AN ANALYSIS OF THE TEMPORAL CHANGES IN THE FORESTS OF HIMACHAL PRADESH- A REVIEW

Dr. Pankaj Sharma, Dr. Abhay Mahajan, Kiran Lata, Harish Bharti, Dr. S.S. Randhawa

STATE CENTRE ON CLIMATE CHANGE
State Council for Science, Technology & Environment, Himachal Pradesh (HIMCOSTE)
Vigyan Bhawan, Near Udyog Bhawan, Bemloe, Shimla-171001 H.P.
Tele Fax: 0177-2656489
Email: himachal.ccc@gmail.com

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Forests of Himachal Himalaya

Forests are the storehouse of the rich biodiversity and are critical for ecological balance of an area. They constitute the essential life support system besides being a source of timber, fuel, fodder and medicines etc. They ought to be recognized as water reservoirs, natural source of soil nutrition, soil creators and soil binders. The Himalayan ranges are among the youngest mountains in the world, are active as well as fragile, and are facing threat from mankind in the name of development. Because of increased anthropogenic activities such as change in land use practices and population explosion the natural landscape has been modified resulting in fragmentation of forests with poor species composition (Noss and Harris, 1986; Roy and Shrivastava, 2000). The State of Himachal Pradesh, a part of North Western Himalaya lies between 30^0 22′ 40″ to 30^0 12′ 40″ N Latitudes and 75^0 47′55″ to 79^0 04′ 20″ E Longitudes and extends from 200-6900 m amsl. The unique and socio-economically important floral diversity makes Himachal Pradesh as one of the most fascinating hill state of the country. Its hilly terrain system known for natural wealth, forests, meadows, rivers and steep valleys is enriched with rich cultural heritage. The majestic array of perpetual lofty snow peaks presents an astonishing panoramic view. The state is known for its forests and their floral and faunal diversity. Among the 45,000 species of plants found in the country as many as 3295 species (7.3%) are reported in the state (Anon., 1993). The large altitudinal range supports tropical, sub-tropical, temperate, sub-alpine, alpine and tundra vegetation. In Himachal unlimited scope exists for intensification and diversification of forest cover.

Forest type is a category of forest defined with reference to its geographical location, climatic and edaphic features, composition and condition. Champion and Seth defined forest type as a unit of vegetation which possesses (broad) characteristics in physiognomy and structure sufficiently pronounced to permit of its differentiation from other such units. This is irrespective of physiographic, edaphic or biotic factors. The state has 35 forest types which belong to 8 forest type groups *viz*., Tropical Moist Deciduous, Tropical Dry Deciduous, Subtropical Pine, Himalayan Moist Temperate, Himalayan Dry temperate, Sub Alpine Forests, Moist Alpine Scrub and Dry Alpine Scrub (ISFR, 2009; Champion and Seth, 1968).

The recorded forest area of Himachal Pradesh is 37,033 km^2, which constitutes 66.52 per cent of the total geographical area (55,673 km^2). Forests of Himachal Pradesh are legally classified as reserve forest (5.12%), demarcated forest (30.75%), un-demarcated protected forest (58.48%), un-classed forest (2.64%) and other forests (3.02%) (Table 1).

Table 1 Legal Classification and area of Forests in Himachal Pradesh

Category	**Area (Km^2)**	**% to total**
Reserved forest area	1896	5.12
Demarcated forest area	11387	30.75
Un-demarcated protected forest	21656	58.48
Un-classed forests	976	2.64
Other forest managed by forest department	370	1.00
Other forest not managed by forest department	748	2.02
Total	37033	100

Source: India State of Forest Report (ISFR), 2015

The forest cover of the state based on satellite data is 14,696 km^2, which constitute only 26.39 per cent of geographical area and have per capita forest cover of 0.214 ha (ISFR, 2015). The ban on green felling by the Supreme Court judgment since 1985 has resulted in the protection of different tree species (Nanda, 2005). This had also led to a halt in silvicultural management of the forests that was mandatory for the health and growth of the forests to have sustained benefits from the forests. The repercussion of such decision on regeneration status and overall growth of the forests has not been studied to justify such developments in the past. As Himachal forests face a wide variety of biotic pressures therefore, it is important to monitor constantly the impact that these pressures are having on the ground and alert the State Forest Department about unusual risk from any quarter. While forestry crops are of long gestation period, intensive monitoring of our forest resources is the need of the day as these meager resources are under great pressure.

Changing Land use pattern of Himachal Pradesh

Over the years land use and cropping patterns in the Himachal Pradesh have been changing profoundly. The expansion of cultivation at the expense of forests has been relatively more reflective in Himachal Pradesh than other parts of India (Melkania and Melkania, 1987). The introduction of horticultural cash crops and the commercialization of agriculture have placed greater demands on the forests of the

state which have not only been undergoing a change in area but also a change in composition primarily due to human interference (Gouri *et al.*, 2004). Deforestation is one of the major drivers of global warming and climate change. It is essential that regular temporal assessments of forest cover change are carried out to know the previous patterns and predict future trends (Apan, 1999). The various workers have comprehensively delineated the area under different land-cover/use classes in Himachal Pradesh (Chandrashekhar *et al*., 2003) (Table 2).

Table 2. Area under different land-cover/land-use classes in Himachal Pradesh

S. No.	Land-use/land-cover class	Area (km^2)	% age	S. No.	Land-use/land-cover class	Area (km^2)	% age
1.	Alpine meadow	5346.21	9.6	**16.**	Sal	306.97	0.55
2.	Alpine scrub	2086.92	3.8	**17.**	Scrub	2152.55	3.87
3.	*Betula/Rhododendron*	455.09	0.8	**18.**	Temperate broadleaved	408.83	0.73
4.	Chilgoza	76.98	0.1	**19.**	Temperate grassland	2154.36	3.87
5.	Chir pine	2005.52	3.6	**20.**	Temperate scrub	321.64	0.58
6.	Blue pine	2193.6	3.9	**21.**	Orchard	542.77	0.97
7.	Deodar	2153.35	3.9	**22.**	Agriculture	7924.46	14.2
8.	Dry deciduous	26.78	0.1	**23.**	Barren	10097.78	18.1
9.	*Ephedra*	81.97	0.2	**24.**	Water	386.43	0.69
10.	*Hippophae*	258.43	0.5	**25.**	Settlement	14.45	0.03
11.	Juniper	208.41	0.4	**26.**	Snow	6160.76	11.1
12.	Mixed conifer	3226.72	5.8	**27.**	Cloud	659.21	1.18
13.	Moist deciduous	1573.62	2.8	**28.**	Shadow	3945.54	7.09
14.	Oak	879.38	1.6		**Total**	**55,673.42**	**100 %**
15.	Riverine	24.66	0.04				

(Chandrashekhar *et al*., 2003).

Forest management and government initiatives

To arrest forest degradation, the Himachal government has been involved in raising monoculture tree plantations of species such as pine which offer relatively less ecological and economic services to forest dependent communities as compared to mixed broadleaved forests (Baland *et al*., 2008). Another grievous cause of concern is the replacement of oak by pine in the Western Himalayas. *Nautor* is an ancient right under which landless people are permitted to break fresh agricultural land in common land areas by village elders (ODA, 1993). The un-demarcated forest is the land that was designated for allocation under *nautor* rights. This practice of giving away un-demarcated forest land to landless cultivators under the provisions of the said rules has resulted in deforestation in the Himalayan state (Gupta, 2007). An

another policy in the history of forest management in Himachal is the Timber Distribution (TD) system under which landowners or right holders claim rights to timber, primarily to meet house construction or repair needs. This policy while meeting the basic needs of the local population has also been the single largest reason for timber harvest in Himachal Pradesh due to the rampant misuse of these rights. However, as of now the green felling ban is being imposed in the state and practically there is no silvicultural management. In addition to the above mentioned rising population pressure and inappropriate policies of the government have further threatened forest sustainability and are contributing to deforestation and forest degradation. Further, as per National Mission for Sustaining the Himalayan Ecosystem and National Mission for Green India, the community based management of the local ecosystems are to be promoted in the state with incentives to community organization and panchayats for protection and enhancement of forest lands. Further, in the mountain states like Himachal Pradesh the aim is to maintain two-third area under forest cover in order to prevent soil erosion and land degradation and ensure stability of fragile Himalaya (National Forest policy, 1988).

Temporal analysis of changes in the forests of Himachal Pradesh

The profound changes in the land use and agri-horticulture cropping patterns along with the rapid urbanization, establishment of hydropower projects, expansion of huge network of national highways in the state, is continuously putting pressure on the forest resources and hence the cover is changing. However to cope up the forest losses due to various developmental activities there are various schemes in place of the respective departments (Compensatory Afforestation Management and Planning Authority, River Valley Projects & Flood Prone Rivers *etc*.).

Forest Survey of India (FSI), responsible for assessment and monitoring of the forest resources of the country regularly. The forest cover mapping was started in 1987 and since then regular assessment of forest cover is being done by FSI using remote sensing satellite data on a biennial basis. While Forest cover includes, all lands, more than one hectare in area, with a tree canopy density of more than 10 per cent irrespective of the ownership and legal status. Such lands may not necessarily be a recorded forest area. The Forest area/recorded forest area- refers to all the geographical areas recorded as 'Forests' in the Government records. Recorded forest

area largely consists of Reserved Forests (RF) and Protected Forests (PF), which have been constituted under the provisions of Indian Forest Act 1927. The recorded forest area may also include all such areas which have been recorded as forests in the revenue records or have been constituted so under any state act or local law. The Dense forest includes all lands with a forest cover having a canopy density of >40 %, however there is very dense forest (VDF) class having >70% of forest cover but due to unavailability of temporal data of this class we collated VDF and MDF (Moderately dense forest) in dense class only. Open forests are lands with forest cover having a canopy density between 10 to 40 per cent and Scrubs as degraded forest lands having canopy density less than 10 per cent.

The secondary data source is being analysed by the Forest Survey of India which involves the interpretation of satellite data entails a series of steps to extract useful information for forest cover using LISS-III sensor data, choice of 1:50,000 map scale and one ha area as minimum mapping unit (MMU). The digital image processing of satellite data for forest cover mapping takes in to consideration the reflectance behaviour of canopy cover.

Altitudinal distribution of forest covers in the state

The altitude wise distribution of forest cover in the state is being assessed by FSI from time to time. The maximum forest cover (34.34%) is in the 2000-3000m altitudinal zone followed by 27.03% in 1000-2000m altitudinal zone. The least forest cover (0.18%) is above 4000 m zone (ISFR, 2015) (Table 3).

Table 3 Altitude-wise Forest Cover in Himachal Pradesh (Area in Km2)

Altitude-Zone	Dense Forest	Open Forest	Total	Per cent
0-500m	430	296	726	4.94
500-1000m	1883	1182	3065	20.85
1000-2000m	2366	1606	3972	27.03
2000-3000m	3804	1243	5047	34.34
3000-4000	1119	740	1859	12.64
>4000m	03	24	27	0.18
Total	**9,605**	**5,091**	**14,696**	**100**

Source: ISFR, 2015; [Based on Shuttle Radar Topography Mission (SRTM), Digital Elevation Model].

Growing stock in forests, trees outside forest (TOF), Agroforestry and urban area in Himachal Pradesh

The volume of growing stock is significantly decreased since 2009 to 2015 in forests as well as in trees outside forests in the state of Himachal Pradesh (Table 4; Fig. 1). In agroforestry, growing stock volume is 15.81 (million cum) which fall under 4.14% of the geographical area of the state whereas in urban area (urban tree cover of the state: 18 km^2) growing stock is 0.15 (ISFR, 2013).

Table 4 Temporal analysis of growing stock in forests and trees outside forest (TOF) in Himachal Pradesh

Years	Volume of Growing Stock (million cu m)		
	In Forest	In TOF	Total
2009	322.40	21.23	343.63
2011	321.314	21.146	342.46
2013	317.295	20.763	338.058
2015	317.576	21.003	338.579

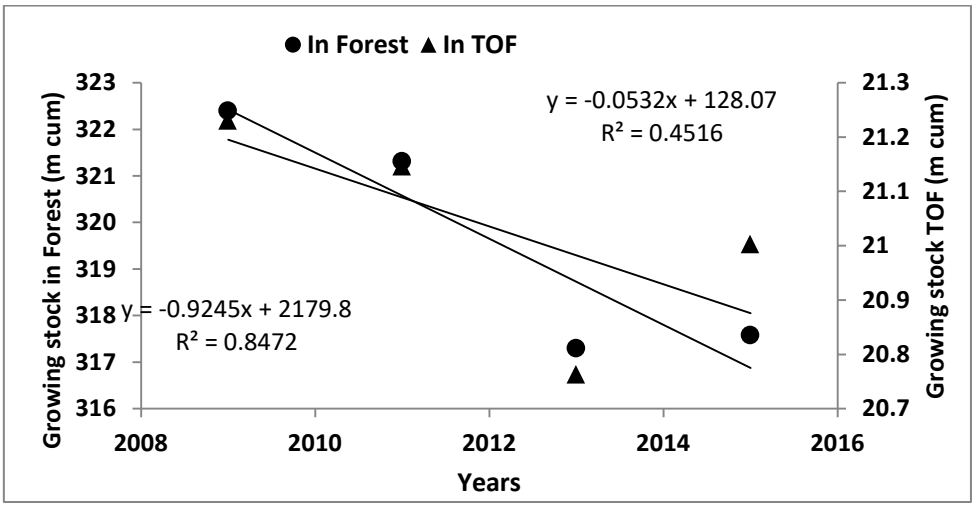

Figure 1 Growing stock in forests and trees outside forest (TOF) in Himachal Pradesh

Temporal variation in tree cover of Himachal Pradesh

Tree cover implies trees outside forest which are less than 01ha as per FSI methodology. There has been a significant increasing trend in the tree cover in Himachal Pradesh since 2009 as it increased from 397 km^2 in 2001 to 757 km^2 in the year of 2015 (Fig. 2).

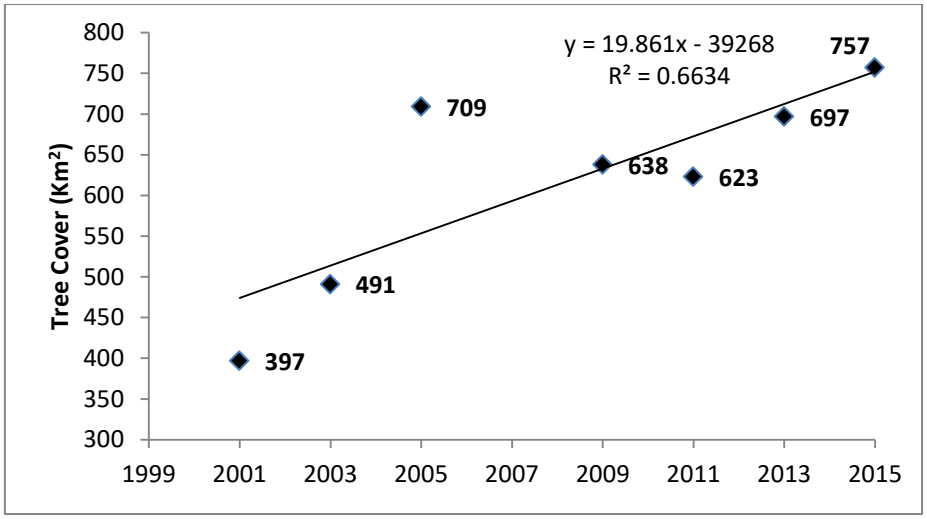

Figure 2 Tree cover of forests and trees outside forest (TOF) in Himachal Pradesh

The temporal analysis of the State of Forest Reports by Forest Survey of India is being done for Himachal Pradesh since 1991 till 2015. The various parameters were analysed district-wise were, total forest cover; dense forest cover, open forest cover, scrub area and total percent change in the area under different classes.

Total forest cover:

The total forest cover of Himachal Pradesh showed an increase of 13 km^2 in 2015 (14,696 km^2) as compared to the 2013 (14,683 km^2). The total forest cover of the state showed a significant increase from 1991 to 2015. There has been a constant increase in forest area from year 2001 onwards whereas a huge increase (1278 km^2) during the 1999 to 2001 owing to the increase in areas of Kangra (391 km^2), Solan (191 km^2), Una (185 km^2), Kullu (141 km^2) and Mandi (117 km^2) districts. The total forest covers of various districts of Himachal Pradesh are shown in Table 5. and Fig. 3.

Dense forest cover: The maximum dense forest area in 2015 is of Shimla (1776 km^2) followed by Chamba (1626 km^2), Kangra (1531 km^2) and Kullu (1371 km^2) The districts of Kinnaur, Kullu, Shimla, Sirmaur and Hamirpur showed declining trend in dense forest cover over last 24 years whereas Lahaul and Spiti grew by 0-47 sq km (Table 6; Fig. 4).

Open forest cover: Open forest cover is maximum in Chamba (811 km^2) followed by Sirmaur (687 km^2) and Shimla (616 km^2) districts of the state. There has been a abrupt increase in open forests in the year 2003 when compared with 2001.

Except Una and Kangra, other districts showed increasing trend of Open Forest Cover with maximum in Lahaul & Spiti (Table 7; Fig. 5).

Scrubs: Area under scrubs in the state has decreased since 1995 substantially. The maximum scrubs area is in Kinnaur (72 km^2) followed by Sirmaur (56 km^2) and Solan (38 km^2). District-wise temporal trend analysis of area under scrubs in Himachal Pradesh is shown in Table 8 and Fig. 6.

Table 5 A temporal enumerations (1991-2015) of total forest area of various districts of H.P.

Total forest cover area (km^2)												
District	**1991**	**1993**	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2011**	**2013**	**2015**
Bilaspur	166	157	157	158	235	301	358	362	362	362	362	362
Chamba	2017	2124	2060	2061	2301	2342	2413	2413	2436	2437	2437	2437
Hamirpur	216	213	223	223	188	274	242	242	245	244	244	245
Kangra	1433	1755	1744	1744	1639	2030	1867	1879	2062	2064	2064	2068
Kinnaur	633	629	629	632	649	647	613	597	602	600	604	604
Kullu	1948	2044	2044	2044	1974	2115	1933	1941	1958	1959	1959	1959
Lahaul-Spiti	17	19	83	83	150	154	180	185	193	194	194	195
Mandi	1301	1309	1309	1315	1539	1656	1648	1651	1673	1675	1675	1676
Shimla	2220	2425	2425	2425	2390	2449	2383	2379	2384	2386	2386	2392
Sirmaur	1019	1019	1019	1024	1108	1112	1379	1379	1383	1385	1385	1385
Solan	415	418	418	422	492	683	819	823	849	850	850	850
Una	395	390	390	390	417	602	518	518	521	523	523	523
Total	**11780**	**12502**	**12501**	**12521**	**13082**	**14360**	**14353**	**14369**	**14668**	**14679**	**14683**	**14696**

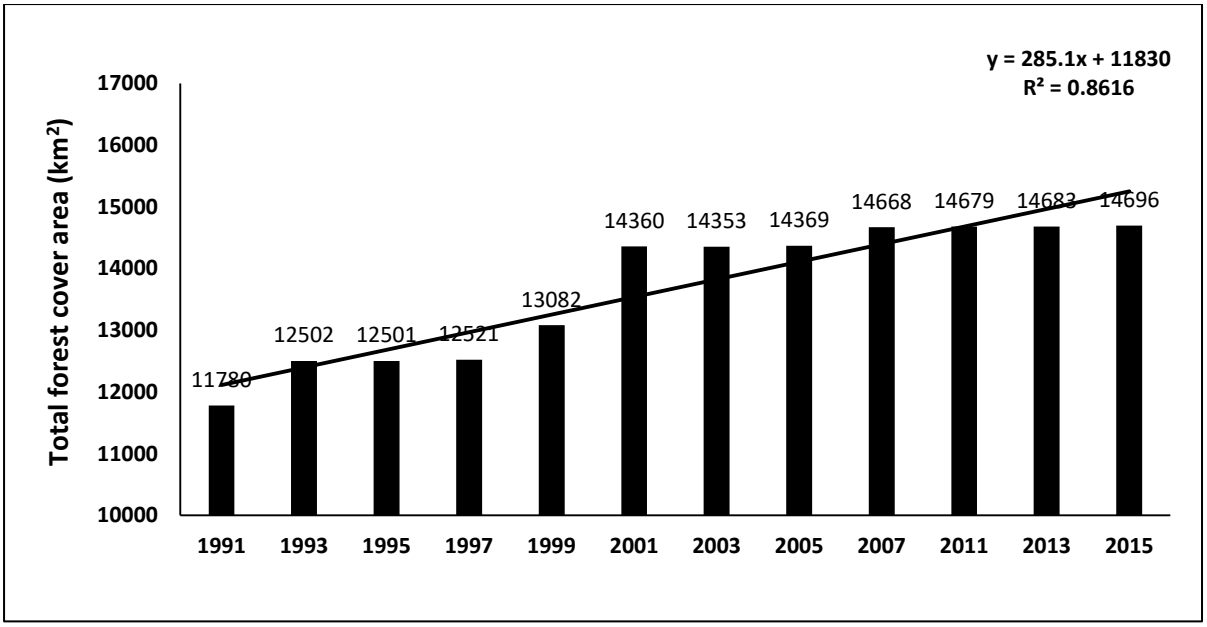

Figure 3 Temporal analysis to the total forest area of Himachal Pradesh

Table 6 A temporal enumeration (1991-2015) of dense forest cover of various districts of H.P.

Dense forest cover (km²)												
Districts	**1991**	**1993**	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2011**	**2013**	**2015**
Bilaspur	101	49	49	59	65	135	105	104	195	195	195	195
Chamba	1625	1801	1767	1768	1585	1652	1566	1567	1626	1626	1626	1626
Hamirpur	156	151	151	150	93	181	109	109	131	130	130	130
Kangra	808	1071	1071	1071	1338	1719	1386	1384	1531	1531	1531	1531
Kinnaur	565	547	547	541	436	432	365	340	345	344	344	344
Kullu	1817	1911	1911	1907	1631	1749	1412	1414	1375	1372	1371	1371
Lahaul-Spiti	-	15	49	49	34	36	35	35	47	47	47	47
Mandi	839	848	848	848	982	1112	1011	1007	1108	1108	1108	1108
Shimla	1921	2094	2094	2084	1808	1878	1781	1768	1776	1776	1776	1776
Sirmaur	740	740	740	736	742	755	687	687	698	698	698	698
Solan	164	164	164	173	274	459	353	350	459	459	459	459
Una	175	174	174	174	132	321	166	163	316	320	320	320
Total	**8911**	9565	9565	9560	9120	10429	8976	8928	9607	9605	9605	**9605**

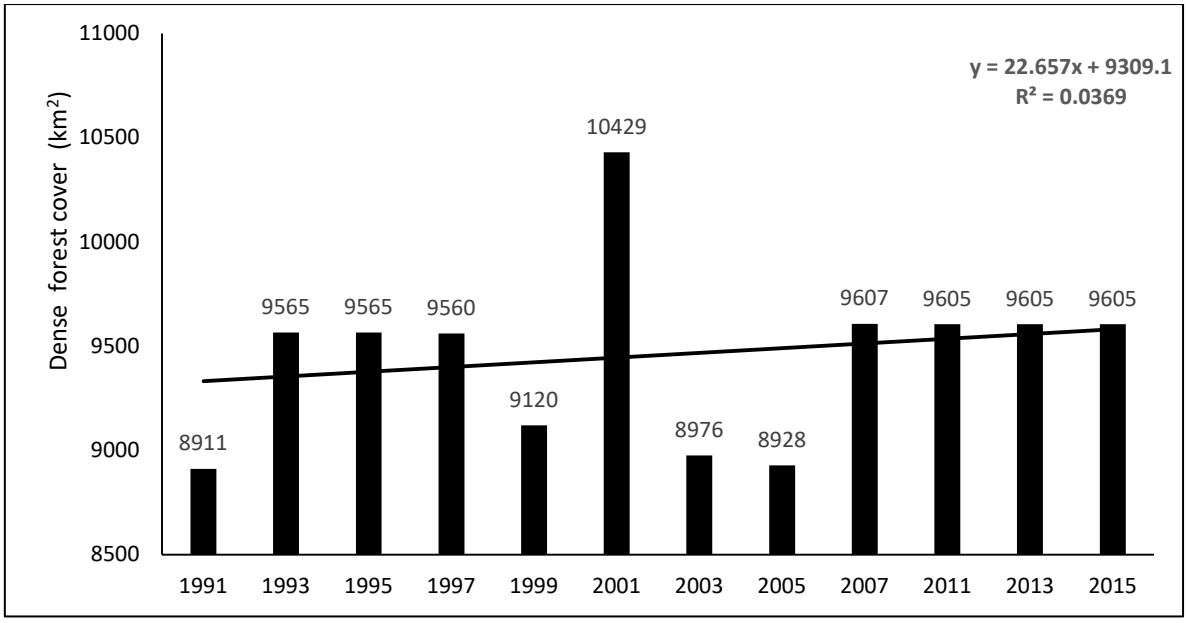

Figure 4 Temporal analysis to the dense forest cover of H.P.

Table 7 A temporal enumerations (1991-2015) of open forest cover of various districts of H.P.

Open forest cover (km²)												
Districts	**1991**	**1993**	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2011**	**2013**	**2015**
Bilaspur	65	108	108	99	170	166	253	258	167	167	167	167
Chamba	392	323	293	293	716	690	847	846	810	811	811	811
Hamirpur	60	62	72	73	95	93	133	133	114	114	114	115
Kangra	625	684	673	673	301	311	481	495	531	533	533	537
Kinnaur	68	82	82	91	213	215	248	257	257	256	260	260
Kullu	131	133	133	137	343	366	521	527	583	588	588	588
Lahaul-Spiti	17	4	34	34	116	118	145	150	146	147	147	148
Mandi	462	461	461	467	557	544	637	644	565	567	567	568
Shimla	299	331	331	341	582	566	602	611	608	610	610	616
Sirmaur	279	279	279	288	366	357	692	692	685	687	687	687
Solan	251	254	254	249	218	224	466	473	390	391	391	391
Una	220	216	216	216	285	281	352	355	205	203	203	203
Total	**2869**	**2937**	**2936**	**2961**	**3962**	**3931**	**5377**	**5441**	**5061**	**5074**	**5078**	**5091**

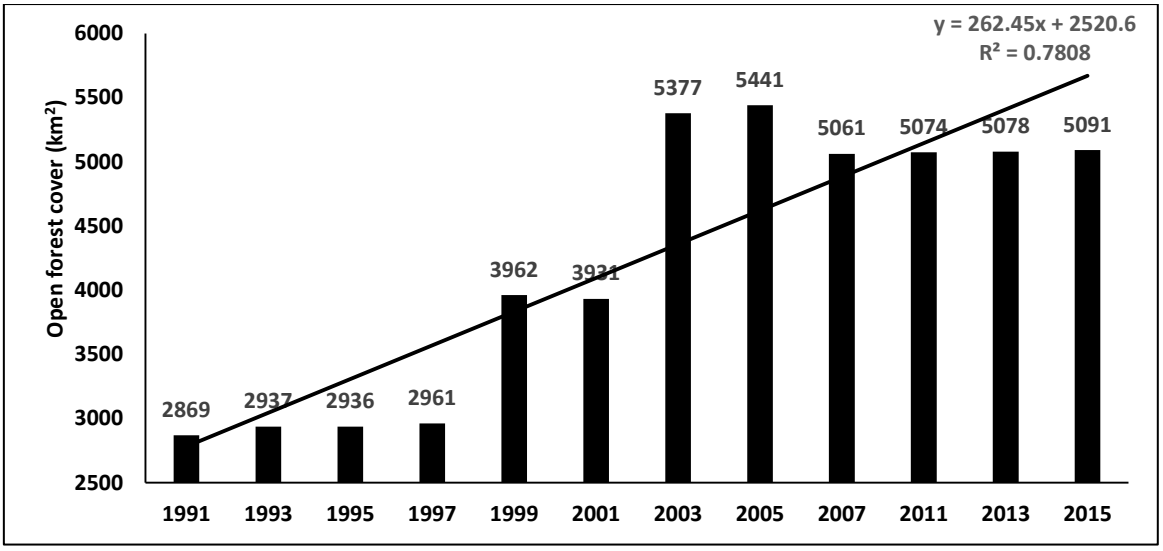

Figure 5 Temporal analysis to the open forest cover of H.P.

Table 8 A temporal enumerations (1991-2015) of Scrubs of various districts of H.P.

Scrub (Km²)											
Districts	**1993**	**1995**	**1997**	**1999**	**2001**	**2003**	**2005**	**2007**	**2011**	**2013**	**2015**
Bilaspur	-	11	11	10	10	-	4	0	0	0	0
Chamba	-	202	202	35	31	-	52	37	38	21	21
Hamirpur	-	4	4	2	2	-	5	0	0	0	0
Kangra	-	119	118	28	38	-	20	11	11	3	4
Kinnaur	-	716	712	124	113	-	67	70	70	69	72
Kullu	-	37	37	22	20	-	22	23	23	23	23
Lahaul-Spiti	-	262	260	45	84	-	48	31	31	28	27
Mandi	-	81	79	46	42	-	39	29	29	29	29
Shimla	-	176	176	81	56	-	28	32	32	31	31
Sirmaur	-	119	111	97	92	-	54	56	56	56	56
Solan	-	91	88	63	61	-	38	38	38	38	38
Una	-	27	27	13	17	-	6	0	0	0	0
Total	1845	1845	1825	566	566	389	383	327	328	298	301

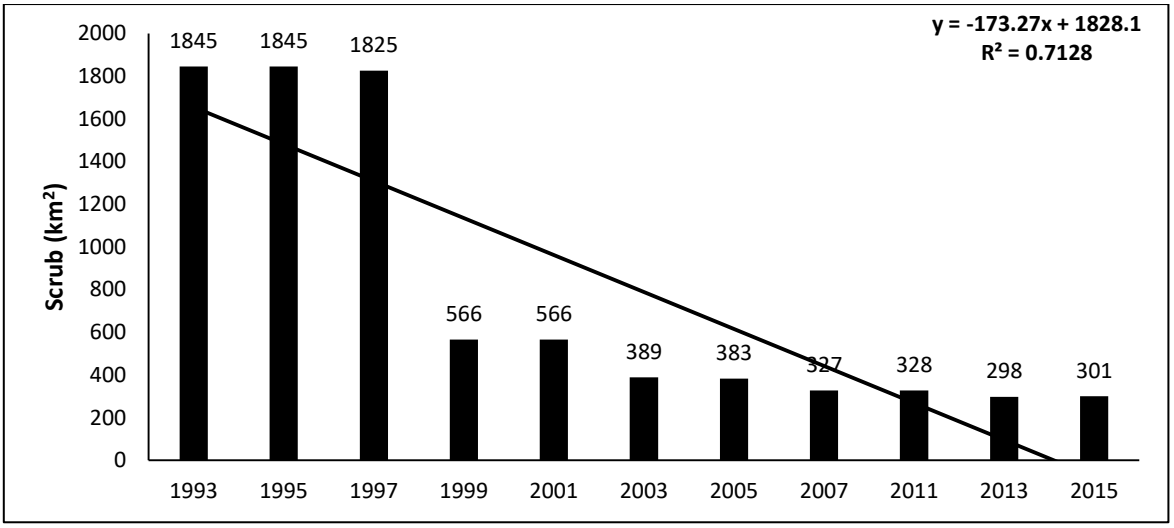

Figure 6 Temporal analysis to the Scrubs of H.P.

District-wise percent change in the different forest covers of Himachal Pradesh

The percent change in the different forest covers of Himachal Pradesh was analysed at district level between 1991 and 2015 years (Table 9). District Kullu and Shimla showed very little increase in total forest cover 0.6 % and 7.7% respectively in last 24 years whereas only Kinnaur showed a decline in total forest cover by 4.6% owing to the construction of number of hydropower projects and various anthropogenic activities in the last two decades (Fig. 7). Lahaul and Spiti district showed increase in the cover due to various types of successive plantation initiatives. Dense Forest area of Solan, Bilaspur, Kangra and Una showed maximum percent increase i.e. 179.9%, 93.1%, 89.5%, 82.9%, respectively. The districts of Sirmaur, Shimla, Hamirpur, Kullu and Kinnaur showed decline in dense forests in last 24 years (i.e. from 1991 to 2015) (Fig. 8). Open forests in Lahaul and Spiti, Kullu, Kinnaur, Bilaspur, Sirmaur, Chamba and Shimla increased substantially whereas open forests in Kangra (14.1%) and Una (7.7%) decreased during last 24 years (Fig. 9). The scrubs in the state are declining consistently since year 1995. The district of Bilaspur, Hamirpur and Una are left with no scrubs as per record of ISFR, 2015. The district-wise percent decrease and area is shown in Table 9 and Fig. 10.

Table 9 District-wise percentage change in various forest categories in the state of H.P.

Districts	Total forest cover area (km^2)			Dense forest cover (km^2)			Open forest cover (km^2)			Scrub (km^2)		
	1991	2015	% Change	1991	2015	% Change	1991	2015	% Change	1995	2015	% Change
Bilaspur	166	362	118.1	101	195	93.1	65	167	156.9	11	0	-100.0
Chamba	2017	2437	20.8	1625	1626	0.1	392	811	106.9	202	21	-89.6
Hamirpur	216	245	13.4	156	130	-16.7	60	115	91.7	4	0	-100.0
Kangra	1433	2068	44.3	808	1531	89.5	625	537	-14.1	118	4	-96.6
Kinnaur	633	604	-4.6	565	344	-39.1	68	260	282.4	712	72	-89.9
Kullu	1948	1959	0.6	1817	1371	-24.5	131	588	348.9	37	23	-37.8
Lahaul-Spiti	17	195	1047.1	0	47	-	17	148	770.6	260	27	-89.7
Mandi	1301	1676	28.8	839	1108	32.1	462	568	22.9	79	29	-64.2
Shimla	2220	2392	7.7	1921	1776	-7.6	299	616	106.0	176	31	-82.4
Sirmaur	1019	1385	35.9	740	698	-5.7	279	687	146.2	111	56	-52.9
Solan	415	850	104.8	164	459	179.9	251	391	55.8	88	38	-58.2
Una	395	523	32.4	175	320	82.9	220	203	-7.7	27	0	-100.0
Total	**11780**	**14696**	**24.8**	**8911**	**9605**	**7.8**	**2869**	**5091**	**77.5**	**1845**	**301**	**-83.7**

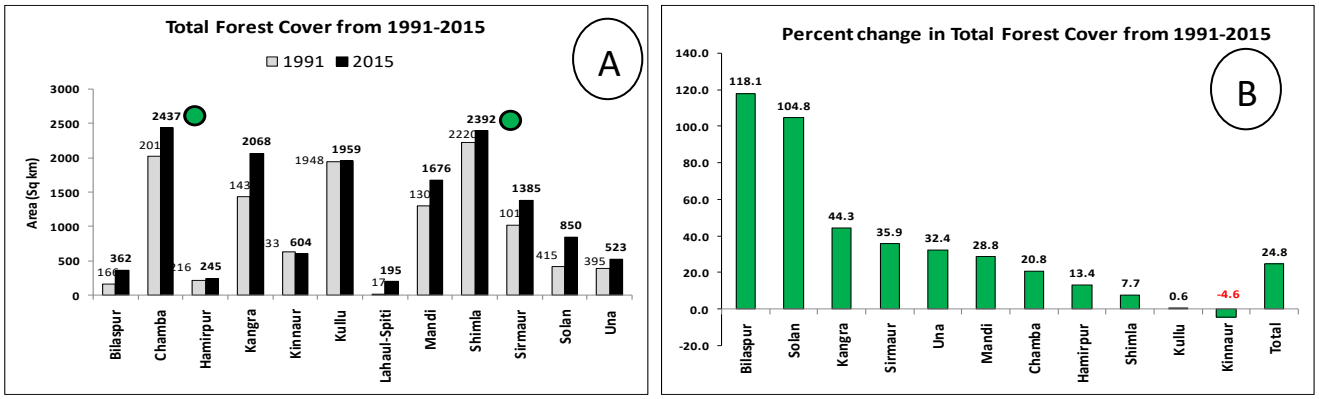

Figure 7 District-wise temporal trend analysis of area under total forest cover (A) and percent change (B)

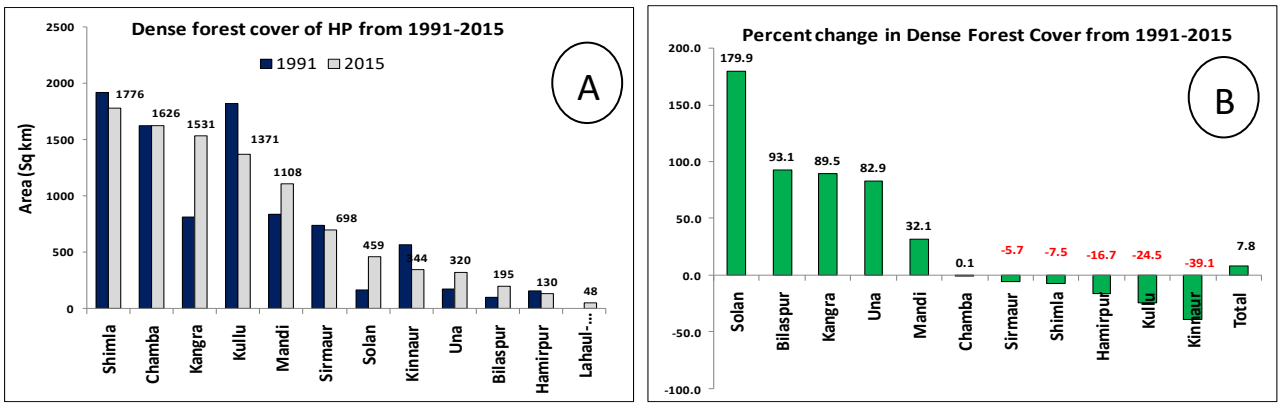

Figure 8 District-wise temporal trend analysis of area under dense forests (A) and percent change (B)

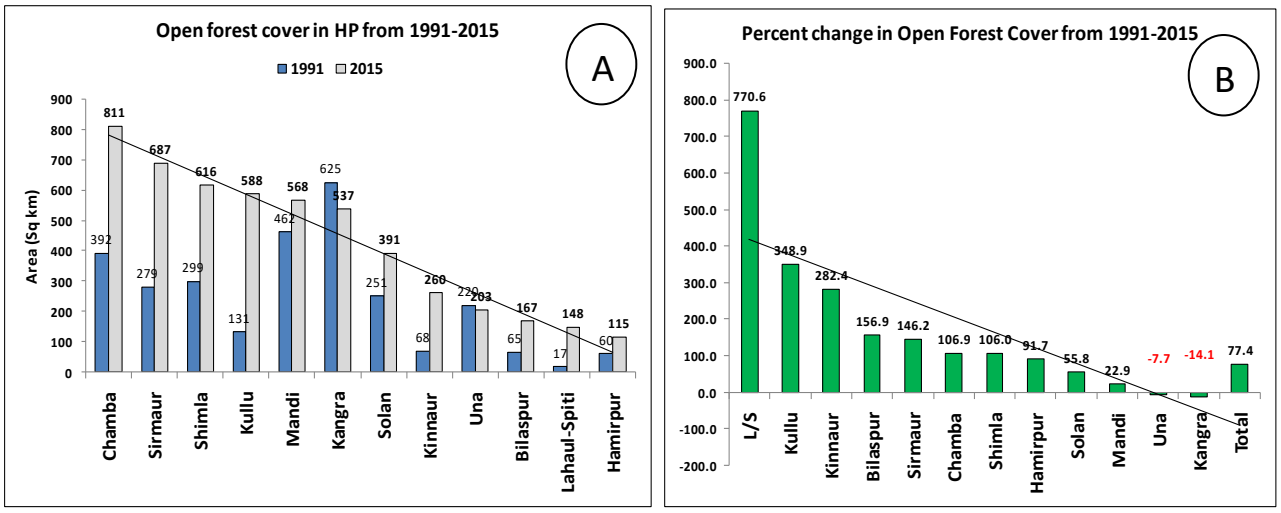

Figure 9 District-wise temporal trend analysis of area under open forests (A) and percent change (B)

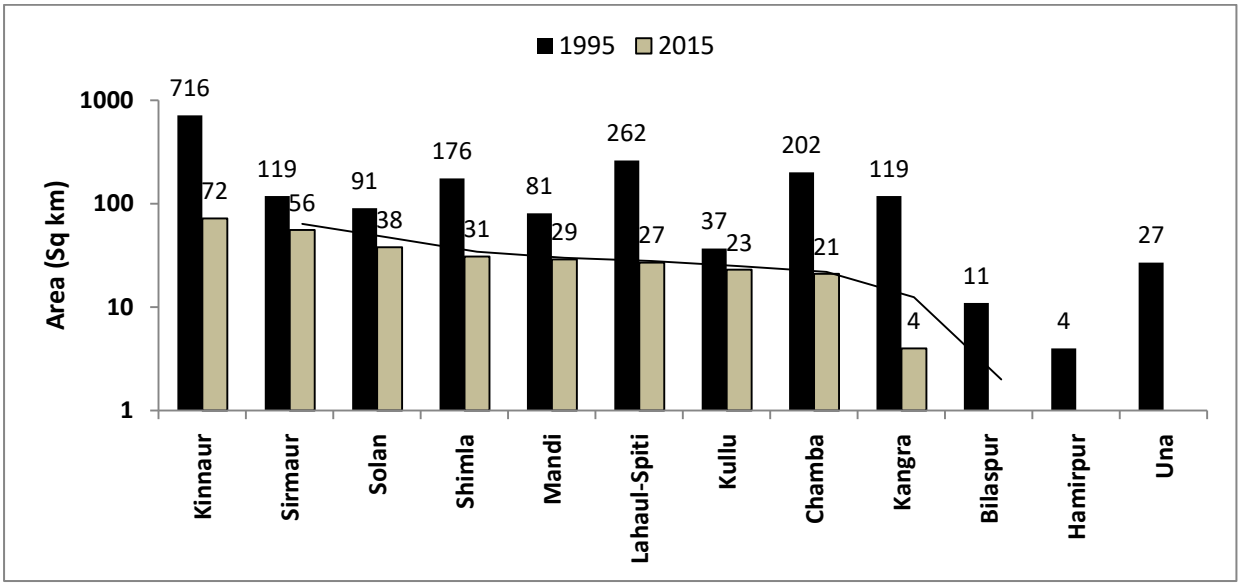

Figure 10 District-wise temporal trend analysis of area under scrubs in Himachal Pradesh

Vulnerability of forest of Himachal Pradesh to fires

Over the years, forest fire occurrence across the globe have engulfed vast tract of forest land besides resulting in soil degradation, change in climate condition and adverse impact on ecology. Vulnerability analysis primary entails information on regimes and forest strata that face frequent occurrence of forest fires due to various reasons. Remote sensing and GIS play an important role not only in detecting the active fire locations, but also help in assessment of fire risk based on several factor such as topography, climate and other biological factor. An increase in dryness period due to low rainfall leads to an increase in the dryness of the vegetation. The regions facing

frequent occurrences of forest fire may affect forest fire may affect forest strata, cause soil erosion, land degradation, variation in temperature and climate condition, affect wildlife and cause other serious impact.

Forest survey of India using Moderate Resolution Imaging Spectro-radiometer (MODIS) sensor data has been carrying out near real time monitoring of forests in various districts of India and Himachal Pradesh. Based on this data, the district-wise vulnerability of the forests is assessed in the states including Himachal using various parameters. Vulnerability analysis primarily entails information on regimes and forest strata that face frequent occurrence of forest fire due to various reasons. The analysis of the data revealed that 3rd week of February to 1st week of May has been crucial period of forest fire across the country as well as across the state. The temporal analysis of the number of fire incidences in the state showed that year 2008-09 (168) had maximum incidences followed by year 2009-10 (125) and 2007-08 (104) (Table 10). Furthermore, eight districts of the state were analysed for fire vulnerability studies by FSI and out of these some extent of the forest area in Una district was found to be highly vulnerable. A substantial area of different forest classes in the districts of Sirmaur and Solan was also found to be moderately vulnerable due to preponderance of chir-pine forests in these areas (Table 11). The vulnerability parameters are supported with ground data from the state forest department. The outcome of the study using suitable criteria building methods and local conditions can be used to prepare appropriate strategies for managing fires on scientific basis.

Table 10. Temporal data of forest fire incidences in various parts of Himachal Pradesh

S. No.	Year	Number of fire incidences
1	2004-05	9
2	2005-06	12
3	2006-07	48
4	2007-08	104
5	2008-09	168
6	2009-10	125
7	2010-2011	6

Table 11 Status of forest fire vulnerability in various districts of the state along the forest cover (Km2) (ISFR, 2011)

District	Vulnerability	VDF	MDF	OF	Scrub
Hamirpur	Less vulnerable	39	91	114	0
Kangra	Less vulnerable	310	1221	533	11
Kullu	Less vulnerable	586	785	588	23
Mandi	Less vulnerable	373	735	567	29
Shimla	Less vulnerable	739	1037	610	32
Sirmaur	Moderately vulnerable	130	568	687	56
Solan	Moderately vulnerable	55	404	391	38
Una	Highly vulnerable	18	302	203	0

Abbreviations: MDF=Moderately Dense Forest; OF=Open Forest; VDF=Very Dense Forest

Issues and concerns

Degradation of forests in the Himachal Pradesh has a compounded effect, owing to the fragility in this part of Himalaya. The Himalayan forest resources are under tremendous pressure. Intensified cultivation, indiscriminate removal of timber, fuel wood, fodders and other forest produce, forest fire and encroachment has led to forest degradation and deforestation. The loss and degradation of forest results in soil erosion, loss of biological, damage to wildlife habitats and degradation of watershed areas and deterioration of the quality of life (Sharma and Chand, 2014). The cumulative effects of deforestation, forest degradation and changes in the species composition of forests in the long run may have far reaching adverse impacts on people, livelihoods, sustainability and the forest ecosystem services in the state.

Fuelwood and fodder are extracted by local residents to sustain their livelihood. Due to diverse climatic conditions and socio-economic status, there is spatio-temporal pattern of fuelwood extraction. Quantity of fuelwood extracted is higher in winter season as compared to summer. Similarly, the high altitude areas of the state experience heavy snowfall and hence are very cold hence the consumption of fuelwood here is therefore comparatively very high. However the extraction of fuelwood to a minor extent can be controlled by providing alternatives. Moreover, the people of the Himachal Pradesh are rearing fewer cattle today due to scarcity of fodder, as a result the fuel requirements which were to some extent met through cow dung cakes, are now

solely dependent on forests (Gouri *et al.*, 2004) such as those of oak which are facing the problem of severe degradation. The total annual consumption of rural domestic fuel in the state is around 2.5 to 3.2 million tones, half of which is extracted from public forests (Singh and Sikka, 1992). However, extraction of fodder for livestock remains the primary threat to forests. In addition to the above, the forests in the state are burnt periodically by the villagers to encourage the growth of grasses and this increases the prevalence of fire-resistant species such as chir-pine. The aggressiveness of chir pine and its capacity to colonize disturbed sites have enabled it to spread at the expense of ban oak forests which are under immense biotic pressure (Singh and Singh, 1984). A decrease in the area of ban oak may be attributed to heavy anthropogenic pressure on oak forests in hill states which results in indiscriminate lopping of the species. Ban oak is a multipurpose species having a good fodder and fuel quality; hence, it is under a high biotic stress in Himachal forests (Saxena *et al.*, 1978; Tiwari and Singh, 1982; Bankoti *et al.*, 1986; Joshi and Tiwari, 2011). Decrease in the area of ban oak may also be due to poor regeneration observed in these forests compared to forests of chir-pine in ground surveys of the study area as the regeneration potential of chir-pine is greater than that of ban oak species.

The forests which have broad-leaved species tend to be more useful and therefore more degraded than coniferous forests. The former are of greater utility due to the finer quality of fuel and fodder, and are also a source of several non-timber forest products. A successive decrease in the forests area of various districts of the state under broadleaved species which includes, *Terminalia belerica*, *T. chebula, Dalbergia sissoo, Albizzia chinensis Pyrus pashia, Juglans regia* and *Celtis australis etc.* has also been observed in the Himachal Pradesh and it is primarily due to the anthropogenic pressure of the forest fringe communities.

In addition to the direct consumptive value and pressures on the forests, indirect impacts on the forests are very high. And in majority of cases, these indirect pressures are far more adverse. For long-term sustainability of Himalayan ecosystems, it has been estimated that the ratio between forests to cultivated land should be a minimum of 2:1 (Singh and Ahuja 2006). Therefore, the recent shifts in intensive agriculture patterns have added further pressures on the forests. Another constantly increasing indirect pressure has come up from the tourism industry in the state which is showing

increasing trend year after year. With more than 200% increase in the number of tourists in some parts of the state (Shah and Mazari 2007), up-gradation of infrastructural facilities becomes necessary. Amongst these, increase in the number of hotels is very prominent. The forests around settlements are relatively more degraded as compared to the forests far away from habitations. This can be attributed to the concentrated extraction of resources from these few preferred areas.

Impact of Climate Change

The immediate repercussions of climate change on the forests are visible in the form of shifting tree line to higher altitudes. Available data on climate suggested that by year 2100, under the most probable scenario temperature of the state is likely to increase by 3^0 and precipitation will decrease by 20% and in that situation the effect will be more visible and alarming also. Himalayan ecosystems are projected to be extremely sensitive under future climate (Chaturvedi *et al*., 2011). Himachal Pradesh, being a part of the Himalayan mountain ecosystem, hosts a unique forests and diverse habitats with large altitudinal variations. Any change in temperature or rainfall pattern will adversely impact the entire ecosystem. Further, Himalayan ecosystems are highly vulnerable due to the stress caused by forest land diversion, increasing pressure from human population, exploitation of natural resources, infrastructure development, mining, and other related challenges. The effect of these current stressors is likely to be exacerbated due to climatic changes, which would be additional (Ravindranath *et al*., 2006). Observed impacts of historical trends include movement of apple orchards to higher altitudes, loss of certain tree species, drying of traditional water sources, reduction in crop yields, and increased vulnerability of winter cropping due to changes in rain fall patterns and planting dates (ADB, 2010). In a study of district level mapping of the state using a composite of biophysical, social and technological indicators (1960–1990) showed lowest adaptive capacity for Chamba and Kullu and highest adaptive capacity for Kangra, Hamirpur, Una, Solan and Sirmour districts. The districts of Hamirpur, Una, Solan, Bilaspur and Sirmaur have been categorised as highly exposed and vulnerable towards climate change whereas, Kullu and Shimla have medium level of vulnerability (O'Brien *et al*., 2004).

For developing a strategy to confront the climate change for forest ecosystems it is useful to consider both, the current vulnerabilities as well as likely impacts on forests

under 'future climate' scenario (Upgupta *et al*. 2015). Further, by protecting the state's rich natural resources which assumes greater importance since this would not only impact the very sustenance of the indigenous communities in the mountainous state of Himachal Pradesh but also the downstream agro-ecosystem.

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