

Deforestation and Forest Cover Changes in the Himachal Himalaya, India

HEMANT K GUPTA

Regional Director, Forest Survey of India, Northern Zone, Shimla 171001, Himachal Pradesh, India

E-mail: ghemant_sml@hotmail.com, hemantgup@gmail.com

ABSTRACT

The extent of forest cover resources on land surface governs many important earth system ecological processes and is the foremost requirement characterizing sustainable forest management. The extent of forest area and decline in forest resources due to deforestation and changes in forest cover have been estimated by conventional and remote sensing techniques by various agencies for India and state of Himachal Pradesh (HP) located in the Western Himalayas. The various forest cover assessments by National Remote Sensing Agency (NRSA) and Forest Survey of India (FSI) shows that deforestation has been halted since 1980s onwards and forest cover has been stabilized in HP. During the nine biennial forest cover assessment conducted by FSI since 1987 onwards the estimated forest and tree cover have shown an increase, until 2001 assessment and minor decline of 7 km² during 2003 assessment in HP. The changes with in forest cover between dense forest to open forest however indicates decline in the productivity of forests. State of Forest Report (SFR) 2003 estimates 778,229 km² (23.65 %) of total geographical area of India under forest and tree cover, whereas, in HP recorded forest area constituted 66.52 % of its geographical area and only 26.66 % area is under forest and tree cover. National Forest Policy 1988 needs to be modified since analysis shows that in HP only 35.5 % geographical area is capable of sustaining forest and tree cover against 66 % envisaged by policy to be brought under forest and tree cover in mountainous and hill states of India.

Key Words: Forest Cover Assessment, Forest and Tree Cover, Forest Policy, Forest Degradation, Deforestation, Change Matrix.

INTRODUCTION

Forests are important source of subsistence, employment, revenue earnings, and raw materials to a number of industries and also play vital role in ecological balance, environmental stability, biodiversity conservation, food security and sustainable development of a country or region. The extent of forest cover on the land surface governs many important earth system ecological processes. The extent of forest resources is the foremost requirement characterizing sustainable forest management. It refers to overall goal of maintaining adequate forest cover and stocking of various forest types and characteristics including tree outside forest to support the social, economic and environmental objectives related to forestry within a county and region. The ultimate aim of monitoring the extent and characteristics of forest resources is to reduce unplanned deforestation; restore and rehabilitate degraded forest

landscapes, manage forest sustainably and evaluate the important function of carbon sequestration by forest and tree outside forest thereby contributing to moderating the global climate. Information on extent of forest resources by way of deforestation and forest cover changes provides a first indication of relative importance of forest in a country or region and is easily understood baseline variable. Estimates of changes in forest areas over time provide an indication of the demand for land for forestry and other land uses, as well as of the impact of significant environmental disaster and disturbances on forest ecosystems (FAO 2005).

The forest resources, in general, have been under mounting pressure owing to increasing human and livestock population. Excessive withdrawals of products have resulted in the depletion and degradation of country's forests and have become a cause of serious concern for the government and the people. For this purpose, it is required to conduct assessment and

monitoring of forest resources on a regular basis. Although, a majority of forest lands happened to be within recorded forest areas, all the changes in forest cover are not necessarily due to changes in forest managed by forest department. It is important from policy and planning point of view to know the extent and quality of forest cover with in recorded forest areas and outside it (FAO 1997; GOI 1999). There is controversy as to the global rate of deforestation and there is need to identify and document deforestation process and monitor the status.

Information on forest cover in India over last five decades can be obtained from three sources, viz, (i) year-wise land use statistics compiled by the Ministry of Agriculture which is based on revenue record (ii) Ministry of Environment and Forests compiles information on forest area based on legal status of land and the source of information is State Forest Departments and (iii) assessment of forest cover using modern technology of remote sensing. Forest area figures obtained from the first two sources is shown in (Table 1). It shows that the recorded forest area of the country in 1951 was 71.80 Mha (Mha = million ha) and it increased to 77 Mha in 1991, showing an increase of about 7 %. Forest area as per records of Ministry of Agriculture shows an increase of about 68 % in the last five decades but it is mostly because of discrepancies in the revenue records of earlier period. Maximum increase was observed in the first two decades (i.e.1951-61 and 1961-71). The difference in the two sources of information is mainly due to the fact that though lot of area has been notified as recorded forests by the respected State/UT Governments, yet proper survey and demarcation have not been updated.

Table 1. Forest area in last five decades (in million ha)

| Year | Recorded Forest | Forest area as land use |
|------|-----------------|-------------------------|
| 1951 | 71.80 (21.84) | 40.48 (14.24) |
| 1961 | 68.96 (20.98) | 54.19 (18.09) |
| 1971 | 74.83 (22.76) | 63.77 (21.03) |
| 1981 | 75.00 (22.82) | 67.47 (22.19) |
| 1991 | 77.00 (23.42) | 67.87 (22.24) |

Source: *Ministry of Environment and Forests,

** Ministry of Agriculture

Figures in parentheses are percent of geographic area/ reported area

In a number of cases, settlement dispute and encroachment cases related to forest lands have not been settled (FSI 2003). Though more than one-fifth of India's geographic area is recorded as forest area, it was not known with certainty how much forest area actually bears forest cover before the assessment of forest cover using remote sensing technology.

The National Forest Policies (1952-1988) aim at having one-third of country's land area under forest and tree cover. Therefore, unless one has information on area bearing forest and tree cover, it can not be said with certainty how much more area is required is to be brought under forest and tree cover to achieve the goal set by the National Forest policy. It requires huge human and material resources to assess forest cover of the country using traditional survey methods. However, in the early eighties, National Remote Sensing Agency (NRSA), Hyderabad, Department of Space, took the initiative of assessing forest cover of the country using remote sensing technology. NRSA analyzed satellite data pertaining to the period 1972-75 and 1980-82, and estimated forest cover of the country to be 55.52 million ha and 46.35 million ha for the respective periods. As per the assessment made by NRSA India's forest cover was 16.89% of geographic area in 1972-75 and it came down to 14.10% in 1980-82. Though this assessment had short comings, it was a land mark development in the history of forest survey in India as for the first time use of satellite data for assessment of forest cover in the country was demonstrated (Agarwal et al 1999; FSI 2003).

Almost simultaneously, Forest Survey of India (FSI), an organization under the Ministry of Environment and Forests, Government of India, which was mandated to undertake forest survey of the country using conventional ground inventory, also developed the capability of interpreting satellite data for assessment of forest cover. It published its first assessment of forest cover in 1987 based on satellite data of 1981-83. Its initial estimates of forest cover of the country were 64.80 million ha (19.70% of the geographic area). A reconciliation exercise between NRSA and FSI led to the final figure 64.20 million ha (19.52 %) of forest cover in India. Later, the FSI started assessing forest cover by estimating the gross net deforestation (or change in forest cover) status of the country on a biennial basis and the findings are reported in the State of Forest Report (SFR), a biennial publication.

The first seven SFRs (1987 to 1999) gave information of only forest cover while later SFR's (2001 and 2003) provided information of forest cover as well

as tree cover. The extent of forest cover in first seven assessments and that of forest and tree cover in the eighth and ninth assessment for India, 12 districts of Himachal Pradesh are analyzed based on nine SFR's published by FSI and correlated with the results and discussion of other studies for reasons of forest cover change in the state and policy on forest cover.

Definitions

Deforestation is the removal of the tree crop from a piece of land, without the intention of reforesting it, often to use land for cultivation, mining, road construction and for use of the wood as fuel or for commercial logging. As per FAO, deforestation means conversion of any forest (natural, modified, or planted) to other uses, e.g. cropland, pastures, or urban land.

Forest degradation means reduction in productivity and/or diversity of a forest due to unsustainable harvesting (removals exceeding replacements, changes in species composition, etc.), fire (except for fire-dependent forest systems), pests and diseases, removal of nutrients, and pollution or climate change (e.g. changes in productivity, total organic matter, and forest composition).

Forest cover: All lands, more than one hectare in area with a tree canopy density of more than 10 percent. Such lands may not be statutorily notified as forest area.

Forest area: Geographic area recorded as forest in government records. It is also referred to as 'recorded forest area'.

Dense forests: All lands with a forest cover having a canopy density of 40% and above.

Open forest: All lands with a forest cover having a canopy density of 10 to 40%.

Scrub: All lands, generally in and around forest areas, having bushes and/or poor tree growth chiefly of small or stunted trees with canopy density less than 10%.

Tree cover: Tree cover refer to the computed area covered by crown of trees that is too small to be delineated by digital interpretation of remote sensing data used for forest cover delineation.

Tree outside Forests: Tree wealth existing outside recorded forest areas.

Non-Forest Area: Geographic area outside recorded forest area.

Digital Image Processing (DIP): Interpretation and classification of land use or land cover from digital data (from remote sensing satellites) using computer-aided technology.

Visual Interpretation: a non-computer based method of satellite data interpretation, normally by using magnifying glass and light table.

STUDY AREA

The Indian Himalayas cover an area of 523,000 km² representing 16 per cent of the total area of the country. The whole Himalayan region corresponds to 38 per cent the total land resources in India. The Himalayas are sub-divided into Western and Eastern Himalaya. Out of 14 physiographic zones in India, western Himalayas has geographical area of 338,556 km² and recorded forest area of 98,165 km² spreading over state of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Sikkim and Darjeeling of West Bengal, Gurdaspur, Hoshiarpur and Roopnagar of Punjab are partially covered (Negi 2000).

Himachal Pradesh is almost wholly mountainous with altitudes ranging from 350 meters to 6,975 meters above the mean sea level (Figure 1). It is located between 30°22' 40"N to 33°12' 20"N latitudes and 75°45' 55"E to 79°04' 20"E longitudes. It has a deeply dissected topography, complex geological structure and a rich temperate flora in the sub-tropical latitudes. Physiographically, the state can be divided into following five zones:

Wet Sub-temperate zone: Palampur and Dharamsala of district Kangra, Jogindernagar area of district Mandi and Dalhousie area of district Chamba.

Humid Sub-temperate zone: Districts Kullu, Shimla, parts of district Mandi, Solan, Chamba, Kangra and Sirmour.

Dry Temperate-alpine Highlands: Major parts of district Lahaul-Spiti, Pangi of district Chamba and district Kinnaur.

Humid Sub-tropical zone: District Sirmour, Bhattiyat valley of district Chamba, Nalagarh area of district Solan, Dehragopipur and Nurpur areas of district Kangra.

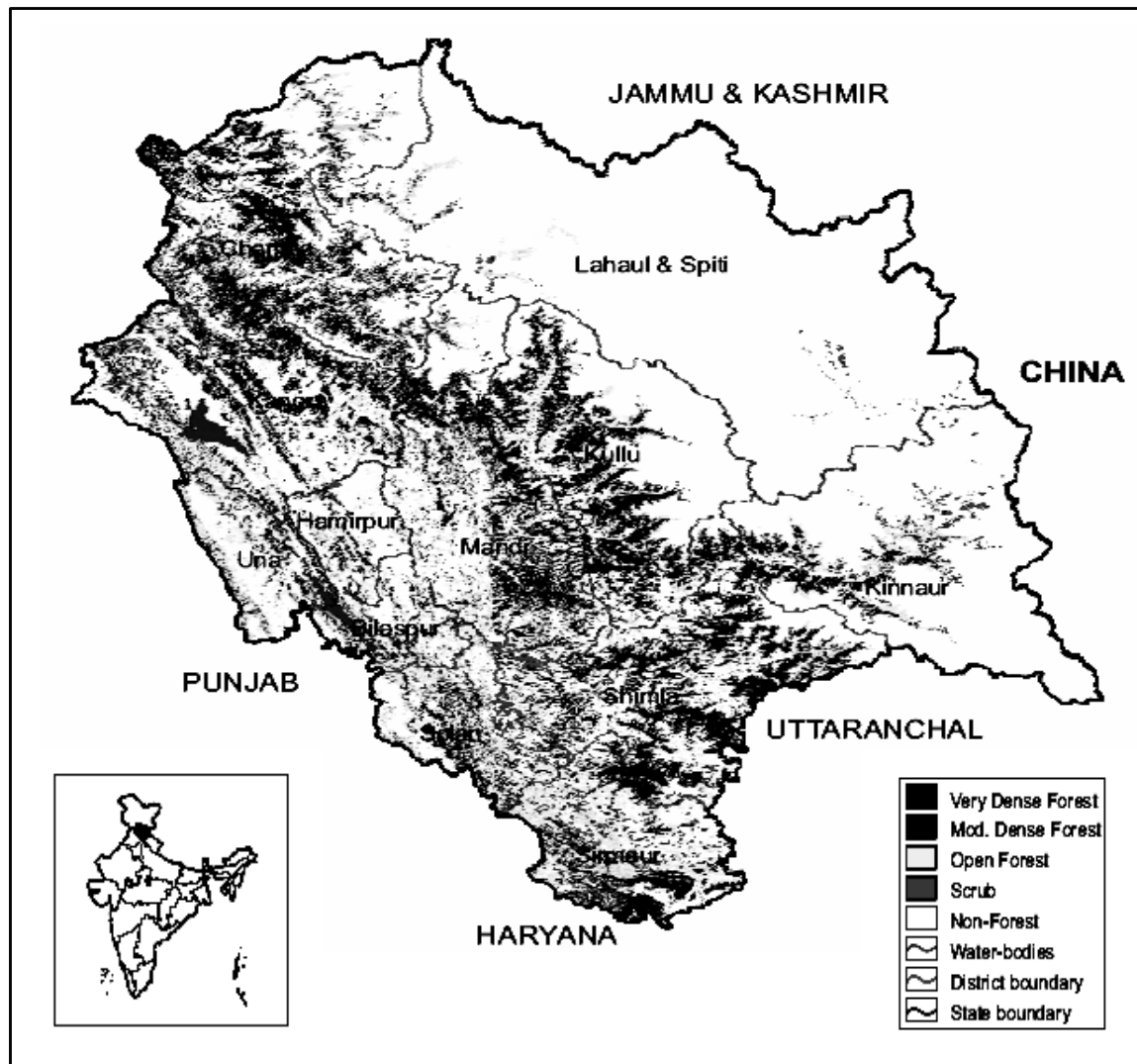


Figure 1. Study area

Sub-Humid Sub-tropical zone: Sirmour and Indora area of district Kangra.

Climatically, Himachal Pradesh can be divided into three zones (i) The *Outer Himalayas*, (ii) The *Inner Himalayas* and (iii) *Alpine zone*. The first zone gets annual rainfall between 1500 mm and 1750 mm. In the second zone, it varies between 750 mm to 1000 mm and the Alpine zone remains under snow for about five to six months. The average annual rainfall in the state is about 1600 mm. The climate varies between hot and humid in the valley areas to freezing cold in the home of perpetual snow.

The forest and other natural ecosystems of region are crucial for its environmental, ecological and

economic well-being having its impact on Indo-Gangetic plains. Forests are primary livelihood source for the rural population and source of fresh water for both urban and rural population. Forests, besides performing important ecological functions, provide essential services, like food, fuel wood, fodder, timber, raw material for forest based industries and non-timber forest products. Due to large differences in altitude and precipitation, the forest vegetation types in this region range from tropical to alpine. The forests of HP is characterized by temperate conifer, mixed forest (Himalayan moist and dry temperate forests), sub-alpine forest, tropical moist deciduous, sub-tropical pine forests and broad leaved forests (tropical dry deciduous and sub-tropical dry evergreen forests (Joshi et al 2001). As per records nearly

66% of the geographical area of Himachal Pradesh is forestlands; however, the extent of actual forest cover on all categories of land is 26 % only. The area recorded as forests, however does not reveal about the actual coverage or quality of forest, and the parallel process of diversion of forest land for non-forestry purpose. The deterioration of the quality, stocking condition and productivity of forests is a matter of serious concern as is deforestation (Negi 1991, GOI 1999).

MATERIALS AND METHODS

The forest cover assessment is principally based on interpretation of satellite data. The techniques of assessment have changed and improved over time owing to development in technology in the fields of remote sensing, data acquisition and processing and improvements in the skills of technical personnel. For the first assessment, reported in SFR 1987, the satellite data was interpreted visually at a scale of 1:1 million. The subsequent assessments till 1999 were based on visual interpretation of satellite data at a scale of 1:250,000. The SFR 2001 and 2003 are however based on digital interpretation of satellite data at 1:50,000 scales. An abstract of satellites, sensors and data properties used for various forest cover assessments carried out by FSI is shown in (Table 2).

The scale of interpretation imposes a limitation (called cartographic limit) on mapping of any geographic feature. For instance, at 1:250,000 scale, the smallest area of forest cover that could be delineated was 25 hectare (ha) while at 1:50,000 scale this limit comes

down to 1 ha. The implication of cartographic limit was that during the eighth and ninth assessment (2001 and 2003), smaller patches of forest and tree canopies (1 to 25 ha in extent), could also be detected and mapped. At the same time, small gaps and blanks inside forested areas could also be identified and delineated to the extent possible (Rawat et al 2003; Pandey 2000).

During the 2001 assessment, the cover on account of all other trees that could not be captured by the satellite data was also estimated. These trees comprise tree groves and woodlots smaller than 1 ha in area or narrow strips of tree plantation along linear features (e.g. roads, canals, bunds etc.) or scattered tree on farms, homesteads and urban areas. These were estimated using field inventory methods. Thus a complete assessment on forest and tree cover of the country was made during the eighth and ninth assessment. The first seven SFR's (1987 to 1999) gave information of only forest cover while SFR's (2001 and 2003) provided information of forest cover as well as tree cover. The district-wise information of forest cover change and population pressure in HP is derived from SFR's and census reports.

RESULTS

The aim of Forest Survey of India in monitoring forest resources is to know the dynamic changes of forest resources in terms of forest quantity and quality over a period of time. The comparative data of forest and tree cover as estimated by the FSI in its nine SFR's for India and Himachal Pradesh are shown in (Table 3).

Table 2. Satellite data for Forest Cover assessment (1987 to 2003)

| Assessment and Year | Data Sensor | Sensor Resolution | Data Form | Spatial Interpretation | Spectral | Scale of |
|----------------------|-------------|--------------------|---------------|------------------------|----------|-------------|
| 1 st 1987 | 1981-83 | Landsat – MSS | Hard Copy FCC | 80m | 4 Bands | 1:1 million |
| 2 nd 1989 | 1985-87 | Landsat – TM | Hard Copy FCC | 30m | 7 Bands | 1:250,000 |
| 3 rd 1991 | 1987-89 | Landsat – TM | Hard Copy FCC | 30m | 7 Bands | 1:250,000 |
| 4 th 1993 | 1989-91 | Landsat – TM | Hard Copy FCC | 30m | 7 Bands | 1:250,000 |
| 5 th 1995 | 1991-93 | IRS-1B LISS II | Hard Copy FCC | 36.25 m | 4 Bands | 1:250,000 |
| 6 th 1997 | 1993-95 | IRS-1B LISS II | Hard Copy FCC | 36.25 m | 4 Bands | 1:250,000 |
| 7 th 1999 | 1996-98 | IRS-1C/1D LISS III | Hard Copy FCC | 23.5 m | 4 Bands | 1:250,000 |
| 8 th 2001 | 2000 | IRS-1C/1D LISS III | Digital | 23.5 m | 4 Bands | 1:50,000 |
| 9 th 2003 | 2002 | IRS-1D LISS III | Digital | 23.5 m | 4 Bands | 1:50,000 |

Table 3. Forest and Tree cover of India and Himachal Pradesh in different SFR's (1987 to 2003)

| Cycle | Year of Publication | Forest cover estimates for India (km ²) | Percentage of total area of country | Forest cover estimates for Himachal Pradesh (km ²) | Percentage of the total area of state |
|-----------------------|---------------------|---|-------------------------------------|--|---------------------------------------|
| First | 1987 | 640,819 | 19.49 | 12,882 | 23.14 |
| Second | 1989 | 638,804 | 19.43 | 13,377 | 24.03 |
| Third | 1991 | 639,364 | 19.45 | 11,780 | 21.16 |
| Fourth | 1993 | 639,386 | 19.45 | 12,502 | 22.46 |
| Fifth | 1995 | 638,879 | 19.43 | 12,501 | 22.45 |
| Sixth | 1997 | 633,397 | 19.27 | 12,521 | 22.49 |
| Seventh | 1999 | 637,293 | 19.39 | 13,082 | 23.50 |
| Eighth | 2001 | 675,538 | 20.55 | 14,360 | 25.79 |
| Forest and Tree cover | | 757,009 | 23.03 | 14,757 | 26.50 |
| Ninth | 2003 | 678,333 | 20.64 | 14,353 | 25.78 |
| Forest and Tree cover | | 778,229 | 23.68 | 14,844 | 26.66 |

Table 4. Forest cover change of Himachal Pradesh (1972 to 2003)

| Assessment Year and Data Period | Forest Cover (km ²) | | | Forest Cover (km ²) | | | |
|---------------------------------|---------------------------------|-------------|--------|---------------------------------|----------------|------------|------------|
| | Dense Forest | Open Forest | Total | Scrub | Un-interpreted | Non-forest | GrandTotal |
| 1972-75* | 12,500 | 2,600 | 15,100 | - | - | - | - |
| 1980-82* | 6,700 | 2,400 | 9,100 | - | - | - | - |
| 1981-83 | 9,908 | 2,974 | 12,882 | 2,448 | - | 40,390 | 55,720 |
| 1985-87 | 7,100 | 6,277 | 13,377 | NA | NA | NA | 55,670 |
| 1987-89 | 8,911 | 2,869 | 11,780 | 1,918 | 18,967 | 23,008 | 55,673 |
| 1989-91 | 9,565 | 2,937 | 12,502 | 1,845 | - | 41,326 | 55,673 |
| 1991-93 | 9,565 | 2,936 | 12,501 | 1,845 | - | 41,327 | 55,673 |
| 1993-95 | 9,560 | 2,961 | 12,521 | 1,825 | - | 41,327 | 55,673 |
| 1996-98 | 9,120 | 3,962 | 13,082 | 566 | - | 42,025 | 55,673 |
| 2000 | 10,429 | 3,931 | 14,360 | 566 | - | 40,747 | 55,673 |
| 2002 | 8,976 | 5,377 | 14,353 | 389 | - | 40,931 | 55,673 |

Note: *Year represent on indicative period of data collection by NRSA. A large difference in, figures for open forest cover between 1972-75 and 1980-82 are due to difference in definitions used by the NRSA and FSI.

Forest Cover Change of Himachal Pradesh

The estimated forest cover change in Himachal Pradesh from 1972 to 2003 is shown in Table 4. The difference in data between 1972-75, 1980-82 and after 1981-83 is because it was collected by NRSA and FSI respectively using different methodology and criteria. The estimated forest cover change in 12 districts of Hima-

chal Pradesh based on SFR's from 1991 to 2003 is shown in Table 5.

Forest cover change and variations in dense and open forests with in districts is shown in (Table 5). There was an overall increase in forest area up to year 2001 in HP, while there are variations within districts. As for example, 7 districts i.e. Hamirpur (-32 km²), Kangra (-163 km²), Kinnaur (-34 km²), Kullu (-182

Table 5. District-wise forest cover change of Himachal Pradesh from 1991 to 2003 (in km²)

| District | Forest | 1991 | 1993 | Change | 1995 | Change | 1997 | Change | 1999 | Change | 2001 | Change | 2003 | Change |
|------------------|--------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Bilaspur | Dense Forest | 101 | 49 | -52 | 49 | 0 | 59 | +10 | 65 | +6 | 135 | +70 | 105 | -30 |
| | Open Forest | 65 | 108 | +43 | 108 | 0 | 99 | -9 | 170 | +71 | 166 | -4 | 253 | +87 |
| | Total | 166 | 157 | -9 | 157 | 0 | 158 | +1 | 235 | +77 | 301 | +66 | 358 | +57 |
| Chamba | Dense Forest | 1,625 | 1,801 | +176 | 1,767 | -34 | 1,768 | +1 | 1,585 | -183 | 1,652 | +67 | 1,566 | -86 |
| | Open Forest | 392 | 323 | -69 | 293 | -30 | 293 | 0 | 716 | +423 | 690 | -26 | 847 | +157 |
| | Total | 2,017 | 2,124 | +107 | 2,060 | -64 | 2,061 | +1 | 2,301 | +240 | 2,342 | +41 | 2,413 | +71 |
| Hamirpur | Dense Forest | 156 | 151 | -5 | 151 | 0 | 150 | -1 | 93 | -57 | 181 | +88 | 109 | -72 |
| | Open Forest | 60 | 62 | +2 | 72 | +10 | 73 | +1 | 95 | +22 | 93 | -2 | 133 | +40 |
| | Total | 216 | 213 | -3 | 223 | +10 | 223 | 0 | 188 | -35 | 274 | +86 | 242 | -32 |
| Kangra | Dense Forest | 808 | 1,071 | +263 | 1,071 | 0 | 1,071 | 0 | 1,338 | +267 | 1,719 | +381 | 1,386 | -333 |
| | Open Forest | 625 | 684 | +59 | 673 | -11 | 673 | 0 | 301 | -372 | 311 | +10 | 481 | +170 |
| | Total | 1,433 | 1,755 | +322 | 1,744 | -11 | 1,744 | 0 | 1,639 | -105 | 2,030 | +391 | 1,867 | -163 |
| Kinnaur | Dense Forest | 565 | 547 | -18 | 547 | 0 | 541 | -6 | 436 | -105 | 432 | -4 | 365 | -67 |
| | Open Forest | 68 | 82 | +14 | 82 | 0 | 91 | +9 | 213 | +122 | 215 | +2 | 248 | +33 |
| | Total | 633 | 629 | -4 | 629 | 0 | 632 | +3 | 649 | +17 | 647 | -2 | 613 | -34 |
| Kullu | Dense Forest | 1,817 | 1,911 | +94 | 1,911 | 0 | 1,907 | -4 | 1,631 | -276 | 1,749 | +118 | 1,412 | -337 |
| | Open Forest | 131 | 133 | +2 | 133 | 0 | 137 | +4 | 343 | +206 | 366 | +23 | 521 | +155 |
| | Total | 1,948 | 2,044 | +96 | 2,044 | 0 | 2,044 | 0 | 1,974 | -70 | 2,115 | +141 | 1,933 | -182 |
| Lahul & Spiti | Dense Forest | 0 | 15 | +15 | 49 | +34 | 49 | 0 | 34 | -15 | 36 | +2 | 35 | -1 |
| | Open Forest | 17 | 4 | -13 | 34 | +30 | 34 | 0 | 116 | +82 | 118 | +2 | 145 | +27 |
| | Total | 17 | 19 | +2 | 83 | +64 | 83 | 0 | 150 | +67 | 154 | +4 | 180 | +26 |
| Mandi | Dense Forest | 839 | 848 | +9 | 848 | 0 | 848 | 0 | 982 | +134 | 1,112 | +130 | 1,011 | -101 |
| | Open Forest | 462 | 461 | -1 | 461 | 0 | 467 | +6 | 557 | +90 | 544 | -13 | 637 | +93 |
| | Total | 1,301 | 1,309 | +8 | 1,309 | 0 | 1,315 | +6 | 1,539 | +224 | 1,656 | +117 | 1,648 | -8 |
| Shimla | Dense Forest | 1,921 | 2,094 | +173 | 2,094 | 0 | 2,084 | -10 | 1,808 | -276 | 1,878 | +70 | 1,781 | -97 |
| | Open Forest | 299 | 331 | +32 | 331 | 0 | 341 | +10 | 582 | +241 | 566 | -16 | 602 | +36 |
| | Total | 2,220 | 2,425 | +205 | 2,425 | 0 | 2,425 | 0 | 2,390 | -35 | 2,444 | +54 | 2,383 | -61 |
| Sirmour | Dense Forest | 740 | 740 | 0 | 740 | 0 | 736 | -4 | 742 | +6 | 755 | +13 | 687 | -68 |
| | Open Forest | 279 | 279 | 0 | 279 | 0 | 288 | +9 | 366 | +78 | 357 | -9 | 692 | +335 |
| | Total | 1,019 | 1,019 | 0 | 1,019 | 0 | 1,024 | +5 | 1,108 | +84 | 1,112 | +4 | 1,379 | +267 |
| Solani | Dense Forest | 164 | 164 | 0 | 164 | 0 | 173 | +9 | 274 | +101 | 459 | +185 | 353 | -106 |
| | Open Forest | 251 | 254 | +3 | 254 | 0 | 249 | -5 | 218 | -31 | 224 | +6 | 466 | +242 |
| | Total | 415 | 418 | +3 | 418 | 0 | 422 | +4 | 492 | +70 | 683 | +191 | 819 | +136 |
| Una | Dense Forest | 175 | 174 | -1 | 174 | 0 | 174 | 0 | 132 | -42 | 321 | +189 | 166 | -155 |
| | Open Forest | 220 | 216 | -4 | 216 | 0 | 216 | 0 | 285 | +69 | 281 | -4 | 352 | +71 |
| | Total | 395 | 390 | -5 | 390 | 0 | 390 | 0 | 417 | +27 | 602 | +185 | 518 | -84 |
| Himachal Pradesh | Dense Forest | 8,911 | 9,565 | +654 | 9,565 | 0 | 9,560 | -5 | 9,120 | -440 | 10,429 | +1,309 | 8,976 | -1,453 |
| | Open Forest | 2,869 | 2,937 | +68 | 2,936 | -1 | 2,961 | +25 | 3,962 | +1,001 | 3,931 | -31 | 5,377 | +1,446 |
| | Total | 11,780 | 12,502 | +722 | 12,501 | -1 | 12,521 | +20 | 13,082 | +561 | 14,360 | +1,278 | 14,353 | -7 |

km²), Mandi (-8 km²), Shimla (-61 km²) and Una (-84 km²) have shown decrease, whereas Bilaspur (+57 km²), Chamba (+71 km²), Lahul and Spiti (+26 km²), Sirmour (+267 km²) and Solan (+136 km²) have shown increase in SFR 2003, with over all net decrease of forest cover of 7 km².

Forest Cover Change Matrix (SFR 2001 & 2003)

The 'Forest Cover Change Matrix' describes the change in forest cover for a given region (state or UT) over a period of two assessments by showing the extent of areas changing from one class of land cover to another between the two periods. Forest cover change matrix shows that there has been a net decrease of 1453 km² of dense forests and 177 km² of scrub forests in Himachal Pradesh between eighth (2001) and ninth (2003) assessments, whereas there is an increase of 1446 km² of open forests and 184 km² of non-forests. Thus, the overall area remaining same, there has been a shift with in four categories of forests. The forest cover change matrix of HP is shown in (Table 6).

Table 6. Forest cover change (km²) matrix of Himachal Pradesh for the period 2001 to 2003

| Forest type | Total change | Dense | Open | Scrub | Non-forest |
|-------------|--------------|--------|--------|-------|------------|
| Dense | 10,429 | 8,146 | 1,126 | 20 | 1,137 |
| Open | 3,931 | 661 | 2,892 | 7 | 371 |
| Scrub | 566 | 20 | 140 | 196 | 210 |
| Non-forest | 40,747 | 149 | 1,219 | 166 | 39,213 |
| Total | 55,673 | 8,976 | 5,377 | 389 | 40,931 |
| Net Change | | -1,453 | +1,446 | -177 | +184 |

After the publication of results of SFR 2003, ground verification was carried out in HP during 2006, and it was found that there has been a real increase of 6 km² in the dense forest cover and 64 km² in the open forest cover. The increase in dense forest cover is due to plantation efforts in Solan (45 km²), Bilaspur (12 km²) and Sirmour (7 km²) districts with Chir (*Pinus roxburghii*), Khair (*Acacia catechu*) and Eucalyptus. This discrepancy has been attributed due to significant change made in the methodology during the year 2000 wherein the scale of interpretation was reduced from 1:250,000 to 1:50,000 so as to delineate the forest cover down to 1 ha which was earlier 25 ha. As a result,

a large number of patches between 1 and 25 ha were picked up and delineated. Thus, the density of these patches was overestimated due to limited ground verification which was published in SFR 2001 and has affected the results of 2003 assessment. Subsequently detailed field verification was made in HP, in which many of these patches were found under open forest or non-forest category thus leading to the shift with in four categories of forests, showing overall increase of 6 km² in dense forests (FSI 2006).

Population Pressure and Forest Cover

Based on population of HP as per 2001 census and percentage of forest cover as per SFR 2003 in each district vary considerably from 1.30 % in Lahul and Spiti to 48.81 % in Sirmour district. Similarly per capita forest area is 0.06 ha in Hamirpur district to 0.78 ha in Kinnaur district (Table 7)

DISCUSSION

Trends in Change of Indian Forest

The SFR 2003 assessed the actual forest cover area in India 678,333 km² or 20.64 % (Dense forest 390,564 km² and Open forest 287,769 km²) of its geographic area as against 675,538 km² or 20.55 % (Dense forest 416,809 km² and Open forest 258,729 km²) assessed in SFR 2001. Thus, there was a decrease of 26,245 km² in dense forest and increase of 29,040 km² in open forest during 2003.

The dense forest cover has reduced from 46.42 Mha in 1972 to 36.73 Mha in 1995-97, while 1995-97 dense forest cover reduced by 1.7 Mha and open forest cover increased by 1.2 Mha, thereby indicating conversion of dense forest to open and some to shrub forests (Khare et al, 2000). In 1946-47, i.e. immediately before independence, the recorded area under forests in the provinces of British India (excluding the area that was transferred to Pakistan as a result of partition) was 39.94 Mha (Lal 1989). This increased to 76.52 Mha in 1993-95 even when actual forest cover declined significantly. Of the 62.7 Mha of forest area in the late 1940s, the area under control of the Forest Department was 44.35 Mha (70.7 %) (Pachauri and Sridharan 1998). By the early 1980s, the combined pressure of commercial exploitation and expanding population had caused serious damage to India's forests. Between 1975 and 1982, India lost 1.4 Mha of forests. At the same

Table 7. Population pressure and forest cover in various districts of Himachal Pradesh

| District | Geographical area (km ²) | Forest Area 2002-03 (km ²) | Population 2001 Census | Forest Cover SFR 2003 (km ²) | Forest cover to Geographic area (%) | Forest area Geographic area (%) | % of total forest area in the district | Per capita forest cover (ha) |
|-------------|--------------------------------------|--|------------------------|--|-------------------------------------|---------------------------------|--|------------------------------|
| Bilaspur | 1,167 | 428 | 340,885 | 358 | 30.68 | 36.68 | 1.16 | 0.11 |
| Chamba | 6,522 | 5,030 | 460,887 | 2,413 | 37.00 | 77.12 | 13.58 | 0.52 |
| Hamirpur | 1,118 | 219 | 412,700 | 242 | 21.65 | 19.59 | 0.59 | 0.06 |
| Kangra | 5,739 | 2,842 | 1,339,030 | 1,867 | 32.53 | 49.52 | 7.67 | 0.14 |
| Kinnaur | 6,401 | 5,093 | 78,334 | 613 | 9.58 | 79.57 | 13.75 | 0.78 |
| Kullu | 5,503 | 4,952 | 381,571 | 1,933 | 35.13 | 89.99 | 13.37 | 0.51 |
| Lahul&Spiti | 13,841 | 10,133 | 33,224 | 180 | 1.30 | 73.21 | 27.36 | 0.54 |
| Mandi | 3,950 | 1,860 | 901,344 | 1,648 | 41.72 | 47.09 | 5.02 | 0.18 |
| Shimla | 5,131 | 3,418 | 722,502 | 2,383 | 46.44 | 66.61 | 9.23 | 0.33 |
| Sirmour | 2,825 | 1,843 | 458,593 | 1,379 | 48.81 | 65.24 | 4.98 | 0.30 |
| Solan | 1,936 | 728 | 500,557 | 819 | 42.30 | 37.60 | 1.97 | 0.16 |
| Una | 1,540 | 487 | 448,273 | 518 | 33.64 | 31.62 | 1.32 | 0.12 |
| Total | 55,673 | 37,033 | 6,077,900 | 14,353 | 25.78 | 66.52 | 100.00 | 0.24 |

time, 1.44 Mha was re-afforested every year during the same period. The area deforested consisted of dry deciduous forests (64 %), tropical rain forests (15 %), moist deciduous forests (11 %), and hill and montane areas (11 %) (Pachauri and Sridharan 1998).

FAO (1997) report estimates the gross annual depletion rate of forest cover during 1980-90 was 0.34 Mha or a total loss of 3.4 Mha for the ten year period. During the same period, there were afforestation efforts which added about one million ha annually to the plantation area. Thus, while the total area of natural forests of 55 Mha in 1980 reduced to 50 Mha by 1995, the total area of natural and plantation forests increased from 58 Mha in 1980 to 65 Mha in 1995. The World Bank report estimated the forest loss to have been up to one Mha per year during the 1970's to 1980 in India. Thus no firm data are available for the extent of loss of forest cover in India or its annual rate of deforestation. However, there is general agreement that losses were high during the 1970's but that trends were reversed from the 1980's onwards (Khare et al. 2000).

Agents of Change in Indian Forests

The causes of change in forests in India area is highly debated issue. While some analyst blames deforestation primarily on subsistence activity such as shifting cultivation, grazing and fuel collection, other regards the government policy and commercial logging as the more

important causes. It is difficult to separate the causes from the effects of deforestation and forest degradation as it form a vicious circle. Some direct causes of deforestation are land clearances for agri-culture (including shifting cultivation), other land use changes and land transfers, different forms of encroachments, over-grazing, fire, uncontrolled and wasteful logging, and illegal felling plants. But the incidences of over-grazing and other biotic interference do not allow the desired results in regeneration. The decline in forest cover is attributed to the various phenomena, which exert pressure on the forest base i.e. increase in the total population leading to a corresponding increase in the aggregate requirement/demand for forest-based produce; specifically, requirement of forest biomass for energy and commercial uses, increase in the population of livestock directly dependent on forests for fodder and grazing, increase in the require-ment of land for purposes other than forestry, e.g. agriculture, roads, river valley projects, mining and quarrying, and urban and industrial development activities (Negi 1991, Rowe et al. 1992).

Changes and Agents of Change in the Forests of Himachal Pradesh

Empirical studies show that Himachal Pradesh suffered from severe deforestation during 1970's till 1982 due to various pressures on forests (Pria 1984). Extension of

cultivation at the expense of forest has been notable in Himachal Pradesh compared to other parts of India (Melkania and Melkania 1987). The trends in forest cover change in the state have been roughly the same as the whole of India (Table 3). Alongside a change in area there has also been a change in composition of forests in Himachal Pradesh, which can be largely attributed to human interference (Deshingkar et al. 1997). A variety of activities and processes has brought about changes in the area and composition of forest. A case study of Chamba district shows the primary cause of deforestation in the past was commercial extraction of timber combined with cutting of wood for subsistence activities as an additional factor only after 1950 (Flint and Richards 1991). The total annual consumption of rural domestic fuel in the entire state in between 2.5 – 3.2 million tones (MMg) and nearly half of the total domestic fuel is obtained from public forests (Singh and Sikka 1992). Policy has also had a major impact on deforestation for instance the *nautor* (redistributed lands) policy of allocation of un-demarcated forest land to landless cultivators. In HP, right holders are entitled to fell timber to the extent of 150,000 m³ standing volume against a total growing stock of 96.8 million m³. An average 100,000 m³ or one third of timber produced in HP is consumed under timber distribution by right holders. Until 1994, the use of natural forests for making fruit packing cases was also a major source of forest loss. The decline in forest area in districts could be because of the expansion of towns, road network, infrastructural development, housing and tourism (GOI 2005).

The average per capita consumption of fuel-wood in HP is 0.6 Mg per year resulting in the removal of 1.9 million m³ of wood per year mostly from the forests, which is far higher than the estimated regrowth of 0.7 million m³. This implies a reduction of forest stocks over the last 20-30 years resulting into forest degradation (Holden and Sankhyan 1998). Rai and Chakra-barti's (1996) annual estimates of timber consumption for house construction and other allied domestic use in HP are 1.68 million m³ and small timber 0.92 million m³ during 2006. Of the total removal from the forests around 70% is used as fuel-wood and 30% is used as small timber. It is found that the trees produced 70% timber and 30% fuel-wood and therefore, the accentuated demand for fuel-wood varies considerably, exacerbate the situation leading to depletion of forests. However, decrease in dense natural forest and increase in open forest shows signs of qualitative decrease or forest degradation due to various pressures exerted to

meet local and commercial needs from forests. The trends shows that rate of forest cover loss have lowered in last 15 years, but change within natural forests are affecting the productivity of forests. The forest cover assessments have enabled to keep track on health of forests and changes happening within and outside the recorded forests.

Policy on Forest Cover

Considering the importance of forest cover as an important parameter of the state of forests, a forest policy needs to set standards for forest cover with respect to the geographical area of a country. The national forest policy 1988, envisages bringing one third of the geographic area under forest and tree cover to maintain ecological balance and environmental stability. It also stresses the need of keeping two-thirds of the land area in hills and mountainous regions under forest and tree cover. However, there were no laid down norms with regard to forest/tree cover with respect to the total land area, while formulating the National Forest Policy of 1952. In 1939, the forest area in European countries was 41.35 % of the total land area has formed the basis in setting the policy goal. It was argued in the 1952 Forest Policy that an oppressive sun, desiccating hot winds, periodic monsoons, steep mountain slopes, a lower productivity, and a predominantly agriculture population, a proportion somewhat higher than that of Europe would appear desirable. However, from the practical consideration, it was decided to keep a considerably low percentage i.e. 33.3 % (quoted in Pandey 2000). However present estimates shows that the forest cover of the country is less than the goal laid down in the policy. In view of this it is necessary to examine the present land-use of the country so as to explore the possibility of finding out land which can be brought under forest cover to achieve stipulated objectives.

The forest in Himachal Pradesh constitutes largest land use (66.52 % of total land area of the state) but only 26.66 % land has good forest cover. Himachal Pradesh Forest Sector Policy and Strategy examines that forest and tree cover cannot be extended beyond 35.5 % in the mountainous state (Table 8). Therefore, the Government of India needs to modify policy with regard to maintaining forest cover of 66 % in mountainous states.

It has revising policy objectives of maintenance of forest cover based what can achieved with regard to maintenance of geographical area under forests. The

Table 8. Area (km²) capable of sustaining trees in Himachal Pradesh

| Land Classification | Area | Percent of Total Area |
|---|--------|-----------------------|
| Forest Area (Legal) | 37,033 | 66.5 |
| State Area (4,000m and above altitude unsuitable for tree crops) | 19,020 | 34.16* |
| Thus total legally classified forest area that cannot sustain tree crops | 20,020 | 35.95** |
| Legally classified forest area that can sustain tree crops (37,033-20,020) | 17,013 | 30.5 |
| Area under Horticulture | 2,230 | 4.0 |
| Land Area under Miscellaneous tree crops included in agriculture | 568 | 1.0 |
| Total Area which is supporting or can support tree crops over forest, agriculture and horticulture land | 19,811 | 35.5 |
| Total Geographical Area | 55,673 | 100 |

*It is estimated that 19,020 km² is part of legally classified forest area, without private ownership, is uncultivable and cannot sustain tree crops and **an area of about 1,000 km² below 4,000 m altitude under streams, nallahs etc, cannot sustain tree crops.

Source: Himachal Pradesh Forest Sector Policy and Strategy, December 2005, GOHP.

actual forest cover of HP shows an increasing trend over the years. This is the result of the ban in green felling in the state and including of horticultural types into the forest cover. Despite this, the decadal rate of increase in forest cover is slow and shall need a long time to achieve the prescribed unit of 66 % as per policy. Regeneration of forests becomes essential as more and more forest areas become degraded due to increase in open and scrub forests because of social and economic causes, besides forest fires and other natural phenomenon. The equation between forest degradation and forest regeneration should be maintained to ensure that the forest cover does not get depleted.

CONCLUSIONS

Assessment of forest cover using remote sensing techniques has established trends of forest cover change in India and HP. The trends in HP indicate that forest cover has stabilized for the last 15 years but changes with in the natural forests are affecting the productivity of forests. The variation in forest cover due to distribution pattern, population pressure and per capita forest cover in each district suggest that measures are needed to check forest degradation where population and forest extraction pressure are high. The assessment of area capable of sustaining forest and tree covers in HP is 35.5 % only; hence policy needs to be modified and has to be realistic with regard to maintenance of 66 percent area under forest cover in mountainous and hill

states. District level information on forest cover change needed to be utilized to direct planning and implementation efforts to prevent forest degradation and increase forest and tree cover in the available areas.

ACKNOWLEDGEMENTS

I thank Jai Gopal, Rajesh Kumar and Kamaljeet of FSI, Zonal office, Shimla for providing data and technical help. I thank also the referees for providing comments to improve the draft of this paper.

REFERENCES

- Agarwal, A., Narain, S., and Sen, S. (Editors) 1999. State of India's Environment. The Citizens Fifth Report, Centre for Science and Environment, New Delhi.
- Deshingkar, P., Bradley, P.N., Chadwick, M.J., Leach, G. 1997. Adapting to climate change in a Forest-based Land Use System: A case study of Himachal Pradesh, India. Stockholm Environment Institute, Stockholm. 92 pages.
- FAO. 1997. State of the World Forests. FAO, Rome. 200 pages.
- FAO. 2006. Global Forest Resources Assessment 2005. Progress Towards Sustainable Forest Management. FAO, Rome. 320 pages.
- Flint, E.P. and Richards, J.F. 1991. Historical analysis of changes in land use and carbon stock of vegetation in South and Southeast Asia. Canadian Journal of Forest Research 21: 91-110.

- FSI (Forest Survey of India). 1987-2003: State of Forests Reports (SFR), Ministry of Environment and Forests, Govt. of India, Forest Survey of India, Dehradun.
- FSI (Forest Survey of India). 2006. State of Forest Report 2003. Communication no. 22-205/2003-NFDMC-4865 to Principal Chief Conservator of Forests, Himachal Pradesh Forest Department, Shimla.
- Government of India, 2005. Chapter 1 Himachal Pradesh: A Profile, and Chapter 4. Forestry. pages 39-58 & 73-84, In: Himachal Pradesh Development Report. Planning Commission, Government of India, New Delhi.
- GOHP. 2005. Himachal Pradesh Forest Sector Policy and Strategy, 2005. Government of Himachal Pradesh, Forest Department, Shimla. 54 pages.
- GOI, 1999. Status of Forestry in India, Vol. I. Executive Summary, and Vol. II. Issues and Programmes, National Forestry Action Programme-India. Ministry of Environment and Forests, Government of India, New Delhi. 238 pages.
- Holden, Stein T. and Sankhyan, P.L. 1998. Population pressure, agriculture change and environmental degradation in the Western Himalayan Region of India. *Forum for Development Studies* 2: 271-300.
- Joshi, P.K., Singh, Sarnam, Agarwal, S. and Roy, P.S. 2001. Forest cover assessment in western Himalayas, Himachal Pradesh using IRS 1C/1D WiFS data. *Current Science* 80(8): 941-947.
- Khare, A., Sarin, M, and Saxena, N.C. 2000. Joint Forest Management: Policy, Practices and Prospects. WWF-India and IIED-UK, London. 142 pages.
- Lal, J.B. 1989. India's Forests Myth and Realty. Natraj Publishers, Dehradun. 302 pages.
- Melkania, N.P. and Melkania, U. 1987. Man and environment in Himachal Pradesh, India. Pages 81-99, In: Chadha, S.K. (Editor) Himachal Himalayas: Ecology and Environment. Today and Tomorrow's Printers and Publishers, New Delhi.
- Negi, S.S. 1991. Forests and their degradation. Pages 41-67, In: Negi, S.S. (Editor) Environmental Degradation and Crisis in India. Indus Publishing, New Delhi.
- Negi, S.S. 2000. Himalayan Forests and Forestry. Indus Publishing, New Delhi. 300 pages.
- Pandey, V.N. 2000. National forest cover assessment in biodiversity and environment; Remote sensing and Geographic Information System perspectives. Pages 9-17, In: Roy, P.S., Singh, Sarnam and Toxopeus, A.G. (Editors) Biodiversity and environment. Indian Institute of Remote Sensing (National Remote Sensing Agency), Dehradun, India.
- PRIA 1984. Deforestation in Himachal Pradesh. Society for Participatory Research in Asia (PRIA), New Delhi. 44 pages.
- Rai, S.N. and Chakrabarti, S.K. 1996. Fuelwood, Timber and Fodder from Forests of India. Forest Survey of India, Dehradun. 35 pages.
- Rawat, J.K., Saxena, A. and Gupta, Sudhanshu. 2003. Remote sensing satellite based forest cover mapping: Some recent developments. *Indian Cartographer* 23: 195-198.
- Rowe, R., Sharma, N and Browder, J. 1992. Deforestation: problems, causes and concern's. Pages 33-45, In: Sharma, N.P. (Editor) Managing the World's Forests, Looking for Balance Between Conservation and Development. Kendall & Hunt Publishing, Iowa, USA.
- Singh, D.V. and Sikka, B.K. 1992. Wood Balance Study of Himachal Pradesh, Agro Economic Research Centre, Himachal Pradesh University, Shimla. 120 pages.
- Pachauri, R.K. and Sridharan, P.V. 1998. Looking back to think ahead, growth with resource enhancement of environment and nature. *Green India* 2047: 95-138. Tata Energy Research Institute, New Delhi.

Table 5. District-wise forest cover change of Himachal Pradesh from 1991 to 2003 (in km²)

| District | Forest | 1991 | 1993 | Change | 1995 | Change | 1997 | Change | 1999 | Change | 2001 | Change | 2003 | Change |
|------------------|--------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Bilaspur | Dense Forest | 101 | 49 | -52 | 49 | 0 | 59 | +10 | 65 | +6 | 135 | +70 | 105 | -30 |
| | Open Forest | 65 | 108 | +43 | 108 | 0 | 99 | -9 | 170 | +71 | 166 | -4 | 253 | +87 |
| | Total | 166 | 157 | -9 | 157 | 0 | 158 | +1 | 235 | +77 | 301 | +66 | 358 | +57 |
| Chamba | Dense Forest | 1,625 | 1,801 | +176 | 1,767 | -34 | 1,768 | +1 | 1,585 | -183 | 1,652 | +67 | 1,566 | -86 |
| | Open Forest | 392 | 323 | -69 | 293 | -30 | 293 | 0 | 716 | +423 | 690 | -26 | 847 | +157 |
| | Total | 2,017 | 2,124 | +107 | 2,060 | -64 | 2,061 | +1 | 2,301 | +240 | 2,342 | +41 | 2,413 | +71 |
| Hamirpur | Dense Forest | 156 | 151 | -5 | 151 | 0 | 150 | -1 | 93 | -57 | 181 | +88 | 109 | -72 |
| | Open Forest | 60 | 62 | +2 | 72 | +10 | 73 | +1 | 95 | +22 | 93 | -2 | 133 | +40 |
| | Total | 216 | 213 | -3 | 223 | +10 | 223 | 0 | 188 | -35 | 274 | +86 | 242 | -32 |
| Kangra | Dense Forest | 808 | 1,071 | +263 | 1,071 | 0 | 1,071 | 0 | 1,338 | +267 | 1,719 | +381 | 1,386 | -333 |
| | Open Forest | 625 | 684 | +59 | 673 | -11 | 673 | 0 | 301 | -372 | 311 | +10 | 481 | +170 |
| | Total | 1,433 | 1,755 | +322 | 1,744 | -11 | 1,744 | 0 | 1,639 | -105 | 2,030 | +391 | 1,867 | -163 |
| Kinnaur | Dense Forest | 565 | 547 | -18 | 547 | 0 | 541 | -6 | 436 | -105 | 432 | -4 | 365 | -67 |
| | Open Forest | 68 | 82 | +14 | 82 | 0 | 91 | +9 | 213 | +122 | 215 | +2 | 248 | +33 |
| | Total | 633 | 629 | -4 | 629 | 0 | 632 | +3 | 649 | +17 | 647 | -2 | 613 | -34 |
| Kullu | Dense Forest | 1,817 | 1,911 | +94 | 1,911 | 0 | 1,907 | -4 | 1,631 | -276 | 1,749 | +118 | 1,412 | -337 |
| | Open Forest | 131 | 133 | +2 | 133 | 0 | 137 | +4 | 343 | +206 | 366 | +23 | 521 | +155 |
| | Total | 1,948 | 2,044 | +96 | 2,044 | 0 | 2,044 | 0 | 1,974 | -70 | 2,115 | +141 | 1,933 | -182 |
| Lahul & Spiti | Dense Forest | 0 | 15 | +15 | 49 | +34 | 49 | 0 | 34 | -15 | 36 | +2 | 35 | -1 |
| | Open Forest | 17 | 4 | -13 | 34 | +30 | 34 | 0 | 116 | +82 | 118 | +2 | 145 | +27 |
| | Total | 17 | 19 | +2 | 83 | +64 | 83 | 0 | 150 | +67 | 154 | +4 | 180 | +26 |
| Mandi | Dense Forest | 839 | 848 | +9 | 848 | 0 | 848 | 0 | 982 | +134 | 1,112 | +130 | 1,011 | -101 |
| | Open Forest | 462 | 461 | -1 | 461 | 0 | 467 | +6 | 557 | +90 | 544 | -13 | 637 | +93 |
| | Total | 1,301 | 1,309 | +8 | 1,309 | 0 | 1,315 | +6 | 1,539 | +224 | 1,656 | +117 | 1,648 | -8 |
| Shimla | Dense Forest | 1,921 | 2,094 | +173 | 2,094 | 0 | 2,084 | -10 | 1,808 | -276 | 1,878 | +70 | 1,781 | -97 |
| | Open Forest | 299 | 331 | +32 | 331 | 0 | 341 | +10 | 582 | +241 | 566 | -16 | 602 | +36 |
| | Total | 2,220 | 2,425 | +205 | 2,425 | 0 | 2,425 | 0 | 2,390 | -35 | 2,444 | +54 | 2,383 | -61 |
| Sirmour | Dense Forest | 740 | 740 | 0 | 740 | 0 | 736 | -4 | 742 | +6 | 755 | +13 | 687 | -68 |
| | Open Forest | 279 | 279 | 0 | 279 | 0 | 288 | +9 | 366 | +78 | 357 | -9 | 692 | +335 |
| | Total | 1,019 | 1,019 | 0 | 1,019 | 0 | 1,024 | +5 | 1,108 | +84 | 1,112 | +4 | 1,379 | +267 |
| Solan | Dense Forest | 164 | 164 | 0 | 164 | 0 | 173 | +9 | 274 | +101 | 459 | +185 | 353 | -106 |
| | Open Forest | 251 | 254 | +3 | 254 | 0 | 249 | -5 | 218 | -31 | 224 | +6 | 466 | +242 |
| | Total | 415 | 418 | +3 | 418 | 0 | 422 | +4 | 492 | +70 | 683 | +191 | 819 | +136 |
| Una | Dense Forest | 175 | 174 | -1 | 174 | 0 | 174 | 0 | 132 | -42 | 321 | +189 | 166 | -155 |
| | Open Forest | 220 | 216 | -4 | 216 | 0 | 216 | 0 | 285 | +69 | 281 | -4 | 352 | +71 |
| | Total | 395 | 390 | -5 | 390 | 0 | 390 | 0 | 417 | +27 | 602 | +185 | 518 | -84 |
| Himachal Pradesh | Dense Forest | 8,911 | 9,565 | +654 | 9,565 | 0 | 9,560 | -5 | 9,120 | -440 | 10,429 | +1,309 | 8,976 | -1,453 |
| | Open Forest | 2,869 | 2,937 | +68 | 2,936 | -1 | 2,961 | +25 | 3,962 | +1,001 | 3,931 | -31 | 5,377 | +1,446 |
| | Total | 11,780 | 12,502 | +722 | 12,501 | -1 | 12,521 | +20 | 13,082 | +561 | 14,360 | +1,278 | 14,353 | -7 |