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THE DYNAMICS OF FOREST COVER OF INDIA BASED ON ASSESSMENTS DONE BY FOREST SURVEY OF INDIA FROM 1987 TO 2015

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ABSTRACT

The paper presented an analytical overview of the forest cover changes in the country since 1987 based on published reports of Forest Survey of India for clear appreciation of status of forest cover changes in the country. The first national perspective of Forest cover based on remote sensing data pertaining to 1981-83 was published in 1987 which estimated FC at 19.52% of the GA. That served as first bench mark at the National /State level. The methodology, quality of data, scale of mapping and interpretation techniques, since than, has improved gradually, some changes particularly in 1989, 2001 and 2009 have been quite significant. Technological advancement rendered the forest cover data of previous assessments incompatible. Thus, comparing the original time series of FC overlooking the change in technology/ methodology might lead to inconsistent inferences.

The complete data series beginning from 1987 was revised in 2009 by applying corrections on account of change in scale, capture of small patches and impact of polygon centric approach to overcome to a considerable extent the constraint of incompatibility. The technology and interpretation technique from 2009 to 2015 assessments remained largely unchanged. The analysis of revised data brought out that the FC increased in 2nd cycle then decreased gradually (except minor increase in 1993) till 1997. From 6th cycle, FC showed improvement (barring slight decline in 2011) till 14th cycle. The overall increase in FC in the country (between 1st to 14th cycle) was estimated as 60854 Km^2 i.e. 1.85% of GA of the country. The FC grew annually by 194540 ha from 1984 to 1993, 264940 ha from 1994 to 2003 and 149060 ha from 2004 to 2013. Overall average annual growth of forest cover was estimated as 202847 ha for the entire period.

The distribution of forest cover declined drastically with increase in altitude. Areas above 2000 m altitude contained only 8.39% of the total forest cover. More than half of the forest cover (52.47%) was contributed by areas below 500 m altitude. Analysis of digitized forest boundaries of 12 States/UT brought out that 73.15% (86.95% VDF, 78% MDF and 64.56 % OF) of forest cover was contributed by recorded forest areas and 26.85% (13.05% VDF, 22% MDF and 35.44% OF) by outside areas.

Key words: Forest cover, Growing stock, Assessment, Recorded forest area, Altitude.

Introduction

The assessment forest resources in India till 1965 was limited to enumerations/sampling based estimate of growing stock of valuable timber species aimed at estimating annual yields of Teak, Sal, Deodar and Pines to meet the demand of industries, railways and Ship building. In 1965, Pre-investment survey of forest resources commenced in certain locations with assistance from FAO/UNDP. The objective was to assess the availability of raw material for setting up of Industrial units.

National commission on Agriculture (1976) recommended setting up of a dedicated institution for periodic assessment of forest resources in the country which resulted in establishment of Forest Survey of India in 1981. The organisation was mandated to carryout forest resources assessment for the entire country periodically. Since then, various experts in the field of forestry, research, industry, statistics and management discussed and finalised various procedural aspects of forest survey. As a result it was possible to generate estimates at a Natural level.

The first assessment was published in 1987 and thereafter at the interval of every two year (except in 2007). From 1987 to 1999 the mangrove though included in forest cover, were not classified density wise. From 2001 mangrove were also classified into canopy density classes. So far, 14 independent assessment reports have been published. A critical review of all assessments at one place to discern correct perspective of changes in FC at the National/State level was long overdue.

An attempt in the paper have been made to critically examine the FC along with changes in technology introduced in making assessments since 1987.

Methodology

The satellite data for the whole country for each cycle of assessment was procured from National Remote Sensing Centre and subjected to geometric correction.

The distribution of forest cover declined drastically with increase in altitude. The paper highlighted the substantial contribution of area outside recorded forests.

Tree vegetative area masked out. Non shadow image created by removing shadows. The image thus obtained was interpreted to categorise into canopy density classes of the forest cover. Shadows were interpreted using ratio indices and contextual approach. The changes detected in forest cover were verified on the ground to the extent possible. The information was shared with respective State Forest Department for validation before applying post classification corrections. The boundaries overlaid on the classified FC to generate maps and area statistics. As the technology gradually improved over these years so was the method of interpretation.

Overview of Forest cover from 1987 to 2015

The status of forest cover assessed from 1987-2015 is presented in the table 1.

The first national level assessment of FC was made by Forest Survey of India using Landsat imagery on 1:1 million scale for the period 1981-83 and estimated the FC at 19.7% of the GA of the country. Around the same time National Remote Sensing Agency also made an independent assessment and estimated the FC at 14.10%. These two sets of assessments were reconciled at 19.52% i.e. 642041 km^2 which comprised of 361412 km^2 dense forest, 276583 km^2 open forest and 4046 km^2 mangroves. This provided the much needed first bench mark at the National /State level though, 11524 km^2 area remained un-interpreted due to clouds and shadows (FSI, 1987) para 2.13, page -16, table 2.3, page -38, State of Forest Report).

The IInd cycle (1989) applied 1:250,000 scale and used imageries of thematic mapper (TM) and assessed decline in FC to the tune of 0.19 million ha during the preceding 4 years, the annual decline being 47,500 ha .The dense forest increased by 17058 km^2 which was more than off-set by decrease of 19174 km^2 in Open Forest (Forest Survey of India (1989) page -9, State of Forest Report).The Forest Cover (1704 km^2 of Tea garden included) declined by 0.52% (from 19.52 % to 19.47 %) in 1989.

The IIIrd cycle (1991), recorded increase of 560 km^2 (28000 ha/year) over the previous cycle and the total FC increased to 19.49% despite the fact that 19093 km^2 could not be interpreted due to clouds/ shadows.

The IVth (1993) cycle registered further increase of 925 km^2 (Forest Survey of India (1993) para 3.1, page 9, State of Forest Report and , estimated the FC at 19.47% of the GA of the country.

The forest cover declined in Vth assessment (1995) by 507 km^2. The decrease was primarily due to shifting cultivation in North Eastern States whereas other part of the country recorded increase (Forest Survey of India (1995) page 3, State of Forest Report). The over all FC was pegged at 19.45% of the geographical area.

The VIth assessment (1997) estimated net loss of 6203 km^2 (Forest Survey of India (1997) table 2.2a, page -6 State of Forest Report). The FC declined to 19.27% of the GA.

The VIIth cycle (1999) assessed 3896 km^2 (dense forest increased by 10098 km^2, mangrove by 44 km^2 and the open forest reduced by 6246 km^2) overall increase in the FC (Forest Survey of India (1999) para 2.2, page -10, State of Forest Report).

The VIIIth assessment (2001) recorded unusual jump

Table 1: The status of forest cover assessed from 1987-2015.

Year of report	Forest cover (Km^2)					Change in forest cover (Km^2)	Forest cover as % of geographical area
	VDF	DF	OF	Mangrove	Total		
1987	Not classified as VDF	361412	276583	4046	642041	-	19.52
1989		378470	257409	4255	640134	-1907	19.47
1991		385610	250842	4242	640694	560	19.49
1993		385576	250275	4256	640107	-587	19.47
1995		385756	249311	4533	639600	-507	19.45
1997		367260	261310	4827	633397	-6203	19.27
1999		377358	255064	4871	637293	3896	19.39
2001		416809	258729	Mangroves classified under respective density classes	675538	38245	20.55
2003	51285	339279	287769		678333	2795	20.64
2005	54569	332647	289872		677088	-1245	20.60
2009	83510	319012	288377		690899	13811	21.02
2011	83471	320736	287820		692027	1128	21.05
2013	83502	318745	295651		697898	5871	21.23
2015	85904	315374	300395		701673	3775	21.34
change since 1987	39866		23812		59632		1.82

(Source: FSI (1987,1989,1991,1993,1995,1999, 2001,2003,2005, 2009, 2011, 2013 & 2015) India State of Forest Reports)

of 38245 km^2 i.e. 6% in the FC of the country. The dense cover increased by 9% increase and the open forest by 1.4 %. The sudden increase in the FC was, primarily, due to huge change of scale, resolution and minimum mapable limit (Forest Survey of India (2001) para 3.02, page -19, State of Forest Report) making smaller patches upto 1 ha (from 25 ha. earlier) discernible in the imageries. The overall FC of the country increased to 20.55% of the GA.

The similarity in spectral response pattern of lantana, sugarcane and cotton with those of tree canopy and limitations in remote sensing technology caused abrupt fluctuations in IXth cycle (2003) though the net gain was 2795 km^2 (Forest Survey of India (2003) page 9, State of Forest Report). The next cycle (2005) reported decrease of 1245 Km^2 (Forest Survey of India (2005) State of Forest Report) followed by 13811 Km^2 increase in 2009 assessment. As % of GA, the FC improved to 21.02% (Forest Survey of India (2009) India State of Forest Report) in 2009.

The latest three assessments (2011, 2013 and 2015) estimated increase in FC by 1128 Km^2, 5871 Km^2 and 3775 Km^2 and in % age terms the FC was estimated as 21.05%, 21.23% and 21.34% of the GA respectively (Forest Survey of India (2011, 2013 & 2015) India State of Forest Reports).

Not with standing fluctuations in successive assessments the overall gain in FC (dense+open) between 2015 compared and 1987 assessment was 59632 Km^2.

The unusual variations in various categories of FC as discussed above presented an ambiguous scenario which warranted further analysis of the mode of interpretation and technology used in making assessments.

Technological advancement introduced in Forest Cover Mapping

A number of technological advancement were incorporated in FC assessments technique over these years. In the 2nd assessment (1989) itself , the minimum mappable area improved from 400 ha to 25 ha, spatial resolution from 80 m to 30 m and the scale from 1:1 million to 1:2.50000 allowing interpretation of smaller areas up to 25 ha. As evident, the first two assessments were incompatible.

The minimum mappable area and the scale of mapping from 1991 to 1999 was same , however, 1995 and 1997 assessments used imageries of IRS-1B LISS- II with coarser resolution of 36.5m and interpretation was done through digital along with visual mode. In 1999, area of 11 states of the country was digitally interpreted using spatial resolution of 23.5 m with October-December, 1998 data period and rest of the States were visually interpreted using spatial resolution of 36.25 m with 1996-1997 data period (FSI (1999) page ix, State of Forest Report). Due to changes in methods and technology from 1989 to 1999, the successive assessments were also not compatible.

Another significant change took place in 2001 assessment. The minimum mappable area improved to 1 ha. and the scale of mapping from 1 : 2,50,000 to 1 : 50,000 allowing capture and interpretation of smaller areas up to 1 ha which were un-interpretable earlier. The mode of interpretation also switched over from visual to digital format. A new class viz. Very dense forest was introduced and the mangroves were also classified. The assessments prior to 2001 were thus, could not be compared with 2001. The methodology remained largely unchanged up to 2005.

In the next assessment i.e. 2009, vector based (polygon centric) approach was introduced which improved precision resulting in 1.9% (Forest Survey of India (2009) page 7, India State of Forest Report) more capture of FC at National level. The new approach allowed image to image correspondence which was not the case with previous assessments. The significant changes in quality of data, advanced techniques and experience gained over all these years improved precision tremendously, however, the issue of incompatibility remained.

Revised estimates of forest cover

Owing to constraints, as discussed in the foregoing narration, the time series data were, strictly, not comparable. The FC assessed in the IIIrd cycle (1991) was revised with the aid of clear images available later on to add the FC pertaining to the areas left un–interpreted earlier. Experience gained in forest cover mapping over these years made it possible to revise all previous assessments in 1997 (FSI, 1997) table 1.2, page 3, State of Forest report) to make these comparable. Some of the changes detected during 2001 and 2003 could not be verified immediately, therefore not included in the assessment. With extensive ground verification done later and also with aid of advanced technology and availability of better quality data, the estimates of 2001 and 2003 were corrected subsequently (FSI, 2005) table 1.2 and 1.3, page 3 and 4, State of Forest report). The major technological changes introduced in 2001 and 2009 influenced the quality of estimates significantly rendering the previous data incomparable. To overcome this constraint, to a extent possible, the time series data was smoothened and harmonised again in 2009 by

incorporating corrections for change in scale of mapping, inclusion of smaller patches and vector based approach. Some interpretational corrections in 2009 assessment were incorporated in 2011 after validation.

All revisions done so far, have been summarised in table 2 for eliciting correct trend of FC in the country.

The examination of revised data brought out that the FC increased in 2nd cycle then decreased gradually (except minor increase in 1993) till 1997. From 6th cycle, FC showed improvement (barring slight decline in 2011) till 14th cycle. The overall FC in the country improved significantly (60854 Km^2) between 14th (701673 Km^2) and 1st cycle (640819 Km^2).

Decadal change in Forest Cover

The decadal rate of increase of the FC in 1st decade of periodic assessment (1984-1993) was 0.59% which improved to 0.81% in 2nd decade and slightly declined to 0.45% of the GA of the country in the 3rd decade. The average decadal rate of increase (1984 to 2013), however, was 0.62% of the GA of the country. The FC grew annually by 194540 hectares from 1984 to 1993, 264940 hectares from 1994 to 2003 and 149060 hectares from 2004 to 2013. The average improvement in FC over a span of past 30 years (1984-2013 wrt. data period) was 202847 hectares per annum Table 3.

Recent trends in forest cover

Overall at National Level

The time series considered in the analysis presented in the preceding para, was based on harmonised data from 1987 to 2009 and original data afterwards. The process of harmonisation did have its own limitations. It could generate better approximation but impact of

Table 2: Revised forest cover for eliciting correct trend of FC in the country.

Assessment cycle	Year of report	Forest cover (Km^2)						
		Original Estimate	Revised in 1993	Revised in 1997	Revised in 2005	Revised in 2009	Revised in 2011	Final figure as on date
1	1987	642041	-	640819	-	640819	-	640819
2	1989	640134	-	638804	-	662803	-	662803
3	1991	640694	639182	639364	-	662308	-	662308
4	1993	640107	-	639386	-	662334	-	662334
5	1995	639600	-	638879	-	660273	-	660273
6	1997	633397	-	-	-	659550	-	659550
7	1999	637293	-	-	-	664737	-	664737
8	2001	675538	-	-	653898	668806	-	668806
9	2003	678333	-	-	677816	686767	-	686767
10	2005	677088	-	-	-	690171	-	690171
11	2009	690899	-	-	-	-	692394	692394
12	2011	692027		-	-	-	-	692027
13	2013	697898		-	-	-	-	697898
14	2015	701673		-	-	-	-	701673
Change in 2015 compared to 1987	59632							60854

(Source: FSI (1987,1989,1991,1993,1995,1999, 2001,2003,2005, 2009, 2011, 2013 and 2015) India State of Forest Reports)

Table 3: The decadal change is analysed in the following manner.

Decade	Data period	Assessment cycles	Decadal change Km^2	Decadal change as % of GA	Annual increase in hectares	Annual increase as % of total FC
1984-1993	1981-83 to 1991-93	1st to 5th	19454	0.59	194540	0.30
1994-2003	1994 to 2003	6th to 9th	26494	0.81	264940	0.40
2004-2013	2004 to 2013	10th to14th	14906	0.45	149060	0.22
Overall	1984 to 2013	1st to 14th	60854	0.62	202847	0.32

Table 4:

Category	Year of assessment				Over all change
	2009	2011	2013	2015	
Very Dense Forest	83428	83471	83502	85904	2476
Moderately Dense Forest	320238	320736	318745	315374	-4864
Open Forest	288728	287820	295651	300395	11667
Total Forest Cover	692394	692027	697898	701673	9279

(Source: FSI (2009,2011,2013 and 2015) India State of forest reports.

technological changes could not ruled out completely. The procedure and technology used in FC mapping remained unchanged from 2009 onwards, therefore Table 4 showcased the comparison of these assessments to discern more reliable current trend.

Table 4 revealed 9279 Km^2 increase in over all FC of the country since 2009 assessment. Precisely speaking, the above gain was the outcome of overall changed between 2006 to 2013 corresponding to the data period of the satellite imageries used in interpretation. The increase in FC from 2006 to 2013 was estimated at 132557 hectares per year which, however, was at variance with the decadal change as brought out in table-3 above. The VDF increased @ 35371 hectares, the OF @ 166671 hectares whereas, the MDF decreased @ 69486 hectares annually during 2006-2013. The decline of MDF might possibly be, partly due to its up gradation to VDF and partly due to degradation to OF category.

Category wise at States/UT Level

Very Dense Forest (VDF): The VDF remained unchanged in Gujarat, Haryana, Himachal Pradesh and Sikkim whereas Assam, Chhattisgarh, Jammu & Kashmir, Goa, Jharkhand and Uttarakhand recorded net decline and rest of the States/UT's registered net positive change. No State/UT recorded continuous increase in all last 3 assessment cycles. States showing continuous decline in all the last 3 cycles given in Table 5.

Table 5:

S. No.	States	Year of assessment			Net change from 2009 (Km^2)
		2011	2013	2015	
1	Arunachal Pradesh	-5	-40	-24	-69
2	Orissa	-13	-18	-19	-50
3	West Bengal	-3	-13	-23	-39
4	Maharashtra	-3	-16	-8	-27
5	Madhya Pradesh	-7	-8	-3	-18

Moderately Dense Forest (MDF): Net improvement in 2015 compared to 2009 was assessed in Bihar (128 Km^2), Chandigarh (3.87 Km^2), Daman & Diu (5.2 Km^2), Delhi (7.31 Km^2),Goa (2 Km^2), Jammu & Kashmir (55 Km^2), Lakshadweep (0.51 Km^2), Manipur (451 Km^2), Meghalaya (83 Km^2), Orissa (76 Km^2), Punjab (2 Km^2) and Tamil Nadu (126 Km^2), (Forest Survey of India (2009, 2011, 2013 and 2015) India State of forest reports). Other States/UT's recorded decrease, out of these, the MDF was on continuous decline in the States given in Table 6.

Open Forests (OF): States showing increase in all last 3 assessments in States depicted in Table 7.

Manipur (-763 Km^2), Nagaland (-318 Km^2), Meghalaya (-226 Km^2), Mizoram (-148 Km^2), Andhra Pradesh (-121 Km^2), Andaman and Nicobar Island (-115 Km^2), Madhya Pradesh (-115 Km^2), Tripura (-85 Km^2), Chhattisgarh (-16 Km^2) and Sikkim (-1 Km^2) registered net decline in 2015 compared to 2009 in OF category (Forest Survey of India (2009, 2011, 2013 and 2015) India State of forest reports).

Table 6:

States	Change in MDF cover (Km^2) wrt previous cycle			Net decline (Km^2)
	2011	2013	2015	
Andhra Pradesh	-135	-163	-274	-572
Mizoram	-63	-186	-42	-291
Assam	-154	-59	-77	-290
Arunachal Pradesh	-55	-105	-113	-273
Madhya Pradesh	-21	-65	-19	-105
Tripura	-16	-45	-32	-93
Maharashtra	-19	-45	-23	-87
Haryana	-6	-4	-1	-11

(Source: FSI (2009,2011,2013 and 2015) India State of forest reports.

Table 7:

States	Change in OF cover (Km^2) wrt previous cycle			Total change (Km^2)
	2011	2013	2015	
West Bengal	2	4323	20	4345
Tamil Nadu	74	341	2186	2601
Jharkhand	65	749	8	822
Assam	152	57	32	241
Rajasthan	53	23	79	155
Maharashtra	18	47	27	92
Gujrat	17	45	7	69
Uttar Pradesh	1	23	30	54
Himachal Pradesh	13	4	13	30
Daman & Diu	0.5	1.87	4.99	7.36

(Source: FSI (2009,2011,2013 and 2015) India State of forest reports.

Altitudinal Zonation of Forest Cover

The data of Shuttle Radar Topography Mission (2006) was used to generate Digital Elevation Model to determine altitudinal zonation of forest cover in the country (Forest Survey of India (2015) India State of forest report). Based on the altitude wise scatter of forest cover in 2013 and 2015 assessment cycles, mean was worked out to present the average distribution.

Table 8 showed that the FC declined rapidly with increase in altitude. The areas upto 500 msl possessed 52.47% of the total FC of the country, 80.68% was below 1000 msl and 91.6% below 2000 msl. The analysis gave insight into the prospects of expanding FC in each altitudinal zone .

Recorded forest and Forest cover

There is growing eagerness, particularly, among the

Table 8:

Altitude zone (above msl)	GA of the zone (Km^2)	Average forest cover (Km^2) based on 2013 & 2015 assessments			
		VDF	MDF	OF	Total
0-500m	2264564	30552	155490	181131	367173
500-1000m	606210	21735	97248	78402	197384
1000-2000m	115776	14827	36838	24764	76429
2000-3000m	57057	14159	19151	7272	40581
3000-4000m	59627	3393	8037	5870	17299
Above 4000m	184029	39	297	586	921
Total	3287263	84703	317060	298023	699786

(Source: averages were arrived at based on table 2.11, page 27, ISFR, 2013and table 2.11, page 54 of India State of Forest Reports, 2015)

forest managers to know the status of forest cover within the recorded forest areas. Due to unavailability of digitized forest boundaries, the forest cover could not be delineated with reference to recorded forest at a country level. During 2015 assessment , digitized forest boundaries were made available by 12 States/UT and it enabled assessment of forest cover within and outside recorded forests for these States/UT These States together, contributed about 49.36% of the total FC (701673 Km^2) of the country. In respect of these States/UT the following trend scatter of FC within and outside recorded forest emerged Table 9.

Table 9:

States	Forest cover (%age)	
	Within recorded forest area	Outside recorded forest area
VDF	86.95	13.05
MDF	78.00	22.00
OF	64.56	35.44
Total	73.15	26.85

(Source: % ages were arrived at based on table 2.12, page 56, India State of Forest Report, 2015)

Recorded forest areas contributed about 73.15% (253373 Km^2) of the total FC (346368 Km^2) pertaining to these States/UT taken together. In terms of density, 86.95% VDF, 78% MDF and 64.56% OF were within recorded forest areas. A large part (92995 Km^2=26.85%) of FC i.e. 13.05% VDF, 22% MDF and 35.44% OF was contributed by outside areas. Adding tree cover (50679 Km2 , all of which was outside recorded forests) of these States/UT (Forest Survey of India (2015) table 4.2, page 73, India State of Forest Report), the contribution of lands outside recorded forests increased to 143694 Km^2 i.e. 8.17% of the total GA (1758924 Km^2) of theses States/UT (Forest Survey of India (2015) table 2.12, page 56 , India State of Forest Report). Same logic, if, extended notionally to the whole country, the FC outside and within recorded forest in 2015 would be (701673x26.85% + TOF = 92572 Km^2) 280971 Km^2 i.e. 8.55% (188399 Km^2/3287263 Km^2) and (701673x73.15%) 513273.8 Km^2 ie. 15.61% (513274 Km^2/ 3287263 Km^2) of the GA.

Discussion

The 1987 assessment, the first exercise of its kind was great learning experience and presented a broad synoptic view at National/State level. As the quality of data and interpretation techniques improved, the precision of subsequent assessments also improved but the time series of FC remained largely incompatible. With experience over these years, the constraints of remote sensing were overcome to a great extent by ascertaining changes through intensive ground verification. One of the major limitations of remote sensing based FC mapping was the near similarity in reflectance of invasive weeds such as Lantana species and cultivated crops like cotton and sugarcane to trees which caused significant interpretational errors. The changes in successive assessments as discussed above presented, initially, a confusing and ambiguous picture owing to several reasons. The most apparent reason could be the real change in the ground situation brought out by actual increase or decrease in FC due to conservation and protection efforts by the States and local communities. Actual decrease might be due to diversion of forest lands, illegal culling of trees, over grazing encroachments, shifting cultivation or a combination of these factors. Unreal changes might also creep in due to limitations of Remote sensing technology applied for FC assessment. The assessments represented the net outcome of all changes taking place in various States/UT's in the country. It was not possible for Forest Survey of India to meticulously analyse the reasons for changes owing to constraint of resources including time available between successive assessments.

To deal with the incompatibility of data, attempts were made to revise the time series data by incorporating validated corrections to make these comparable, the latest exercise was done in 2009. The procedure and technology of FC mapping from 2009 to 2015 assessments

remained largely unchanged, though the quality further improved with each assessment cycle.

Comparison of the original time series was not advisable on account of incompatibility owing to challenges posed by several factors. The revised data series brought out that the FC of the country grew @ 202847 hectares per annum from 1984 to 2013. The latest 4 assessment (using data pertaining to 2006 to 2013) showed that the rate of increase in FC was maintained at 132557 hectares per year which was very encouraging in view of tremendous pressure on forests for diversion for various developmental projects and increased demand of forest produce by the local communities. The recent trends alerted some of the States showing continuous decline in VDF and MDF (Table 5 and 6).

Altitude wise scatter of forest cover (table-8) highlighted 52.47% contribution of lower areas (>500msl) and 8.39% of high altitudes (<2000 msl). The lower altitudes (<500msl) were already overburdened due to pressure of habitations and have a limited scope for further expansion of FC whereas the high altitudes were mostly non-culturable, though, play an important role in the ecosystem. Therefore, the medium altitudes (>500 msl to < 2000 msl) might be targeted for further expansion of FC in the country.

Lands outside the forest boundaries (based on digitised forest boundaries) emerged as significant (26.85%) contributor to the forest cover (table-9) which was very encouraging since these areas played significant role in agro-ecosystem and directly benefited the farmers and local communities.

Conclusion

A casual look at the changes between successive assessments pointed towards a confusing and ambiguous picture on account of incompatibility of data emerging from variations in the mode of interpretation and advancement in technology.

The constraint of incompatibility was over come to large extent in 2009 with correction of time series of Forest cover of India for change in scale, inclusion of small patches and vector approach. Analysis based on the harmonised data presented an informed perspective. It revealed slight decline in forest cover from 1989 till 1997 followed by increase afterwards. Overall picture highlighted significant (60854 Km^2 i.e. 1.85% of GA) improvement in the FC in the latest assessment (701673 Km^2) compared to first (640819 Km^2). The FC grew annually by 194540 hectares from 1984 to 1993, 264940 hectares from 1994 to 2003 and 149060 hectares from 2004 to 2013. The over all average annual growth was 202847 hectares per annum from 1984 to 2013. The improvement was significant considering tremendous pressure on forest lands for various developmental projects and increase in demand of forest produce to meet the requirement of ever increasing population of domestic animals and forest dependent communities. These findings provided sufficient ground to allay the common perception that the FC of the country was depleting at a fast rate.

The paper, based on 2009 to 2015 assessments, highlighted that the VDF was rapidly decreasing in Arunachal Pradesh, Orissa, West Bengal, Maharashtra and Madhya Pradesh and MDF in Andhra Pradesh, Mizoram, Assam, Arunachal Pradesh, Madhya Pradesh, Tripura and Maharashtra. The OF however, was found improving continuously in West Bengal, Tamil Nadu, Jharkhand, Assam, Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Himachal Pradesh and Daman andDiu.

The rapid increase in FC with decline in altitude was observed. The areas below 500 m altitude contributed 52.47% of the FC of the country (80.68% below 1000m altitude and 91.6% below 2000 m altitude). Forest cover based on digitized forest boundaries of 12 States/UT, revealed 73.15% of the total forest cover within recorded forest areas (86.95% VDF, 78% MDF and 64.56 % OF) and 26.85% outside, though, a clear picture at the National level would emerge only after complete geo- referencing of all forest boundaries in the country. The paper highlighted the substantial contribution of the areas outside recorded forests.

भारतीय वन सर्वेक्षण द्वारा 1987 से 2015 तक किए गए मूल्यांकनों पर आधारित भारत के वनावरण की गतिकी

बी.डी. सुयाल

सारांश

इस शोधपत्र में देश में वनावरण परिवर्तनों के स्तर के स्पष्ट मूल्यांकन हेतु भारतीय वन सर्वेक्षण की प्रकाशित रिपोर्टों पर आधारित 1987 से देश में वनावरण परिवर्तनों का एक विश्लेषणात्मक अवलोकन प्रस्तुत किया गया है। 1981–83 से संबंधित सूदूर संवेदी आँकड़ों पर आधारित वनावरण का पहला राष्ट्रीय परिदृश्य 1987 में प्रकाशित किया गया, जिसने जी ए के 19.52% पर एफ सी का आकलन किया। जिसने राष्ट्रीय/राज्य स्तर पर पहले बैंच मार्क का आकलन किया। तब से क्रियाविधि, आँकड़ों की गुणवत्ता, मानचित्रण के पैमाने और निर्वचन तकनीकों में धीरे–धीरे सुधार हुआ। कुछ परिवर्तन विशेषकर 1989, 2001 और 2009 में काफी महत्वपूर्ण रहे हैं। प्रौद्योगिकीय उन्नति ने गत मूल्यांकनों के वनावरण आँकड़ों को असंगत कर दिया। इस

प्रकार, प्रौद्योगिकी/क्रियाविधि में परिवर्तन की अनदेखी करके एफ सी की मूल समय श्रृंखला के तुलना परस्पर-विरोधी निष्कर्ष दे सकती है। असंगतता के दबाव से पर्याप्त सीमा तक पार पाने के लिए पॉलीगॉन केन्द्रित एप्रोच के प्रभाव और छोटे खण्डों के कैप्चर, पैमाने में परिवर्तन के कारण संशोधनों को लागू करके 1987 से शुरू करके पूर्ण आँकड़ा श्रृंखला को 2009 में संशोधित किया गया। 2009 से 2015 तक मूल्यांकनों की प्रौद्योगिकी एवं निर्वचन तकनीक अधिकतर अपरिवर्तनीय रही। संशोधित आँकड़ों के विश्लेषण से ज्ञात हुआ कि एफ सी दूसरे चक्र में बढ़ी तब धीरे-धीरे 1997 तक (1993 में मामूली वृद्धि को छोड़कर) घटी : छठे चक्र से एफ सी ने चौदहवें चक्र तक (2011 में मामूली गिरावट को छोड़कर) सुधार दिखाया। देश में एफ सी में कुल वृद्धि (1 से 14 चक्र के बीच) 60854 वर्ग कि.मी. के रूप में आकलित की गई उदाहरणार्थ- देश के जी ए का 1.85 प्रतिशत। एफ सी 1984 से 1993 तक 194540 हैक्टेयर, 1994 से 2003 तक 2649.40 हैक्टेयर तक और 2004 से 2013 तक 149060 हैक्टेयर तक सालाना बढ़ी। वनावरण की कुल औसत सालाना वृद्धि सम्पूर्ण अवधि के लिए 202847 हैक्टेयर के रूप में आकलित की गई।

वनावरण का वितरण ऊँचाई में वृद्धि के साथ काफी घटा। 2000 मी. से अधिक ऊँचाई वाले क्षेत्र में कुल वनावरण का केवल 8.39 प्रतिशत था। वनावरण में आधे से ज्यादा (52.47%) का योगदान 500 मी. से कम ऊँचाई वाले क्षेत्र का था। 12 राज्यों/संघ क्षेत्र की अंकीयकृत वन सीमाओं के विश्लेषण से पता चला कि वनावरण के 73.15% (86.95% वी डी एफ, 78% एम डी एफ और 64.50% ओ एफ) में अभिलिखित वन क्षेत्रों का योगदान था और वाहय क्षेत्रों द्वारा 26.85% (13.05% वी डी एफ, 22% एम डी एफ और 35.44% ओ एफ) था।

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