Chapter 4

Application of GIS and Remote-Sensing Technologies to Forest Management

4.1 Introduction

Remote Sensing has proved its potential for providing information on forests and GIS help to integrate the information from various sources and on different themes. Remote Sensing can help in: (a) forest mapping with the possibility of classifying various forest types into crown density classes (Singh 1991, NRSA 1983, FSI 1989); (b) monitoring land development programmes, e.g., afforestation (Saxena et al. 1991); (c) forest biomass mapping using appropriate models which relate field-measured biomass data to remote-sensing derived maps (Tiwari 1994); and (d) charting fuelwood and fodder availability maps through the assimilation of field measurements of quantitative proportions of fodder-yielding trees, and field verified annual fuelwood fall data into a forest biomass map derived from remote sensing (Saxena et al. 1991). Wood constitutes the main source of energy in the watershed. Domestic needs for fuelwood are met by collection from the forests (Plate 4). Overexploitation of forest resources is occurring due to the economic needs of a growing population (they sell firewood, often in the form of logs, to urban areas) (Plates 4 and 5). Trees are rarely found on crop lands. Agro-horticultural systems are lacking here (Saxena et al. 1994a).

The Pranmati Watershed covers 94.05sq.km., of which 61.59sq.km. (about 65%) is under forest cover (Table 3, Chapter 3). However, the crown cover varies greatly depending on the vegeta-

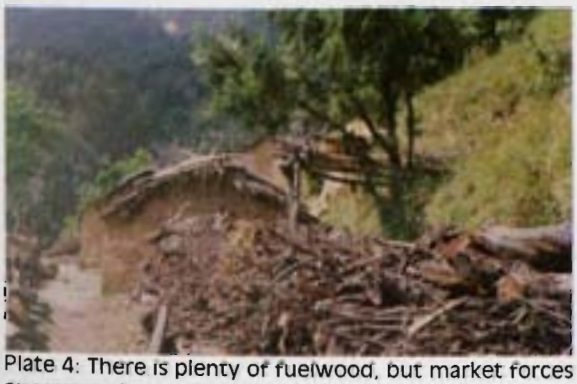

Plate 4: There is plenty of fuelwood, but market forces encourage harvesting for export of even unsplit larger branches/ logs

Plate 5: Export of fuelwood to an urban market

tion type and human use impact. Pine (*Pinus roxburghii*) and oak (*Quercus incana*) dominated mixed forests have dense crown cover at lower elevations. At higher elevations, rhododendrons in association with other oaks (*Quercus dialata / Q. semecarpifolia*) form dense cover. The pine wood has value as timber and its selective felling is regulated by the government. Forest fires do considerable damage. To some extent, aspect affects the type of vegetation, causing deviations from altitudinal control. Southerly- and westerly-facing slopes tend to be warmer, hence vegetation distribution limits are pushed to slightly higher altitudes. The Alpine meadows (not considered here under forest area) are part of the natural vegetation which occurs above 3,000 to about 3,400masl. Pine and oak forests near settlements have become degraded largely due to lopping (cutting of branches) and felling. These are identified as open pine and oak forests (Plate 6). Excessive lopping is denuding oak forests throughout the Uttar Pradesh hills. *Ringal* (*Thamnocalamus spathiflora*), a species of temperate bamboo, is found growing profusely as an undergrowth in mixed forests. Other types of undergrowth consist of *Princepia utilis, Pyracantha crenulata*, and others. The trees comprising the mixed forests are *Q. dialata, Q. semecarpifolia, Lyonia ovalifolia, Neolitsea umbrosa, Cornus capitata*, and *R. arboreum*. Round timber, fuelwood, resin, and bamboo are the important forest products found in the area. Local knowledge on diverse uses of forest products is quite rich.

Plate 6: Trees are lopped excessively to meet the fuel and fodder requirements

4.2 Methodology

The forest areas (depicted in green) on the topographical sheet of 1963 were accepted to depict the extent of forest cover in 1963 (Map 8). This area extended even outside the marked reserved forest area directly under the control of the Forest Department. The 1993 status was visually interpreted from the geometrically corrected and geo-referenced IRS FCC image, taking into consideration the hue, intensity, and altitudinal position in each case. The image was interpreted in respect to vegetation type and crown cover density (Map 9). The differences between the 1963 and 1993 maps with respect to total forest cover were interpreted to be the actual changes in forest cover (Map 10). The results were verified in the field and necessary corrections were incorporated.

Phyto-sociological studies of different forest types were carried out on the basis of altitude, aspect, slope, and so on. Study of tree cover, density, diameter at breast height (DBH, i.e. at 1.52 metres from the ground), and regeneration of tree species were conducted.

The vegetation crown cover density was classified and qualitatively defined as follows: >60% = Dense Forest; 30% - 60% = Open or Degraded Forest.

A Forest Classification map (administrative status) was derived from the working plan maps (originally on a scale of 1 inch : 2 miles) of the Forest Department (Map 14).

Changes in total forest cover were identified in different categories, e.g. transformation to pasture land and transformation into agricultural land (Map 10, Table 6).

4.3. Results

Table 6. Extent of Deforestation (1963-93)

Changes	Area (ha)	% of Total Area
Forests to Agriculture	90.5	84.0
Forests to Pastures	1.6	14.6
Forests to Landslides	0.1	1.4
Total Deforested Area	92.2	100.0

1) The altitudinal distribution of forests shows that the proportion of forest cover is a maximum of 2,400-3,000masl and 1,200-1,600masl elevation zones.

2) In 1963, almost 75 per cent of the total watershed area was shown to be under some kind of forest cover (Map 8), whereas in 1993 it decreased to about 65 per cent (Map 9, Table 7).

Table 7. Vegetation Types as Interpreted through Visual Interpretation of an IRS Image from 1993-Supported by Field Study

Vegetation Type	Area (ha)	% of Total Area
Dense mixed forests	223.30	23.24
Dense oak-rhododendron	195.70	20.81
Dense oak	13.30	1.42
Open oak*	39.70	4.23
Open oak-pine	6.20	0.66
Dense pine	118.20	12.58
Open pine*	19.20	2.05
Total	615.70	65.00

* Degraded forest

3) The distribution of tree species was mapped by combining information on altitude, aspect, and vegetation features as interpreted from the RS image.

4) The legal administrative status of forests is depicted in Map 14.

5) Degraded forests have a distinct relationship to cleared lands, including the agricultural areas (Map 15). Degraded forests are on the periphery of agricultural lands and in easily accessible areas.

6) The loss of forest areas to other land uses (Map 10 and Table 6) was about 10 per cent of the total geographical area in the watershed, which implies that 14 per cent of the total forest area in 1963 was deforested over a period of 30 years. Encroachments on *Panchayat* forest lands towards the upper reaches of the watershed are common. These are gently sloping lands devoid of trees which have been tilled for potato cultivation for the last five to seven years. The climatic and soil conditions here happen to be extremely favourable for potato cultivation. Landslips and landslides have destroyed the forest cover. One such instance is near Kaira village where a large spectacular landslide exists. Such areas also exist near Dungri, Ratgaon, Letal, and Ghunguti. The proposed motorable road would lead to further destruction of forest cover. Thus, the rate and possibility of forest cover loss are threatening and must be minimised as far as possible.

7) Regeneration of forests between the period from 1963 and 1993 is given in Table 8. It was found to be the highest (41.8%) on east-facing slopes, followed by the west and northeast aspects. On the remaining aspects, the regeneration was moderate. The rate was low on southern slopes due to poor moisture conditions and human impact.

8) Regenerated forest types ('Agriculture to Forests' and 'Pasture Land to Forests' in Map 10) was mainly in the region of oak-rhododendron, dense pine, and in the dense mixed and open oak forests (Table 8). This regenerated forest area is only three per cent of the watershed area and 4.8 per cent of the forest area existing in 1963.

9) Forest regeneration was maximum in the elevation range of from 1,600-2,000masl with 20-30° average slopes. Such areas were concentrated in the southern parts of the water-

shed. This perhaps' reflects greater vigilance on the part of the Forest Department in the areas closer to their office which have less hostile terrain.

(10) The distribution of land use and vegetation types in different forest classes is given in Table 9.

Table 8: Extent of Forest Regeneration (1963-93)

Vegetation Type	Area (ha)	% of Area Regenerated
Dense mixed forests	6.6	19.9
Oak-rhododendron	10.2	31.0
Dense oak	1.4	4.2
Open oak	4.7	14.2
Open oak-pine	0.1	0.4
Dense pine	9.3	28.3
Open pine	2.1	2.0
Total Afforested Area	34.5	100.0

Table 9: Distribution of Land Use and Vegetation Types in Different Forest Classes (Based on 1993 RS Interpreted Vegetation Distribution and FD boundaries)

Vegetation Type	*Panchayat* Forests		Reserved Forests		Protected Forests	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Bare rock surface	-	-	-	-	62.3	11.5
Alpine meadows Small	0.3	0.01	-	-	51.7	9.5
pastures	4.6	1.8	-	-	14.2	2.6
Dense mixed forests	13.0	4.9	-	-	120.0	38.9
Oak-rhododendron	52.9	20.0	22.7	17.1	210.0	22.2
Dense oak	7.8	2.9	-	-	5.5	1.0
Open oak	19.4	7.3	-	-	20.3	3.7
Open oak-pine	2.4	0.9	3.8	2.9	-	-
Dense pine	21.0	7.9	81.0	61.0	15.9	2.9
Open pine	3.4	1.3	12.7	9.6	3.1	0.6
Cultivated	-	-	6.8	5.1	36.6	6.7
Landslide (major)	132.8	50.1	1.5	1.1	-	-
River bed	7.1	2.8	4.3	3.3	2.4	0.4
Total	265.1	100	133.0	100	542.3	100

4.4 Conclusions

Encroachments on forest lands have been excessive because of the neglect of forest resources by both the local people and the government. Much of the timber and firewood is not used by the villagers but sold in the market at Tharali. This trade operates through middlemen who promote the felling of the government forests by villagers (Plate 5). The market forces are threatening biological diversity both on the farms and in the forests of the region. Therefore, enforcement of forest conservation is necessary. Patches of chir pine forest are leased to contractors by the Forest Department for resin (local term, *lisa*) collection. Due to over-exploitation and carving of trunks on the up-slope sides, trees also become vulnerable to fires and natural fall. Forest fires are not uncommon in this region. The highland forests have an important protective role against the rampage of runoff water. But the protective function of the forests is constrained when exploitation crosses the threshold. Denudation of forests ultimately leads to a high influx of water in the lowlands and consequently high rates of soil erosion (Ghosh et al. 1995). Forests seem to be better protected when the local people are given the responsibility of managing them. In this way, they do not feel alienated from the forests. Environmental management objectives could be achieved if each settlement has a clearly-defined area to protect, care for, and use (Saxena et al. 1994).