradesh	14.25	17.10	19.95	16.66	33.32	49.98
3	Assam	31.38	37.66	43.94	14.46	28.93	43.39
4	Bihar	3.44	4.13	4.82	5.49	10.98	16.48
5	Chhattisgarh	2.81	3.38	3.94	29.40	58.81	88.21
6	Goa	0.48	0.58	0.68	0.00	0.01	0.01
7	Gujarat	0.93	1.12	1.30	0.68	1.36	2.04
8	Haryana	1.81	2.18	2.54	10.48	20.96	31.43
9	Himachal Pradesh	5.44	6.53	7.62	0.70	1.41	2.11
10	Jammu & Kashmir	87.49	104.99	122.49	3.82	7.64	11.46
11	Jharkhand	3.97	4.76	5.56	6.92	13.84	20.76
12	Karnataka	60.82	72.98	85.15	14.10	28.20	42.30
13	Kerala	16.57	19.88	23.19	5.58	11.17	16.75
14	Madhya Pradesh	14.51	17.41	20.31	4.37	8.74	13.11
15	Maharashtra	43.21	51.85	60.49	69.22	138.44	207.66
16	Manipur	43.38	52.06	60.73	25.53	51.07	76.60
17	Meghalaya	18.43	22.11	25.80	8.75	17.50	26.25
18	Mizoram	21.15	25.38	29.61	5.37	10.74	16.11
19	Nagaland	17.76	21.31	24.87	17.07	34.14	51.20
20	Orissa	13.96	16.76	19.55	4.66	9.32	13.97
21	Punjab	2.01	2.42	2.82	28.10	56.19	84.29
22	Rajasthan	23.66	28.40	33.13	0.91	1.81	2.72
23	Sikkim	1.26	1.51	1.77	13.16	26.32	39.48
24	Tamil Nadu	76.29	91.55	106.81	0.32	0.64	0.96
25	Telangana	0.00	0.00	0.00	11.39	22.79	34.18
26	Tripura	14.17	17.01	19.84	0.00	0.00	0.00
27	Uttar Pradesh	48.05	57.66	67.27	1.06	2.12	3.18
28	Uttarakhand	38.38	46.06	53.73	2.73	5.47	8.20
29	West Bengal	11.32	13.58	15.84	4.26	8.51	12.77
30	A. & N. Islands	7.58	9.09	10.61	7.34	14.68	22.03
31	Chandigarh	0.00	0.00	0.00	0.28	0.55	0.83
32	D. & N. Haveli	0.73	0.87	1.02	0.00	0.01	0.01
33	Daman and Diu	0.00	0.00	0.00	0.06	0.13	0.19
34	Delhi	0.01	0.01	0.01	0.00	0.00	0.00
35	Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00
36	Puducherry	0.01	0.01	0.01	0.00	0.00	0.00
	Total	679.41	815.29	951.17	313.57	627.13	940.70

to be cont.

SI No	States/UTs	Afforestation on Wastelands						Agroforestry		
		Scenario 1 (10%) for OF	Scenario 1 (10%) for MDF	Scenario 2 (20%) for OF	Scenario 2 (20%) for MDF	Scenario 3 (30%) for OF	Scenario 3 (30%) for MDF	Scenario 1 (10%)	Scenario 2 (15%)	Scenario 3 (20%)
1	Andhra Pradesh	5.16	3.12	10.32	6.24	15.48	9.36	20.66	30.98	41.31
2	Arunachal Pradesh	0.44	0.57	0.88	1.13	1.32	1.7	0.17	0.25	0.34
3	Assam	1.07	1.26	2.15	2.51	3.22	3.77	2.61	3.92	5.23
4	Bihar	0.34	0.4	0.68	0.79	1.01	1.19	7.63	11.44	15.26
5	Chhattisgarh	3.77	3.92	7.55	7.84	11.32	11.76	8.62	12.93	17.24
6	Goa	0.23	0.3	0.46	0.61	0.69	0.91	0.06	0.09	0.12
7	Gujarat	10.1	9.52	20.21	19.03	30.31	28.55	10.14	15.22	20.29
8	Haryana	0.16	0.19	0.32	0.38	0.48	0.57	3.92	5.88	7.84
9	Himachal Pradesh	1.07	1.12	2.13	2.24	3.2	3.36	0.39	0.58	0.77
10	Jammu & Kashmir	1.22	1.28	2.44	2.57	3.66	3.85	1.26	1.89	2.52
11	Jharkhand	3.8	3.94	7.59	7.89	11.39	11.83	4.54	6.81	9.09
12	Karnataka	4.76	3.41	9.52	6.82	14.28	10.23	5.38	8.07	10.76
13	Kerala	0.44	0.58	0.88	1.17	1.32	1.75	1.8	2.69	3.59
14	Madhya Pradesh	15.82	8.88	31.65	17.76	47.47	26.63	16.47	24.71	32.94
15	Maharashtra	9.68	7.73	19.37	15.45	29.05	23.18	11.49	17.23	22.97
16	Manipur	0	0.01	0.01	0.01	0.01	0.02	0.16	0.24	0.31
17	Meghalaya	2.09	2.76	4.18	5.52	6.27	8.29	0.13	0.19	0.26
18	Mizoram	0.04	0.05	0.08	0.11	0.12	0.16	0.03	0.04	0.06
19	Nagaland	0.37	0.49	0.73	0.97	1.1	1.46	0.07	0.11	0.14
20	Orissa	5.92	6.15	11.83	12.3	17.75	18.44	7.05	10.57	14.1
21	Punjab	0.65	0.77	1.29	1.54	1.94	2.31	2.84	4.26	5.68
22	Rajasthan	20.82	19.61	41.63	39.21	62.45	58.82	14.51	21.77	29.03
23	Sikkim	0.03	0.04	0.06	0.08	0.09	0.11	0.11	0.16	0.21
24	Tamil Nadu	3.69	1.67	7.37	3.35	11.06	5.02	0.4	0.6	0.81
25	Telangana	2.12	1.52	4.24	3.04	6.37	4.56	0	0	0
26	Tripura	0.02	0.02	0.03	0.04	0.05	0.06	4.65	6.97	9.29
27	Uttar Pradesh	3.79	4.52	7.59	9.03	11.38	13.55	23.26	34.89	46.51
28	Uttarakhand	2.77	2.92	5.55	5.84	8.32	8.76	0.83	1.24	1.66
29	West Bengal	0.13	0.15	0.26	0.3	0.38	0.45	3.63	5.45	7.27
30	A. & N. Islands	0.04	0.04	0.07	0.07	0.11	0.11	-	-	-
31	Chandigarh	0	0	0	0	0	0	-	-	-
32	D. & N. Haveli	0.01	0.01	0.01	0.02	0.02	0.03	-	-	-
33	Daman and Diu	0	0	0	0	0	0	-	-	-
34	Delhi	0.09	0.11	0.19	0.22	0.28	0.33	0.03	0.04	0.06
35	Lakshadweep	0	0	0	0	0	0	-	-	-
36	Pudducherry	0.05	0.05	0.1	0.11	0.15	0.16	0.02	0.02	0.03
	Total	100.68	87.09	201.36	174.19	302.04	261.28	152.84	229.26	305.68

to be cont

SI No	States/UTs	Green Corridor								
		Scenario1 (30%) for OF	Scenario1 (30%) for MDF	Scenario1 (30%) for VDF	Scenario2 (40%) for OF	Scenario2 (40%) for MDF	Scenario2 (40%) for VDF	Scenario3 (50%) for OF	Scenario3 (50%) for MDF	Scenario3 (50%) for VDF
1	Andhra Pradesh	3.11	1.88	1.84	4.14	2.50	2.45	5.18	3.13	3.07
2	Arunachal Pradesh	0.37	0.48	0.41	0.50	0.64	0.55	0.62	0.80	0.69
3	Assam	1.01	1.18	0.95	1.35	1.57	1.27	1.68	1.97	1.58
4	Bihar	1.46	1.71	1.37	1.95	2.28	1.83	2.43	2.84	2.29
5	Chhattisgarh	1.69	1.76	1.44	2.26	2.35	1.92	2.82	2.93	2.40
6	Goa	0.05	0.07	0.06	0.07	0.09	0.08	0.08	0.11	0.10
7	Gujarat	2.50	2.36	2.76	3.34	3.14	3.68	4.17	3.93	4.59
8	Haryana	0.88	1.04	1.06	1.17	1.39	1.42	1.46	1.74	1.77
9	Himachal Pradesh	0.73	0.77	0.67	0.97	1.02	0.89	1.21	1.28	1.12
10	Jammu & Kashmir	0.50	0.53	0.46	0.67	0.71	0.62	0.84	0.88	0.77
11	Jharkhand	0.91	0.94	0.77	1.21	1.26	1.03	1.51	1.57	1.29
12	Karnataka	6.42	4.60	3.20	8.57	6.14	4.27	10.71	7.67	5.34
13	Kerala	0.57	0.75	0.68	0.76	1.00	0.91	0.95	1.25	1.14
14	Madhya Pradesh	5.33	2.99	2.96	7.11	3.99	3.95	8.89	4.99	4.94
15	Maharashtra	10.51	8.38	7.48	14.01	11.18	9.98	17.51	13.97	12.47
16	Manipur	0.28	0.37	0.30	0.37	0.49	0.40	0.46	0.61	0.51
17	Meghalaya	0.22	0.29	0.24	0.30	0.39	0.32	0.37	0.49	0.40
18	Mizoram	0.18	0.24	0.20	0.24	0.32	0.26	0.30	0.40	0.33
19	Nagaland	0.21	0.28	0.23	0.28	0.37	0.30	0.35	0.46	0.38
20	Orissa	1.99	2.07	1.69	2.65	2.76	2.26	3.32	3.44	2.82
21	Punjab	0.67	0.79	0.81	0.89	1.06	1.08	1.11	1.32	1.35
22	Rajasthan	2.05	1.93	2.26	2.73	2.57	3.01	3.42	3.22	3.76
23	Sikkim	0.15	0.19	0.17	0.20	0.26	0.22	0.25	0.32	0.28
24	Tamil Nadu	4.01	1.82	0.47	5.35	2.43	0.62	6.69	3.04	0.78
25	Telangana	1.33	0.96	0.66	1.78	1.27	0.89	2.22	1.59	1.11
26	Tripura	0.22	0.29	0.24	0.30	0.39	0.32	0.37	0.49	0.40
27	Uttar Pradesh	3.17	3.77	3.84	4.22	5.03	5.12	5.28	6.29	6.40
28	Uttarakhand	1.22	1.28	1.12	1.62	1.71	1.50	2.03	2.13	1.87
29	West Bengal	1.06	1.24	0.99	1.41	1.65	1.32	1.76	2.06	1.66
30	A. & N. Islands	0.15	0.15	0.09	0.19	0.20	0.12	0.24	0.25	0.15
31	Chandigarh	0.04	0.02	0.05	0.05	0.03	0.06	0.07	0.04	0.08
32	D. & N. Haveli	0.02	0.03	0.01	0.03	0.04	0.02	0.04	0.05	0.02
33	Daman and Diu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
34	Delhi	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
35	Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Puducherry	0.04	0.04	0.02	0.05	0.05	0.03	0.06	0.06	0.04
	Total	53.06	45.22	39.56	70.74	60.30	52.75	88.43	75.37	65.94

to be cont.

S.No	States/UTs	Plantations on Other Roads			Plantations on Railways			Plantations on Railway Sidings	
		Scenario 1 (20%)	Scenario 2 (40%)	Scenario 3 (50%)	Scenario 1 (10%)	Scenario 2 (20%)	Scenario 3 (30%)	OF	MDF
1	Andhra Pradesh	3.91	5.86	7.82	0.07	0.13	0.20	0.050	0.030
2	Arunachal Pradesh	0.23	0.35	0.47	0.00	0.00	0.00	0.000	0.000
3	Assam	1.09	1.63	2.17	0.02	0.05	0.07	0.019	0.022
4	Bihar	2.00	3.00	4.00	0.04	0.08	0.11	0.029	0.034
5	Chhattisgarh	1.87	2.80	3.74	0.02	0.03	0.05	0.013	0.014
6	Goa	0.11	0.16	0.22	0.00	0.00	0.00	0.000	0.000
7	Gujarat	1.93	2.89	3.86	0.04	0.07	0.11	0.028	0.026
8	Haryana	0.93	1.40	1.87	0.02	0.04	0.06	0.016	0.020
9	Himachal Pradesh	0.84	1.26	1.68	0.00	0.01	0.01	0.003	0.003
10	Jammu & Kashmir	0.44	0.67	0.89	0.00	0.01	0.01	0.003	0.003
11	Jharkhand	0.67	1.00	1.33	0.03	0.07	0.10	0.027	0.028
12	Karnataka	5.91	8.87	11.82	0.05	0.10	0.15	0.039	0.028
13	Kerala	1.55	2.33	3.10	0.01	0.01	0.02	0.005	0.006
14	Madhya Pradesh	9.06	13.59	18.12	0.10	0.21	0.31	0.081	0.045
15	Maharashtra	11.95	17.92	23.89	0.08	0.16	0.24	0.062	0.050
16	Manipur	0.16	0.23	0.31	0.00	0.00	0.00	0.000	0.000
17	Meghalaya	0.10	0.15	0.20	0.00	0.00	0.00	0.000	0.000
18	Mizoram	0.08	0.12	0.16	0.00	0.00	0.00	0.000	0.000
19	Nagaland	0.23	0.34	0.46	0.00	0.00	0.00	0.000	0.000
20	Orissa	6.84	10.25	13.67	0.04	0.07	0.11	0.029	0.030
21	Punjab	2.26	3.39	4.51	0.03	0.06	0.08	0.022	0.026
22	Rajasthan	2.42	3.63	4.84	0.04	0.08	0.12	0.031	0.029
23	Sikkim	0.09	0.14	0.18	0.00	0.00	0.00	0.000	0.000
24	Tamil Nadu	5.84	8.77	11.69	0.06	0.12	0.18	0.047	0.021
25	Telangana	1.85	2.77	3.69	0.03	0.05	0.08	0.021	0.015
26	Tripura	0.24	0.37	0.49	0.00	0.00	0.00	0.001	0.001
27	Uttar Pradesh	8.50	12.75	17.00	0.00	0.01	0.01	0.003	0.003
28	Uttarakhand	0.63	0.95	1.27	0.11	0.23	0.34	0.088	0.104
29	West Bengal	2.10	3.14	4.19	0.04	0.08	0.13	0.032	0.038
30	A. & N. Islands	0.02	0.03	0.04	0.00	0.00	0.00	0.000	0.000
31	Chandigarh	0.07	0.10	0.14	0.0002	0.0004	0.0006	0.0002	0.000
32	D. & N. Haveli	0.03	0.04	0.06	0.00	0.00	0.00	0.00	0.00
33	Daman and Diu	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
34	Delhi	0.58	0.87	1.16	0.0023	0.0046	0.0069	0.0018	0.00
35	Lakshadweep	0.00	0.00	0.00				0.0003	0.00
36	Puducherry	0.08	0.11	0.15	0.0003	0.0007	0.0010		
	Total	74.61	111.91	149.22	0.84	1.69	2.53	0.65	0.58

to be cont.

SI No	States/UTs	Plantation along river & Canals					
		Scenario1 (10%) for OF	Scenario1 (10%) for MDF	Scenario2 (20%) for OF	Scenario2 (20%) for MDF	Scenario3 (30%) for OF	Scenario3 (30%) for MDF
1	Andhra Pradesh	5.13	4.64	10.27	9.27	15.40	13.91
2	Arunachal Pradesh						
3	Assam						
4	Bihar						
5	Chhattisgarh						
6	Goa						
7	Gujarat						
8	Haryana						
9	Himachal Pradesh						
10	Jammu & Kashmir						
11	Jharkhand						
12	Karnataka						
13	Kerala						
14	Madhya Pradesh						
15	Maharashtra						
16	Manipur						
17	Meghalaya						
18	Mizoram						
19	Nagaland						
20	Orissa						
21	Punjab						
22	Rajasthan						
23	Sikkim						
24	Tamil Nadu						
25	Telangana						
26	Tripura						
27	Uttar Pradesh						
28	Uttarakhand						
29	West Bengal						
30	A. & N. Islands						
31	Chandigarh						
32	D. & N. Haveli						
33	Daman and Diu						
34	Delhi						
35	Lakshadweep						
36	Pudducherry						
	Total	5.13	4.64	10.27	9.27	15.40	13.91

to be cont.

SI No	States/UTs	Urban Green Spaces					
		Scenario 1 (2.5%) for OF	Scenario 1 (2.5%) for MDF	Scenario 2 (5%) for OF	Scenario 2 (5%) for MDF	Scenario 3 (7.5%) for OF	Scenario 3 (7.5%) for MDF
1	Andhra Pradesh	3.452	2.087	6.904	4.174	10.38	6.26
2	Arunachal Pradesh	0.000	0.000	0.000	0.000	0	0
3	Assam	0.318	0.372	0.636	0.743	0.96	1.11
4	Bihar	0.586	0.686	1.173	1.372	1.76	2.06
5	Chhattisgarh	1.165	1.210	2.329	2.420	3.5	3.63
6	Goa	0.113	0.150	0.227	0.301	0.34	0.45
7	Gujarat	1.260	1.187	2.520	2.373	3.79	3.56
8	Haryana	0.616	0.734	1.233	1.468	1.85	2.2
9	Himachal Pradesh	0.079	0.083	0.158	0.167	0.24	0.25
10	Jammu & Kashmir	0.362	0.381	0.723	0.762	1.09	1.14
11	Jharkhand	0.807	0.839	1.615	1.678	2.43	2.52
12	Karnataka	2.323	1.664	4.645	3.328	6.98	4.99
13	Kerala	1.106	1.467	2.211	2.933	3.32	4.4
14	Madhya Pradesh	4.044	2.269	8.088	4.538	12.15	6.81
15	Maharashtra	3.204	2.557	6.409	5.113	9.63	7.67
16	Manipur	0.032	0.043	0.064	0.085	0.1	0.13
17	Meghalaya	0.051	0.067	0.101	0.134	0.15	0.2
18	Mizoram	0.155	0.205	0.310	0.409	0.47	0.61
19	Nagaland	0.000	0.000	0.000	0.000	0	0
20	Orissa	8.238	8.558	16.476	17.117	24.76	25.68
21	Punjab	0.784	0.934	1.569	1.868	2.36	2.8
22	Rajasthan	1.144	1.078	2.288	2.155	3.44	3.23
23	Sikkim	0.009	0.012	0.018	0.023	0.03	0.03
24	Tamil Nadu	5.153	2.339	10.306	4.678	15.49	7.02
25	Telangana	0	0	0	0	0	0
26	Tripura	0.070	0.093	0.140	0.185	0.21	0.28
27	Uttar Pradesh	2.276	2.396	4.552	4.793	6.84	7.19
28	Uttarakhand	0.281	0.335	0.563	0.670	0.85	1
29	West Bengal	1.290	1.508	2.580	3.017	3.88	4.53
30	A. & N. Islands	0.014	0.015	0.029	0.029	0.04	0.04
31	Chandigarh	0.034	0.021	0.068	0.042	0.1	0.06
32	D. & N. Haveli	0.021	0.028	0.042	0.055	0.06	0.08
33	Daman and Diu	0.007	0.009	0.014	0.019	0.02	0.03
34	Delhi	0.360	0.429	0.720	0.857	1.08	1.29
35	Lakshadweep	0.003	0.004	0.006	0.008	0.01	0.01
36	Puducherry	0.058	0.060	0.117	0.120	0.18	0.18
	Total	39.42	33.82	78.83	67.63	10.38	6.26

Annexure VIII

State wise Estimated Cost to Implement different Activities for meeting India's NDC Target by 2030

States/UTs	Restoration of impaired Forests (INR Crores)			Restoration of Open Forests (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	1326.00	1591.20	1856.40	316.23	632.45	948.68
Arunachal Pradesh	303.71	364.46	425.20	354.79	709.57	1064.36
Assam	877.01	1052.42	1227.82	337.82	675.64	1013.45
Bihar	81.41	97.70	113.98	73.97	147.94	221.91
Chhattisgarh	76.54	91.85	107.15	394.06	788.12	1182.17
Goa	17.06	20.48	23.89	18.86	37.72	56.59
Gujarat	33.15	39.78	46.41	182.37	364.75	547.12
Haryana	136.01	163.22	190.42	9.38	18.76	28.15
Himachal Pradesh	185.25	222.30	259.35	88.82	177.63	266.45
Jammu & Kashmir	2281.50	2737.80	3194.10	83.52	167.05	250.57
Jharkhand	122.85	147.42	171.99	187.15	374.30	561.45
Karnataka	2254.20	2705.04	3155.88	211.11	422.22	633.33
Kerala	742.46	890.96	1039.45	116.23	232.47	348.70
Madhya Pradesh	323.21	387.86	452.50	969.83	1939.66	2909.50
Maharashtra	1423.50	1708.20	1992.90	444.87	889.73	1334.60
Manipur	915.04	1098.05	1281.05	272.94	545.87	818.81
Meghalaya	400.24	480.29	560.33	200.79	401.59	602.38
Mizoram	463.61	556.34	649.06	371.46	742.91	1114.37
Nagaland	460.69	552.83	644.96	149.83	299.66	449.49
Orissa	524.55	629.46	734.37	486.18	972.35	1458.53
Punjab	91.16	109.40	127.63	12.16	24.31	36.47
Rajasthan	1092.49	1310.99	1529.48	181.41	362.82	544.24
Sikkim	43.39	52.07	60.74	11.78	23.57	35.35
Tamil Nadu	2594.48	3113.37	3632.27	197.96	395.91	593.87
Telangana	1397.18	1676.61	1956.05	0.00	0.00	0.00
Tripura	443.14	531.77	620.39	35.66	71.32	106.98
Uttar Pradesh	1711.13	2053.35	2395.58	129.26	258.53	387.79
Uttarakhand	1309.91	1571.90	1833.88	109.34	218.69	328.03
West Bengal	517.24	620.69	724.13	108.34	216.68	325.02
A. & N. Islands	134.55	161.46	188.37	6.12	12.24	18.36
Chandigarh	0.00	0.00	0.00	0.05	0.09	0.14
D. & N. Haveli	30.23	36.27	42.32	1.79	3.58	5.37
Daman and Diu	0.82	0.98	1.15	0.00	0.00	0.00
Delhi	7.52	9.02	10.52	0.21	0.41	0.62
Lakshadweep	0.73	0.88	1.02	0.00	0.00	0.00
Pudducherry	9.92	11.90	13.88	0.00	0.00	0.00

to be cont.

States/UTs	Afforestation on Wastelands (INR Crores)			Agroforestry (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	890.02	1780.05	2670.07	317.25	475.88	634.50
Arunachal Pradesh	192.26	384.53	576.79	4.86	7.29	9.72
Assam	437.03	874.06	1311.09	69.93	104.90	139.86
Bihar	137.50	275.01	412.51	204.12	306.18	408.24
Chhattisgarh	1079.60	2159.19	3238.79	162.27	243.41	324.54
Goa	161.70	323.40	485.10	1.35	2.03	2.70
Gujarat	4456.88	8913.76	13370.64	2.43	3.65	4.86
Haryana	25.92	51.83	77.75	219.51	329.27	439.02
Himachal Pradesh	374.50	749.00	1123.49	90.72	136.08	181.44
Jammu & Kashmir	316.95	633.91	950.86	8.91	13.37	17.82
Jharkhand	1086.16	2172.32	3258.47	23.76	35.64	47.52
Karnataka	1260.26	2520.51	3780.77	79.11	118.67	158.22
Kerala	309.89	619.77	929.66	249.48	374.22	498.96
Madhya Pradesh	2297.38	4594.76	6892.14	23.22	34.83	46.44
Maharashtra	2827.81	5655.63	8483.44	316.44	474.66	632.88
Manipur	2.28	4.56	6.83	433.89	650.84	867.78
Meghalaya	1199.18	2398.35	3597.53	5.94	8.91	11.88
Mizoram	22.89	45.77	68.66	4.86	7.29	9.72
Nagaland	210.61	421.21	631.82	1.08	1.62	2.16
Orissa	1692.93	3385.87	5078.80	1.35	2.03	2.70
Punjab	182.23	364.46	546.69	152.55	228.83	305.10
Rajasthan	22239.92	44479.84	66719.76	111.51	167.27	223.02
Sikkim	12.93	25.86	38.78	418.77	628.16	837.54
Tamil Nadu	739.47	1478.94	2218.41	1.89	2.84	3.78
Telangana	415.02	830.03	1245.05	7.02	10.53	14.04
Tripura	9.29	18.59	27.88	175.50	263.25	351.00
Uttar Pradesh	921.66	1843.31	2764.97	503.28	754.92	1006.56
Uttarakhand	975.70	1951.39	2927.09	19.17	28.76	38.34
West Bengal	52.15	104.30	150.00	97.20	145.80	194.40
A. & N. Islands	9.52	19.04	27.38	0.00	0.00	0.00
Chandigarh	0.00	0.00	0.00	0.00	0.00	0.00
D. & N. Haveli	1.42	2.83	4.25	0.00	0.00	0.00
Daman and Diu	0.15	0.30	0.44	0.00	0.00	0.00
Delhi	15.05	30.11	45.16	0.00	0.00	0.00
Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00
Pudducherry	10.36	20.71	31.07	0.27	0.41	0.54

to be cont.

States/UTs	Green Corridor (INR Crores)			Plantations along Other Roads (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	494.84	659.79	824.73	477.45	716.18	954.91
Arunachal Pradesh	111.48	148.64	185.80	74.11	111.16	148.21
Assam	280.09	373.46	466.82	317.33	476.00	634.66
Bihar	404.88	539.84	674.80	585.07	877.60	1170.13
Chhattisgarh	330.62	440.82	551.03	384.34	576.52	768.69
Goa	24.00	32.00	40.00	55.58	83.37	111.16
Gujarat	1019.76	1359.68	1699.59	602.81	904.21	1205.61
Haryana	196.74	262.32	327.90	104.47	156.71	208.95
Himachal Pradesh	174.43	232.57	290.71	212.90	319.35	425.80
Jammu & Kashmir	120.84	161.12	201.40	81.69	122.53	163.38
Jharkhand	177.00	236.00	295.00	137.04	205.56	274.08
Karnataka	1160.16	1546.88	1933.60	1124.92	1687.38	2249.84
Kerala	272.91	363.87	454.84	787.04	1180.55	1574.07
Madhya Pradesh	715.00	953.33	1191.67	931.46	1397.18	1862.91
Maharashtra	2093.46	2791.27	3489.09	2508.32	3762.48	5016.64
Manipur	109.17	145.56	181.95	64.27	96.40	128.54
Meghalaya	86.72	115.63	144.54	41.71	62.56	83.42
Mizoram	70.75	94.34	117.92	33.54	50.31	67.08
Nagaland	81.93	109.24	136.56	94.68	142.01	189.35
Orissa	388.33	517.77	647.22	1406.35	2109.52	2812.70
Punjab	149.58	199.44	249.31	454.51	681.77	909.03
Rajasthan	835.17	1113.56	1391.96	1893.46	2840.19	3786.92
Sikkim	44.80	59.74	74.67	28.42	42.64	56.85
Tamil Nadu	743.39	991.19	1238.99	830.02	1245.03	1660.05
Telangana	240.92	321.23	401.54	255.73	383.59	511.45
Tripura	86.72	115.63	144.54	100.83	151.25	201.66
Uttar Pradesh	710.92	947.89	1184.87	1462.57	2193.86	2925.15
Uttarakhand	291.80	389.07	486.34	160.44	240.66	320.88
West Bengal	293.09	390.79	488.48	613.11	919.66	1226.22
A. & N. Islands	27.06	36.08	45.10	3.82	5.74	7.65
Chandigarh	8.83	11.77	14.71	7.62	11.43	15.23
D. & N. Haveli	3.24	4.32	5.40	4.66	6.99	9.33
Daman and Diu	0.98	1.30	1.63	1.60	2.40	3.20
Delhi	3.55	4.73	5.91	64.99	97.48	129.98
Lakshadweep	0.00	0.00	0.00	1.26	1.89	2.53
Pudducherry	6.79	9.05	11.31	10.78	16.17	21.56

to be cont.

States/UTs	Plantations along Railways (INR Crores)			Plantations on Railway Sidings (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	7.95	15.90	23.85	6.14	6.14	6.14
Arunachal Pradesh	0.03	0.07	0.10	0.03	0.03	0.03
Assam	7.21	14.42	21.62	5.57	5.57	5.57
Bihar	11.01	22.02	33.03	8.51	8.51	8.51
Chhattisgarh	3.58	7.16	10.74	2.77	2.77	2.77
Goa	0.20	0.41	0.61	0.16	0.16	0.16
Gujarat	11.29	22.58	33.87	8.73	8.73	8.73
Haryana	2.39	4.77	7.16	1.84	1.84	1.84
Himachal Pradesh	0.87	1.75	2.62	0.68	0.68	0.68
Jammu & Kashmir	0.64	1.28	1.92	0.49	0.49	0.49
Jharkhand	7.07	14.13	21.20	5.46	5.46	5.46
Karnataka	9.68	19.37	29.05	7.48	7.48	7.48
Kerala	3.08	6.17	9.25	2.38	2.38	2.38
Madhya Pradesh	10.73	21.47	32.20	8.30	8.30	8.30
Maharashtra	16.96	33.91	50.87	13.10	13.10	13.10
Manipur	0.00	0.01	0.01	0.00	0.00	0.00
Meghalaya	0.03	0.05	0.08	0.02	0.02	0.02
Mizoram	0.00	0.01	0.01	0.00	0.00	0.00
Nagaland	0.03	0.07	0.10	0.03	0.03	0.03
Orissa	7.59	15.18	22.77	5.87	5.87	5.87
Punjab	5.70	11.40	17.11	4.41	4.41	4.41
Rajasthan	31.71	63.41	95.12	24.51	24.51	24.51
Sikkim	0.00	0.00	0.00	0.00	0.00	0.00
Tamil Nadu	8.65	17.29	25.94	6.68	6.68	6.68
Telangana	3.73	7.46	11.19	2.88	2.88	2.88
Tripura	0.57	1.14	1.70	0.44	0.44	0.44
Uttar Pradesh	1.00	2.01	3.01	0.77	0.77	0.77
Uttarakhand	19.49	38.98	58.47	15.06	15.06	15.06
West Bengal	12.20	24.41	36.61	9.43	9.43	9.43
A. & N. Islands	0	0	0	0.00	0.00	0.00
Chandigarh	0.02	0.04	0.07	0.02	0.02	0.02
D. & N. Haveli	0.00	0.00	0.00	0.00	0.00	0.00
Daman and Diu	0.00	0.00	0.00	0.00	0.00	0.00
Delhi	0.26	0.51	0.77	0.20	0.20	0.20
Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00
Pudducherry	0.05	0.10	0.14	0.04	0.04	0.04

to be cont.

States/UTs	Plantations along Rivers and Canals (INR Crores)			Urban Green Spaces (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	1067.86	2135.73	3203.59	421.58	843.15	1264.73
Arunachal Pradesh				0.00	0.00	0.00
Assam				92.94	185.89	278.83
Bihar				171.51	343.03	514.54
Chhattisgarh				239.61	479.22	718.83
Goa				57.44	114.88	172.33
Gujarat				393.51	787.01	1180.52
Haryana				68.89	137.78	206.68
Himachal Pradesh				20.02	40.05	60.07
Jammu & Kashmir				66.53	133.07	199.60
Jharkhand				166.10	332.20	498.30
Karnataka				442.07	884.13	1326.20
Kerala				560.61	1121.22	1681.83
Madhya Pradesh				415.77	831.54	1247.31
Maharashtra				672.88	1345.76	2018.64
Manipur				13.29	26.59	39.88
Meghalaya				20.86	41.73	62.59
Mizoram				63.89	127.78	191.67
Nagaland				0.00	0.00	0.00
Orissa				1694.71	3389.42	5084.13
Punjab				157.95	315.91	473.86
Rajasthan				895.60	1791.20	2686.80
Sikkim				2.82	5.64	8.45
Tamil Nadu				731.86	1463.72	2195.57
Telangana				0.00	0.00	0.00
Tripura				28.91	57.81	86.72
Uttar Pradesh				418.71	837.42	1256.13
Uttarakhand				66.55	133.09	199.64
West Bengal				377.23	754.46	1131.69
A. & N. Islands				2.80	5.61	8.41
Chandigarh				3.82	7.64	11.46
D. & N. Haveli				3.38	6.76	10.14
Daman and Diu				3.05	6.11	9.16
Delhi				40.23	80.47	120.70
Lakshadweep				1.58	3.16	4.74
Pudducherry				8.30	16.60	24.89

to be cont.

States/UTs	Total Cost (INR Crores)		
	Scenario 1	Scenario 2	Scenario 3
Andhra Pradesh	4,287	6,780	9,273
Arunachal Pradesh	1,071	1,785	2,499
Assam	2,455	3,822	5,189
Bihar	1,708	2,677	3,647
Chhattisgarh	2,703	4,848	6,994
Goa	366	674	982
Gujarat	6,741	12,463	18,186
Haryana	795	1,186	1,577
Himachal Pradesh	1,178	1,939	2,700
Jammu & Kashmir	2,991	4,030	5,069
Jharkhand	1,942	3,582	5,222
Karnataka	6,579	9,971	13,363
Kerala	3,074	4,851	6,628
Madhya Pradesh	5,725	10,228	14,732
Maharashtra	10,347	16,734	23,121
Manipur	1,841	2,627	3,414
Meghalaya	1,985	3,568	5,152
Mizoram	1,061	1,684	2,307
Nagaland	1,029	1,586	2,143
Orissa	6,238	11,087	15,936
Punjab	1,240	1,999	2,759
Rajasthan	27,335	52,213	77,091
Sikkim	593	897	1,201
Tamil Nadu	5,884	8,774	11,665
Telangana	2,352	3,292	4,231
Tripura	911	1,271	1,630
Uttar Pradesh	5,889	8,951	12,014
Uttarakhand	2,997	4,647	6,297
West Bengal	2,110	3,246	4,375
A. & N. Islands	214	299	384
Chandigarh	50	90	131
D. & N. Haveli	74	120	166
Daman and Diu	36	70	105
Delhi	162	282	403
Lakshadweep	33	65	97
Pudducherry	76	134	192

Annexure IX

Adopted Cost Model as per CAMPA (2016)

SI No	Model	Average Rainfall (mm)	Cost (INR / Ha)
1	Model 1: Rate Structure of Planting Tree Species >1200 mm rainfall	>1200 mm	295104
2	Model 2: Rate Structure of Planting Tree Species 1200-800 mm rainfall	1200 - 800 mm	214690
3	Model 3: Rate Structure of Planting Tree Species up to 800 mm rainfall with tree spacing of 3.0 m X 3.0 m, with number of seedlings of 1111 per ha	799 - 650 mm	251257
4	Model 4: Rate Structure of Planting Tree Species up to 650 mm rainfall with tree spacing of 4.0 m X 4.0 m, with number of seedlings 625 per ha	649 - 500 mm	139457
5	Model 5: Rate Structure of Planting Tree Species less than 500 mm rainfall, with intensive irrigation	< 500 mm	538043

* Cost norm for restoration of Impaired/ Open Forests has been taken from NAEB, MoEF&CC, which is INR 32,500/- per ha on an average.

** Cost norm for Plantation along NH & SH for making green corridor has been taken from NHAI, GoI, which is INR 2,80,000/- per ha on an average.



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