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EMISSIONS REDUCTION DUE TO AVOIDANCE OF FOREST DEGRADATION: A PILOT STUDY

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ABSTRACT

Deforestation and forest degradation contribute significantly to the warming of global climate systems. Forests on the other hand have the potential to remove the accumulated carbon dioxide from the atmosphere and sequester it into vegetation, soil and carbon continues to be locked for a long time in durable wood products. In view of the importance of the role of forests in mitigation of climate change, a 'Pilot study on REDD-plus' has been carried out on 9907 ha of Timli Forest Range of Kalsi Soil Conservation Division, Uttarakhand with the objectives to estimate the potential of emissions reduction due to avoidance of forest degradation. The Landsat satellite data of study area has been downloaded from USGS website and classified for the three time lines *viz*., 1998, 2008 and 2014 and for four different forest density classes *viz.*, very dense forest, moderately dense forest, open forest and non forest by using ERDAS imagine software. Stratified random sampling technique has been applied for 2014 classified image and data was collected for three carbon pools, *i.e*., above ground biomass, below ground biomass and dead organic matter. Soil Adjusted Vegetation Index (SAVI) image has been generated for the three time lines for estimation of biomass of 1998 and 2008 and for biomass change detection. The study estimated that the total carbon stock for the year 2014 was 6,196,275.74 tonnes while for earlier years of 2008 and 1998 it was estimated to be 6,591,710.06 and 7,199,583.92 tonnes, respectively indicating significant amount of forest degradation.

Key words: REDD-plus, Forest degradation, Carbon stock, Soil adjusted vegetation index.

Introduction

At global level, forest sector is one of the important sources of CO_2 emissions which accounts for 1.6 ± 0.8 GtC annually. This constitutes around 20% of the global CO_2 emissions (Ravindranath and Murthy, 2003). Deforestation, forest degradation, fragmentation and diversion of forest land for non forest purposes are the main sources of CO_2 emissions and also the key issues in developing countries. Recently, tropical forests have gained attention under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) due to their potential role in climate change mitigation. Land Use, Land Use Change and Forestry (LULUCF) is the second-largest source of anthropogenic greenhouse gas (GHG) emissions, dominated by tropical deforestation (Canadell *et al*., 2007; Le Quéré *et al*., 2009).

India is among the first Tropical countries in the world which started managing its forests scientifically and sustainably. India's current forest and tree cover is estimated to be 79.42 million ha, constituting 24.16 % of the geographical area of the country (ISFR, 2015). The situation is so challenging that more than one-third of forests are devoid of humus and half of the forests are characterized by shallow to medium soil depth (ISFR, 2013). All these factors indicate high levels of degradation in our forests and REDD-plus mechanism can significantly contribute towards addressing the causes of this degradation and reducing the large amounts of GHG emissions.

The country is presently gearing up to take up REDD-plus and a number of pilot projects are being conducted by several institutions such as ICFRE, TERI etc. With this background a pilot study was undertaken by the REDD-plus Cell of Indira Gandhi National Forest Academy, Dehradun with the twin objectives to estimate the potential of emissions reduction due to avoidance of forest degradation and to study the drivers of forest degradation and ways to address them for emission reductions.

Material and Methods

Study site

The present study was conducted in Timli Forest Range (Fig. 1). It is located in the eastern part of Doon valley ($30^0 19'$ to $30^0 32'$ N and $77^0 34'$ to $78^0 0'$ E) having an area of 9907 ha falling in Kalsi Soil Conservation Forest

Soil adjusted vegetation index (SAVI) image revealed a 16% decrease in total carbon stock from the year 1998 to 2014 as a result of forest degradation.

Fig. 1: Timli Forest Range of Kalsi Soil Conservation Forest Division.

Division of Shiwalik Circle, Dehradun, Uttarakhand. Most of the forest area is bound by the Yamuna river in northwest and Shiwalik ridge in south.

The vegetation of the study area mainly consist of tropical moist deciduous forests dominated by *Shorea robusta* and its associates such as *Mallotus philippinensis, Terminalia tomentosa, Ehretia laevis, Lagerstroemia parviflora* and plantations of *Tectona grandis*, *Eucalyptus*, *Bamboos* etc. As per Champion and Seth (1968), Moist Shiwalik Sal forests (3C/C2a), Dry Shiwalik Sal Forests (5B/C1a), Northern Dry Mixed Deciduous Forests (5B/C2) and Low Alluvial Savannah Woodland (3/1S1) are the major forest types of the study area. The temperature of this region ranges from 40^0C in summers to very cold (2^0C) in winters (Yadav and Nandy, 2015) and the average annual rainfall is 1550 mm.

Carbon stock estimation

Landsat Satellite data was used for the stratification and classification of the study area for the year 1998, 2008 and 2014 using ARC GIS 10.2 version and ERDAS IMAGINE for the year 2013 and 2014. "The information on circumference at breast height (CBH), height of the tree, canopy density and geographic co-ordinates using measuring tape, hypsometer, densiometer and Geographic Positioning System (GPS; Trimble June/SC)". Volume equations of the species were used for volume estimation.

A hybrid approach combining automated digital classification techniques with visual interpretation was used in this study. Forest cover mapping was carried out on scale of 1:50,000, taking minimum mapping unit (MMU) as 1 ha, into four density classes, *i.e.*, very dense-more than 70% canopy density; moderately dense-between 40% to 70%; open-between 10% to 40% and non forest - less than 10% canopy density using Landsat TM (resolution 30 m) for Year 1998 and 2008 and Landsat 8 (resolution 30 m) for Year 2014.

As per the 'Good Practice Guidance' of Inter Governmental Panel on Climate Change (IPCC), the calculation of GHG inventory requires information on extent of area of an emission category termed as 'Activity data' and emission of GHG per unit of area termed as 'Emission factor' (IPCC, 2003). To estimate emission, land-use and land-cover (LULC) change component (activity data) and a Carbon stock change component (emission factor) were required.

Estimation of Emission factor

For estimating Emission Factors, Forest Survey of India's (FSI) method of Stock-Difference approach was applied. The woody volume of trees for each sample plot was calculated using volume equations (FSI, 1996). Data of specific gravity of the tree species was used following Rajput *et al.* (1996). The current status of carbon stocks in four forest density classes of the study area was used for estimating year wise carbon emissions. Carbon-stock estimates of 2014 were considered as baseline under baseline scenario for estimating emissions for each year. Timli Forest Range consists of 102 compartments with Sal as dominant tree species. Further, on the basis of four forest density classes, the stratification was carried out into four stratums. Three carbon pools *viz.*, (i) Above ground woody biomass, (ii) Below ground biomass and (iii) Dead organic matter, were analyzed for their carbon stock estimation (IPCC, 2006). Stratified random sampling was applied (ISFR, 2013). A total of 100 random sample points (25 sample points in each forest density class) were generated in the 2014 classified image in four forest density stratum *i.e.*, Dense Forest, Moderately Dense Forest, Open Forest and Non Forest with the help of ERDAS Imagine software. Geographic location of the plot location was noted down with the help of geo-referenced stratified satellite image and plot was laid down on the respective point on the ground of plot size of 0.1 ha (ISFR, 2015). By using ranger compass centre of the plot was identified and after fixing centre of the plot, corner of the plot has been fixed at distance of 22.36 m. in four directions (NE at 45°, SE at 135°, SW at 225° and NW at 315°) from the plot centre. All trees with in the plot having diameter 10 cm and above were enumerated species wise. Trees, the stem of which touch the North and West border line of the plot (called border line trees) were enumerated, however, stem of the trees which touches east and south border lines of the plot were treated as "out trees" and were not enumerated. The CBH and tree height were recorded for all the tree species for woody volume calculation within the plot.

Estimation of extent of forest degradation and deforestation

The area of dense forest in 1998 and 2008 converted into moderately dense, open forests and non forest in 2014 was taken as the total amount of forest degradation from 1998 to 2014 and the change detection analysis technique was undertaken for this purpose. Based on area of forest degradation in initial and final time and total time taken, rate of forest degradation was estimated annually.

Non destructive biomass estimation of trees

The CBH as recorded for trees with in the plot was converted into DBH and the volume equations were used to calculate the volume (m^3) of the specific tree species recorded in the sample plot (FSI, 1996). The calculated volume of the particular trees was multiplied with their respective specific gravity (wood density) of the species to obtain the bole biomass.

Above ground biomass (AGB) was obtained by multiplying bole biomass with the Biomass Expansion Factor (BEF) (IPCC, 2006). The BEF for Sal and its associates was taken as 1.74 (Singh, 2014). AGB was used to calculate the below ground biomass (BGB) by multiplying the value of AGB with the constant factor 0.26, which is an IPCC default value (IPCC, 2006). Dead organic matter (DOM) was calculated by multiplying the sum of AGB and BGB with the constant factor 0.11 (IPCC, 2006). Total biomass was calculated by summing all the above calculated biomass, *i.e.,* AGB, BGB and DOM. The carbon storage was calculated by multiplying total biomass with a constant factor 0.47 (IPCC, 2006).

Biomass estimation for the Year 1998 and 2008 using remote sensing and GIS technique

Scientific research has demonstrated that the different vegetation indices can be used for forest classification and biomass estimation (Anderson and Hanson, 1992 and Anderson *et al*., 1993). SAVI (Soil Adjusted Vegetation Index) performs best when vegetation cover was dense since this index has large dynamic ranges and small susceptibility to atmospheric perturbations (McDonald *et al*., 1998). SAVI image was generated for the three time frames of Timli forest range for the estimation of biomass of earlier years and for biomass change detection. Logarithmic regression equation was developed by correlating biomass value estimated from the field survey for the year 2014 and SAVI values of the same coordinates in 2014 satellite image for each plot. Using this regression equation, biomass of entire project site was calculated for 2014 as well as for the years 2008 and 1998 using this logarithmic equation.

Results and Discussion

Area classification for selected time frames

The results in the form of forest density maps for three time frames, *i.e.*, 1998, 2008 and 2014 of the study site (Timli Range) are shown in fig 2.

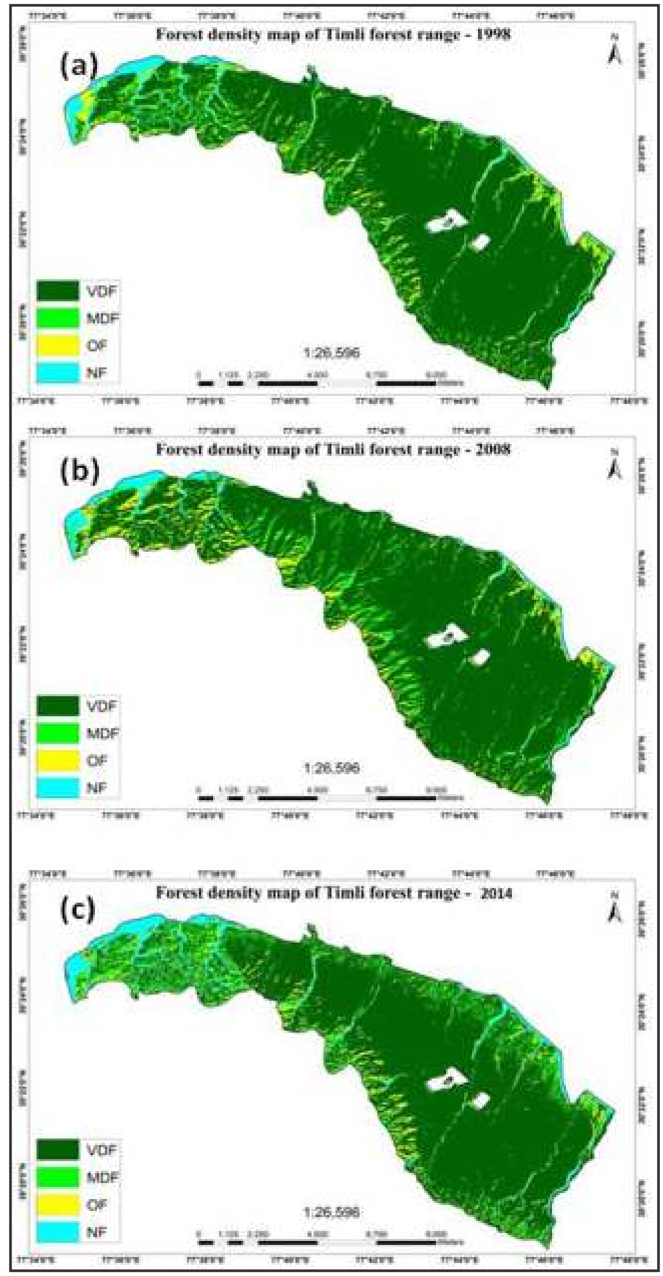

Fig. 2: (a) Forest density map for year 1998; (b) Forest density map for year 2008; (c) Forest density map for year 2014.

The result of the area statistics generated from the classified images of study area for the four density classes and comparison of area statistics for three time frames are given in table 1.

Table 1: Area statistics of forest density classes of three time frames.

Forest density class	Area (hectare)		
	2014	2008	1998
Very dense forest	7696.87	8262.00	8248.86
Moderately dense forest	901.68	522.18	510.30
Open forest	601.56	727.74	675.00
Non forest	778.14	511.17	591.93

As evident from the table 1, the area under very dense forest is maximum in all the three time periods. The table also shows that in 1998 VDF cover was 8248.86 ha which marginally increased to 8262 ha and then decreased to 7696.87 ha by 2014. MDF cover in 1998 was estimated to be 510.30 ha which increased marginally to 522.18 ha in 2008 and was significantly higher at 901.68 by 2014. It is also evident that OF cover decreased by 73.44 ha from 1998 to 2014. The NF cover showed a decrease from 1998 to 2008 by 80.76 ha, which than increased by 266.97 ha to 778.14 by 2014.

Estimation of total biomass and Carbon

Table 2 shows the estimated above ground biomass (ABG) of Timli Range based on logarithmic model developed between satellite data derived soil adjusted vegetation index (SAVI) parameter of the year 2014 and field calculated biomass for the same year. The BGB, DOM calculated on the basis of IPCC default values.

Table 3 shows the estimated AGB of Timli forest range for the year 2008 based on logarithmic model developed between SAVI image of the year 2008 and field calculated biomass of 2014. The BGB, DOM as calculated using IPCC default values.

Likewise, the table 4 shows the AGB of Timli forest range for the year 1998, which is calculated based on logarithmic model developed between SAVI image of the year 1998 and field calculated biomass of 2014. The BGB, DOM as calculated using IPCC default values.

Total Carbon estimation

The total carbon stock of study area of all the three time frames for four different forest density classes (Table 2,3,4). The study revealed decrease in total carbon stock from the year 1998 to 2014. The total carbon stock has decreased by 607,873.86 tonnes from the year 1998 to 2008 while from 2008 to 2014, the carbon stock has been depleted by 395,434.32 tonnes. Overall, there has been a decrease of total carbon stock by 1,003,308.18 tonnes from the year 1998 to 2014, which is equivalent to 3682141 tonnes of CO_2 indicating significant amount of forest degradation. This is equivalent to loss of approximately 16% carbon during the period of 16 years.

Table 2: Total carbon stock using regression model for the year 2014.

Forest density	Area (ha)	Biomass (tonnes/ha)	AGB (tonnes)	BGB (tonnes)	DOM (tonnes)	Total carbon (tonnes)
VDF	7696.87	484.8	3,731,307.54	970,139.96	517,159.22	5,218,606.72
MDF	901.68	430.0	387,739.86	100,812.36	53,740.74	542,292.96
OF	601.56	375.8	226,091.75	58,783.86	31,336.32	316,211.93
NF	778.14	109.5	85,202.44	22,152.63	11,809.06	119,164.13
Total	-	-	4,430,341.592	1,151,888.814	6,140,45.345	6,196,275.74

Table 3: Total carbon stock using regression model for the year 2008.

Forest density	Area (ha)	Biomass (tonnes/ha)	AGB (tonnes)	BGB (tonnes)	DOM (tonnes)	Total carbon (tonnes)
VDF	8262.00	502.1	4,148,111.81	1,078,509.07	574,928.30	5,801,549.18
MDF	522.18	411.0	214,593.87	55,794.41	29,742.71	300,130.99
OF	727.74	387.8	28,2245.74	73,383.89	39,119.26	394,748.89
NF	511.17	132.5	68,125.98	17,712.76	9442.26	95281
Total	-	-	4,713,077.4	1,225,400.1	653,232.52	6,591,710.06

Table 4: Total carbon stock using regression model for the year 1998.

Forest density	Area (ha)	Biomass (tonnes/ha)	AGB (tonnes)	BGB (tonnes)	DOM (tonnes)	Total carbon (tonnes)
VDF	8248.86	558.3	4,605,298.78	1,197,377.68	638,294.41	6,440,970.87
MDF	510.30	395.9	202,040.29	52530.47	28,002.78	2,825,73.54
OF	675.00	396.4	267,540.55	69,560.54	37,081.12	3,741,82.21
NF	591.93	123.0	72,828.05	18,935.29	10,093.96	1,01,857.3
Total			5,147,707.67	1,338,403.99	713,472.28	7,199,583.92

Conclusion

The study analyzed forest degradation for the study area at the interval of 16 years and it is found that there is decrease in area of very dense forest from year 1998 to 2014 (551.99 ha) and increase in area of moderately dense forest (391.38 ha), decrease in area of open forest (73.44 ha) and increase in area of non forest by 186.21 ha from year 1998 to 2014, which shows degradation is prominent due to anthropogenic activities and other means. Carbon emission analysis also performed and it is found that nearly 16% carbon has been lost in 16 years. The study suggests using the preventive measures and effective rules by forest department to tackle the problem of forest degradation at the study site.

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वन निम्नीकरण के बचाव के कारण उत्सर्जन न्यूनीकरण : एक पायलट अध्ययन

मोहित गेरा, जे.एस. जिजू, साधना यादव एवं शशि कुमार

सारांश

निर्वनीकरण और वन निम्नीकरण विश्व जलवायु प्रणालियों के तापन में महत्वपूर्ण रूप से सहयोग करते हैं। जबकि वनों मे वातावरण से संचित कार्बन डाइऑक्साइड को हटाने और इसे वनस्पति मृदा में पृथक करने की क्षमता है तथा कार्बन टिकाऊ काष्ठ उत्पादों में दीर्घ काल के लिए लगातार बन्द रहती है। जलवायु परिवर्तन के न्यूनीकरण में वनों की भूमिका के महत्व के दृष्टिकोण से वन निम्नीकरण के बचाव के कारण उत्सर्जन न्यूनीकरण की क्षमता का आकलन करने के उद्देश्य के साथ कालसी मृदा संरक्षण प्रभाग, उत्तराखण्ड की तिमली वन रेंज के 9907 हैक्टेयर क्षेत्र में 'आर ई डी डी–प्लस पर एक पायलट अध्ययन' किया गया। अध्ययन क्षेत्र के लैण्डसैट सैटेलाइट आँकड़ों को यू एस जी एस वेबसाइट से डाउनलोड किया गया और इरडास इमेजिन सॉफ्टवेयर का उपयोग करके तीन समय लाइनों, यथा– 1998, 2008 और 2014 के लिए और चार विभिन्न वन घनत्व श्रेणियों, यथा– बहुत सघन वन, साधारण सघन वन, खुले वन और गैर वन, के लिए वर्गीकृत किया गया। 2014 वर्गीकृत इमेजों के लिए स्तरित बेतरतीब प्रतिचयन तकनीक प्रयुक्त की गई और कार्बन पूलों, यथा– भूम्यूपरिक जैवमात्रा, भूमि के नीचे जैवमात्रा और मृत आर्गेनिक पदार्थ, के लिए आँकड़े एकत्र किए गए। जैवमात्रा परिवर्तन खोज हेतु तथा 1998 और 2008 की जैवमात्रा के आकलन के लिए तीन समय लाइनों हेतु मृदा समायोजित वनस्पति तालिका (एस ए वी आई) इमेज सृजित की गई। अध्ययन में आकलित किया गया कि वर्ष 2014 के लिए कुल कार्बन स्टॉक 6,196,275.74 टन था जबकि 2008 और 1998 के पूर्व वर्ष के लिए इसे क्रमशः 6,591,710.06 और 7,199,583.92 टन आकलित किया गया, जो वन निम्नीकरण की महत्वपूर्ण मात्रा को दर्शाता है।

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