International Journal of Ecology and Environmental Sciences
www.ecologyjournal.in
Online ISSN: 2664-7133; Print ISSN: 2664-7125; Impact Factor: RJIF 5.28
Received: 10-10-2020; Accepted: 25-10-2020; Published: 12-11-2020
Volume 2; Issue 4; 2020; Page No. 380-385

Challenges and strategy for achieving nationally determined contribution commitment of India

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Abstract
India has submitted its Nationally Determined Contributions targets to United Nations Framework for Climate Change to create additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030. This paper highlights the existing carbon stock and short fall to achieve targets. It has been observed that the overall forest and tree cover is increasing continuously but the area under the different forest cover class is shifting towards the open forest. Carbon stock has also been increased from 2011-2019. The Forest Survey of India has projected that there is a shortfall of 0.25 billion tonnes and 0.75 billion tonnes of CO_2eq against the targets of 2.5-3.0 billion tonnes respectively from the baseline of 2015 under BAU scenario. We estimated that there is shortfall of 1.10 billion tonnes and 1.60 billion tonnes of CO_2eq against the NDC targets under the scenario-II. Similarly, short fall is 0.95 billion tonnes and 1.45 billion tonnes of CO_2eq against the NDC targets from the baseline of 2015 under scenario-III. These targets can be achieved by activities such as restoration of open forest and afforestation on different kinds of available lands like wasteland, agro-forestry, along national & state highways, railway siding, urban landscapes etc. A national level REDD+ project can be developed to provide the ample support to the Union Government and State Government.

Keywords: Afforestation, REDD+, UNFCCC, NDCs, Carbon Sink

1. Introduction
India has communicated its Nationally Determined Contribution (NDC) under United Nations Framework for Climate Change (UNFCCC) in the year 2015 including creation of additional carbon sink of 2.5–3.0 billion tonnes of CO_2equivalent through additional forest and tree cover by 2030 (UNFCCC, 2015). NDCs are the bedrock of India's climate actions post-2020 and these indicate India's "best-efforts" while balancing the developmental imperatives of the country to achieve the goals of sustainable development and poverty eradication. Hence, India has been taking several proactive climate actions to fulfill its obligations as per the principles of common but differentiated responsibilities. Globally, forest plays an important role for intervening the mitigation and adaptation measures towards climate change. The forest ecosystem is the largest contributor of human well-being by playing an integral role in improving and providing alternative local livelihood options and combating the adverse impact of climate change. Forests are also providing the various environmental &biodiversity benefits in the form of various ecosystem services and serve as a major sink of CO_2.
At present the total geographic area of India under forest and tree cover is 24.56%and has increased by 0.40% to its level as per the India's State of Forest Report (ISFR), 2015 (FSI, 2019). The total carbon stock has been estimated 7124.6 million tonnes in 2019 with an increase of 80.6 million tonnes to its level as reported (7044 million tonnes) in ISFR 2015 which offsets greenhouse gas emission (GHG) in the country (ISFR, 2019).
The GHG emissions have increased from 1,301.2 Mt CO_2eq in 2000 to 2,306.3 Mt CO_2eq in 2014 under LULUCF scenario (Land use, Land-use Change and Forestry), an increase of 1,005.10Mt CO_2eq during the 14-year period (MoEFCC, 2018). LULUCF sector remained a sink of GHG emissions over the period in India. The LULUCF sector was a net sink of 301,192.69 Gg CO_2eq in the year 2014.The Forest Survey of India has estimated that the carbon sink in India's forest cover is 7124.6 million tonnes in 2019 (ISFR, 2019). Hence, by taking a round off value of US$ 5 per tonne of CO_2 locked in India's forests (Kishwan *et al*, 2009) [11], this existing carbon stock of 7124.6 mt of CO_2 is worth US$ 35.623 billion, or INR2600.479 billion (@US$-73INR).
However, it is projected that nearly 77% and 68% of the forest grids are likely to be impacted by climate change leading to shifts in forest types in A2 and B2 scenario (Ravindranath *et al*., 2006) [16]. The percentage of forested grids expected to undergo vegetation change range from 3.5% in the North-Eastern states to 73% in Chhattisgarh (Chaturvedi *et al*., 2011) [1]. Hence, an analysis was carried out to examine the gaps, estimation of carbon stock, REDD+ synergy and financial requirement to achieve the National goals.

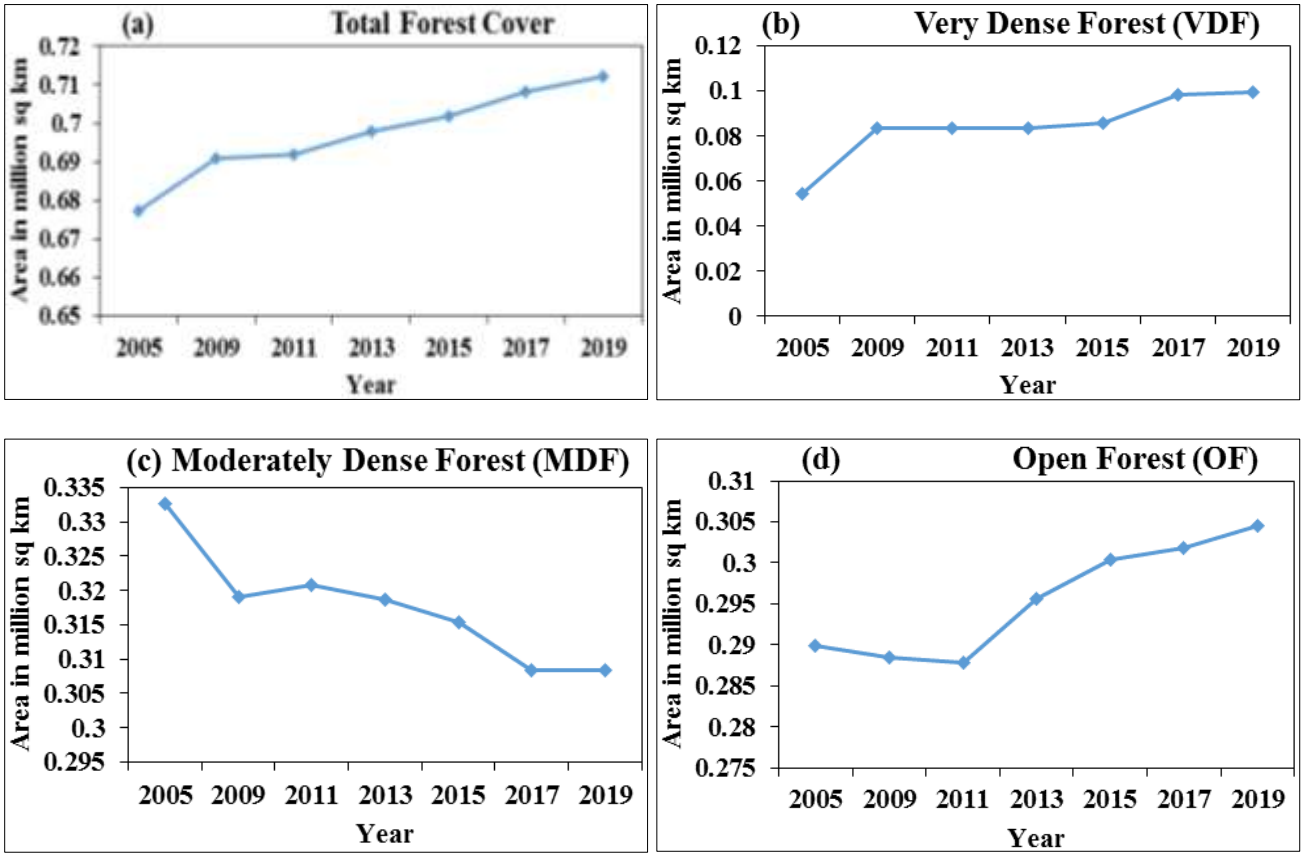
2. Materials and methods
A review of existing policy/rules/Acts/afforestation schemes of Government of India has been carried out to examine the current status of the country towards achieving the NDCs. An attempt has also been made to estimate the shortfalls of carbon sink to achieve the NDCs in BAU scenario along with the its financial implications. The change detection analysis was carried out based on the historical changes of forest cover and carbon stock from 1994 to 2019 to predict the required growth rate in carbon sequestration potential of India's existing forest and tree cover to achieve the targets of NDCs.

To reduce the financial constraint for achieving the NDCs, the concept of REDD+ synergy has been elaborated to get maximum benefits from the overall conservation efforts of India towards increasing forest and tree cover.

3. Results and Discussion

3.1 Change in India's forest cover

The India's forest cover is showing increasing trend since 2005 due to implementation of various afforestation activities and protection of existing forest under the schemes/programmes i.e. plantation activities, participation of local communities towards forest conservation, capacity building of relevant stake holders etc. (Fig 1a). The various afforestation activities including tree plantation were taken up over 8.49 m ha area from 2015-16 to 2019-20 under the various schemes of the Central Government as reported under the Twenty Point Program (MoSPI, 2019). However, the quality of moderately dense forest is showing degradation from 2009 to 2019 (Fig. 1c). It has been observed that the open forest is increasing trend (Fig 1d). So, various interventions are required within the moderately dense forest and open forest areas in order to reduce the decreasing trend in total area under moderately dense forest and increasing trend of open forest.



***Source*:** Forest Survey of India, 2019

Fig 1: Change in Forest Cover of India from 2005 to 2019

3.2 Forest carbon stock in India's Forest and tree cover

India has committed its NDCs under the Paris Agreement (2015). As per the BUR-II of India, the total emission was 2607.49 million tonnes CO_2eq in 2014 (ISFR, 2019). The energy sector has highest emission (73%) followed by agriculture (16%), industrial processes and product use (8%) and waste sector (3%). However, the Land use change and Forestry sector offset approximately 12% of India's total emissions (ISFR, 2019). It has been observed that Forests ecosystem has a significant role in mitigation and adaptation to climate change as the forests are considered as source and sink of carbon. Good quality of forest sequesters and store more carbon as compared to the other ecosystem. The diversity of forests makes it resilient to climate change and also an efficient sink of Carbon in India.

The increasing trend of carbon stock has been observed in Indian forest& tree cover which has increased from 7602 million tonnes in 2011 to 8118.6 million tonnes in 2019 (ISFR, 2019). This exponential growth in net carbon stock in forestry sector of India can play an important role in offsetting the carbon emissions at national level (Fig. 2) and can generate the incentives for the participating communities by means of voluntary carbon market.

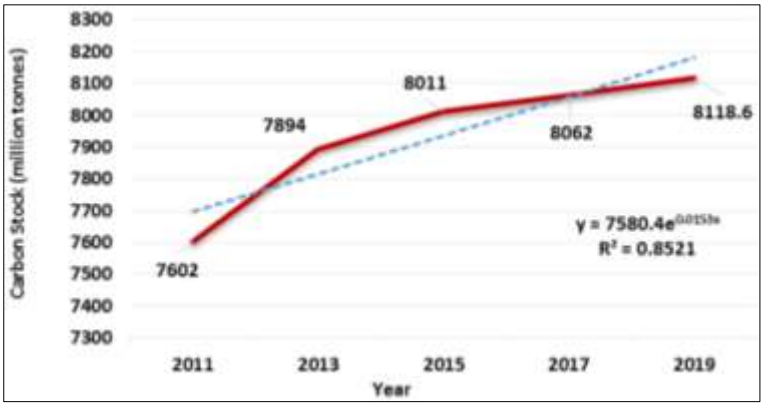


Fig 2: Exponential increase in forest & tree cover carbon stock (sq.km) since 2011

There is the continuous increase in the overall carbon stock in all The different carbon pools of forest ecosystem in India (Table 1).

Table 1: Change in Carbon stock in India's Forest (Million Tonnes)

Year of ISFR	Carbon Stock in Above Ground Biomass	Carbon Stock in Below Ground Biomass	Carbon Stock in Deadwood	Carbon Stock in Litter	Carbon Stock in Soil	Total Carbon in Forest	Carbon in Tree Cover	Forest Carbon from Forest & Tree Cover
2011	2101	663	25	121	3753	6663	939	7602
2013	2192	694	27	130	3898	6941	953	7894
2015	2220	695	29	131	3969	7044	967	8011
2017	2238	699	30	136	3979	7082	980	8062
2019	2256.5	700.8	35.8	127.9	4003.6	7124.6	994	8118.6

***Source*:** Forest Survey of India, 2019

Based on the carbon stock, the carbon sequestration has been estimated (Fig. 3) by using following equation

$$12g\ C + 32\ g\ O_2 \longrightarrow 44CO_2$$

$$1g\ C \longrightarrow 44/12 = 3.67$$

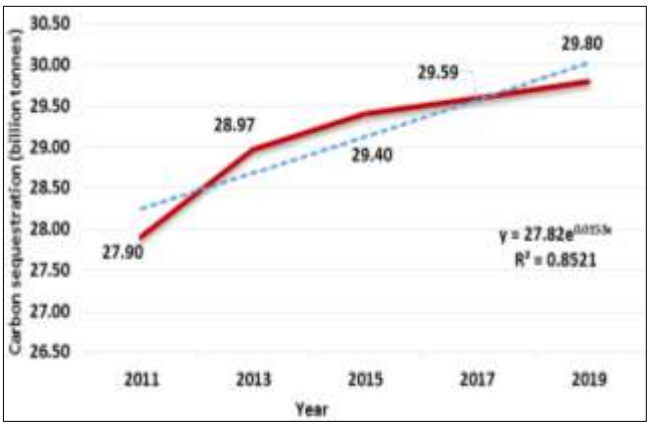


Fig 3: Total Carbon Sequestration by India's Forest& Tree cover

3.3 Gap of Carbon stock and sink to achieve NDCs

India has recognized the importance of adding forest cover and creation of additional carbon sink of 2.5 to 3 billion tonnes CO_2 equivalent by 2030 to achieve. We estimated required carbon sink based on the average annual carbon sink from 2013 to 2015 (Scenario-I), from 2015 to 17 (Scenario-II) and from 2017 to 2019 (Scenario-III) as per the ISFR, 2013, 2015, 2017 and 2019. The comparison was also carried out with Forest Survey of India results (Fig. 4).

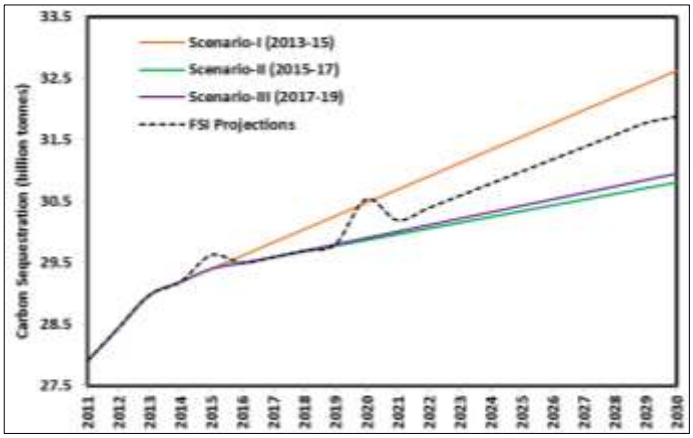


Fig 4: Projected total Carbon Sequestration from Forest & Tree cover

Forest Survey of India has projected that the carbon stock in forest & tree cover was 29.62 billion tonnes CO_2 eq in 2015 and will increase to 31.87 billion tonne CO_2eq in 2030, showing increase of 2.25 billion tonnes CO_2 in 15 years in BAU (Table 2). However, we estimated that the carbon stock was 29.40 billion tonnes CO_2 eq in 2015 and will increase to 32.62 billion tonne CO_2eq in 2030 at a rate of 0.21 billion tonne/year under the Scenario-I, showing increase of 3.22 billion tonnes CO_2 in 15 years in BAU. In scenario-II, carbon stock was 29.40 billion tonnes CO_2 eq in 2015 and will increase to 30.80 billion tonne CO_2eq in 2030 at a rate of 0.094 billion tonne/year which shows an increase of 1.4 billion tonnes CO_2 in 15 years in BAU. Similarly, carbon stock was 29.40 billion tonnes CO_2 eq in 2015 and will increase to 30.95 billion tonne CO_2eq in 2030 at a rate of 0.10 billion tonne/year under the scenario-III which shows an increase of 1.55 billion tonnes CO_2 in 15 years in BAU.

Table 2: Required carbon stock to achieve the target of NDCs under various scenarios

Estimation	Year	Carbon Sink Projection	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
FSI	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				
Scenario-I	2015	29.40	31.90	32.40	-0.72	-0.22
	2020	30.47	32.97	33.47	0.35	0.85
	2030	32.62				
Scenario-II	2015	29.40	31.90	32.40	1.10	1.60
	2020	29.87	32.37	32.87	1.57	2.07
	2030	30.80				
Scenario-III	2015	29.40	31.90	32.40	0.95	1.45
	2020	29.90	32.40	32.90	1.45	1.95
	2030	30.95				

The Forest Survey of India has projected that there is a shortfall of 0.25 billion tonnes and 0.75 billion tonnes of CO_2eq against the targets of 2.5-3.0 billion tonnes respectively from the baseline of 2015 under BAU scenario (ISFR, 2019). However, we estimated surplus of -0.72 billion tonnes and -0.22 billion tonnes of CO_2eq against the NDC targets 2.5-3.0 billion tonnes respectively under the Scenario-I. In scenario-II, shortfall is 1.10 billion tonnes and 1.60 billion tonnes of CO_2eq against the NDC targets 2.5-3.0 billion tonnes respectively. Similarly, shortfall is 0.95 billion tonnes and 1.45 billion tonnes of CO_2eq against the NDC targets 2.5-3.0 billion tonnes respectively from the baseline of 2015 under scenario-III.

These targets can be achieved by activities such as restoration of open forest and afforestation on different kinds of available lands like wasteland, agro-forestry, along national & state highways, railway siding, urban landscapes etc.

3.4 Afforestation schemes and required interventions required

Afforestation activities have potential to increase the overall growth rate of India's existing forests which not only supports in achieving the NDCs target but also helps in the enhancement of carbon stocks. Ministry of Environment, Forest and Climate Change (MoEF&CC) is implementing several schemes and programmes in the country with a view to promote sustainable management of the forest resources and ecological balance. At present, plantation activities are taken up under the various schemes of Central and State Governments (Fig. 5). The various afforestation activities were taken up over 8.49 m ha area from 2015-16 to 2019-20 under the various schemes of the Central Government as reported under the Twenty Point Program (MoSPI, 2019).

Fig 5: Central and State Government plantation schems to achieve NDCs Targets

For achieving the targets of NDCs, the Government of India requires to do some additional efforts primarily in the forestry sector which definitely will have some financial implications. Accordingly, a projection has been carried out to estimate required interventions in terms of plantation and cost. Hence, by developing a full fledge National REDD+ project at country level will help to gain the carbon benefits and can regulate the fund flow mechanism in the participating state. This will help to encourage the local communities and states to take more participation in afforestation activities and to improve the survival rate to gain the maximum benefits for their plantation.

3.5 Afforestation and REDD+ nexus

Article 3.3 of the Kyoto Protocol states that net changes in GHG emissions by sources and removals by sinks through direct human-induced LULUCF activities, limited to afforestation, reforestation and deforestation that occurred since 1990, can be used to meet Parties' emission reduction commitments. Afforestation has been one of the category included in Clean Development Mechanism of Kyoto Protocol signed in 1997 and a mechanism aimed at Reducing emissions from deforestation (RED), which was established during 11th conference of the Parties of Montreal in 2005 and later expanded and renamed REDD+ to include forest degradation and the enhancement of forest carbon stocks. Afforestation can be viewed as an activity of REDD+ because it increases carbon sequestration. In addition, it also contributes in stabilization and improvement of carbon stocks in the forests. This approach could involve restoring carbon stocks in degraded forests, or creating forests in non-forest areas. India has numbers of afforestation programmes to facilitate the implementation of REDD+, and to channelize it towards achieving the NDC target.

In the present scenarios, India has a great potential for implementing a REDD+ project at national level. To implement REDD+ as state level, government has already formulated State REDD+ Action plans (SRAPs) as mandated in NRS (MoEFCC, 2018). In SRAPs, there is clear indication for afforestation in the areas having deforestation and forest degradation (ICFRE, 2018). This sort of plans will help the 300 million forest dependent communities in the country for accruing the REDD+ benefit and providing mitigation and adaption measures towards achieving the ambitious NDCs targets of the country under Paris Agreement. Hence, we can say that national REDD+ implementation in India can provide benefit for the Union Government to achieve the committed targets of NDCs and on the other hand will influence the livelihood of the local communities. The major objectives and interventions that can take part in the National REDD+ Project are as follow:

1. Rehabilitation of degraded natural forests
2. Enhancement of quality of forest i.e. increase the forest cover by each density class to check the extent of degradation.
3. Afforestation & Reforestation
4. Plantation of trees outside forests i.e. Agro-forestry/Social Forestry
5. Capacity building towards conversion of Wasteland by means of plantation
6. Development of landscape wise measurement protocols and continuous monitoring and report
7. Development of National online system for REDD+ reporting for the participating states.

Conclusion

India has communicated its NDC in the year 2015 including creation of additional carbon sink of 2.5–3.0 billion tonnes of CO_2equivalent through additional forest and tree cover by 2030. The quality of moderately dense forest is showing degradation and open forest is showing increasing trend from 2009 to 2019. The increasing trend of carbon stock has also been observed in Indian forest& tree cover. Forest Survey of India has projected that the carbon stock in forest & tree cover was 29.62 billion tonnes CO_2 eq in 2015 and will increase to 31.87 billion tonne CO_2eq in 2030, showing increase of 2.25 billion tonnes CO_2 in 15 years in BAU. However, the carbon stock was estimated 29.40 billion tonnes CO_2 eq in 2015 in this paper and will increase to 32.62 billion tonne CO_2eq in 2030 at a rate of 0.21 billion tonne/year under the Scenario-I, showing increase of 3.22 billion tonnes CO_2. In scenario-II, carbon stock was estimated 29.40 billion tonnes CO_2eq in 2015 and will increase to 30.80 billion tonne CO_2eq in 2030 at a rate of 0.094 billion tonne/year which shows an increase of 1.4 billion tonnes CO_2. Similarly, carbon stock was estimated 29.40 billion tonnes CO_2 eq in 2015 and will increase to 30.95 billion tonne CO_2eq in 2030 at a rate of 0.10 billion tonne/year under the scenario-III which shows an increase of 1.55 billion tonnes CO_2 in 15 years in BAU.

There is a shortfall of 0.25 billion tonnes and 0.75 billion tonnes of CO_2eq against the targets of 2.5-3.0 billion tonnes respectively from the baseline of 2015 under BAU scenario as estimated by Forest Survey of India. In scenario-II, shortfall is 1.10 billion tonnes and 1.60 billion tonnes of CO_2eq against the NDC targets 2.5-3.0 billion tonnes respectively. Similarly, shortfall is 0.95 billion tonnes and 1.45 billion tonnes of CO_2eq against the NDC targets 2.5-3.0 billion tonnes respectively from the baseline of 2015 under scenario-III. These targets can be achieved by activities such as restoration of open forest and afforestation on different kinds of available lands like wasteland, agro-forestry, along national & state highways, railway siding, urban landscapes etc. A national level REDD+ project can be developed to provide the ample support to the Union Government and State Government.

Acknowledgments

The authors express gratitude to the Ministry of Environment, Forest and Climate Change and Forest Survey of India for providing data under the Indian State Forest Report. This support is thankfully acknowledged.

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