Temporal change detection in two watershed areas of Kumaon region and its impact on livelihood of forest fringe communities

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Landscape changes were measured in two watersheds of Western Himalayas over a period of 17 years using satellite images. Whereas the total forest cover was found to have been altered, there was substantial shift among different elements which could be attributed to the increasing populations that live off these watersheds. We have also estimated the livelihood contributions of these watersheds to the dependent populations.

Keywords: Dabka watershed, Khulgad watershed, Kumaon region, landscape changes.

TRADITIONALLY, watersheds are rich in biodiversity and support a variety of forest ecosystems. Over the years, environmental degradation brought out by an increase in the anthropogenic activities has resulted in the depletion of the forest cover in watersheds but the extent and patterns of these changes are hardly estimated. Further, watersheds in general, and hilly areas in particular, constitute a major source of livelihood and income for people living in and around them. Unquestionably the degradation of the watershed is bound to affect the life sustenance of these dependents. This in turn may affect the health of the forests as the dependents would inevitably begin to consume the reducing resources in the watershed.

Therefore, it is important to assess the fate of the changing landscape elements of the watersheds and their consequences to the livelihood of the people. In this article we assess contributions of the watershed to the rural economy and also trace the changes in the landscape structure in two watersheds in the Himalayas.

Description of study area

The study area falls in the Western Himalayas in Almora and Nainital Districts of Kumaon region. The two watersheds chosen for this study are Dabka (Nainital) and Khulgad (Almora) comprising an area of 69.07 sq. km and 33.08 sq. km representing lower and middle Shivalik respectively. Dabka Watershed lies between 79°17′53″–79°25′38″E long. and 29°30′19″–29°24′09″N lat. whereas the Khulgad Watershed lies between 79°32′01″–79°39′24″E long. and 29°39′07″–29°34′23″N lat.

Methodology

Forest cover change

In the present study, forest cover denotes all lands, more than one hectare in area, with a tree canopy density of more than 10%. Such lands may not be statutorily notified as forest area. The topographical maps based on surveys carried out in 1967 and 1969 (1 : 50,000) were used. For estimating changes in forest cover over different years, the satellite imageries (Landsat 1988, 1994, LISS and PAN 1998, 2002, 2005) were registered in polyconic projection from the geo-referenced toposheets of the watershed area. Multidated satellite images were classified using unsupervised classification to delineate the forest cover patches into five density classes, viz. very dense forest (VDF) (>70%), moderately dense forest (MDF) (40–70%), open forest (OF) (10–40%), cropland (CL) and non-forest (NF) area (includes scrub, barren land, water bodies and settlements). To maintain consistency, visual (on-screen) interpretations were carried out.

Forest change detection study: Change detection study was carried out on the basis of estimated area of the thematic maps generated for the different years. The forest cover within the watershed area was analysed through classifying the satellite data of 1988, 1994, 1998, 2002 and 2005 into five classes, viz. very dense forest (VDF) (>70%), moderately dense forest (MDF) (40–70%), open forest (OF) (10–40%), cropland (CL) and non-forest (NF) area (includes scrub, barren land, water bodies and settlements) and creating thematic maps for different years.

By overlaying thematic maps of two subsequent years and integrating the database, changes for various forest density classes were calculated in the form of a matrix. Change matrix describes the changes in the forest cover for a given region over a period of two or more assessments by showing the extent of areas changing from one class of land cover to another between the different periods.

Estimation of stems, shrubs and herbs

Toposheets of both watershed areas were procured from Survey of India. Each watershed was divided into 1 sq. km grids in both forest and NF areas. Total number of grids and those sampled in each of the watershed are provided in Table 1. At the centre of each grid, a plot of 0.1 ha was laid for enumerating trees. For trees outside forest (TOF), plot of 0.1 ha for block plantation and 0.5 ha for scattered stratum were laid out. All trees > 10 cm and above were enumerated, and a number of parameters were recorded. For enumeration of shrubs, four plots of size 3 m × 3 m were laid out 30 m from the centre of 0.1 ha plot along the diagonal, in all the four directions. For herbs, plot of size 1 m × 1 m was laid out at the centre of shrub plot and information on herbs was recorded along with the collar diameter.

Productivity estimation

In both watersheds, all the trees, shrubs and herbs were listed according to their dominance. Socio-economic survey was conducted in 12 villages to ascertain the important resource species, plant parts collected and the prevailing rate at which these are sold. On the basis of this survey, tree, shrub and herb species of economic importance were selected in the watershed for detailed analysis.

For selected tree species, plant parts (fresh flowers, leaves, fruits, etc.) were collected from 1 sq. m area of tree canopy in all the four directions. Fresh weights of collected plant material were noted down in the field, and dry weight of leaves and fruits were recorded at the interval of 2–3 days till its weight became constant. Market value of plant parts was gathered through local market survey and Forest Development Corporation. The total fresh and dry weight of plant parts obtained for the species separately from the collected samples were aggregated over the entire population. From the data available on value of plant parts, the potential total income was estimated.

Similarly, for the selected shrub and herbaceous species, plant parts (whole plant, rhizome, flower, roots, etc.) were extracted from selected samples and estimated over the entire population. Rest of the methodology was similar to that of tree species.

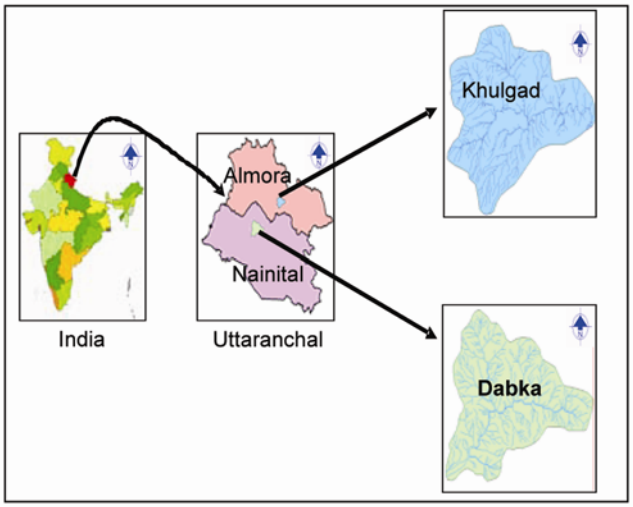


Figure 1. Study area.

Table 1. Details of grids (1 × 1 sq. km) per watershed and those sampled

Watershed	Total grids	Number of grids sampled
Dabka		
Forested	36	33
Non-forested	40	38
Khulgad		
Forested	13	13
Non-forested	25	25

Result and discussions

Forest cover change between 1988 and 2005

In 1988, the forest covers assessed for Dabka and Khulgad Watersheds were about 53.9% (out of 69 sq. km) and 35.0% (out of 33 sq. km) respectively. Assessment done at the end of 17 years, i.e. by 2005, showed that forest cover was 53.8% and 34.8% respectively. Thus, overall forest cover in both the watersheds has remained more or less unchanged; however, there has been a considerable shift from one type of cover to the other (Table 3). In Khulgad, during this 17-year period, there has been a decrease in VDF and increase in MDF. However, between 1998 and 2002 there was a slight decrease in MDF which subsequently increased substantially in 2005. Perhaps owing to the increased population that brought about a demand on agricultural needs, more area has been brought under CL. As most of the NF area (barren land, grassland, scrub and settlement) was converted to CL, the NF area has shown decrease in cover due to increase in CL and settlement.

In Dabka, results indicate that VDF has decreased substantially over the years between 1988 and 2005. Consequently, the decrease in VDF has led to an increase in MDF and OF. In addition, a large number of plantations on the Panchayat land have also led to an increase in MDF and OF. MDF has shown a substantial increase during 1988–94, however, during 1994–98 and 1998–2002 there was noticeable decrease. Between 2002 and 2005 a

Table 2. The change matrix generated for Dabka Watershed

	2005 Assessment					
1988 Assessment	Dense forest	Moderate forest	Open forest	Cropland	Non-forest	Total 2005
Dense forest	615	385	45	0	3	1048
Moderate forest	1	758	117	2	1	879
Open forest	0	3	1578	209	7	1797
Cropland	0	0	2	1220	0	1222
Non-forest	0	0	215	715	1031	1961
Total 2005	616	1146	1957	2146	1042	6907
Net change	–432	267	160	924	–919	

Table 3. The change matrix generated for Khulgad Watershed

	2005 Assessment					
1988 Assessment	Dense forest	Moderate forest	Open forest	Cropland	Non-forest	Total 1988
Dense forest	210	56	45	0	0	311
Moderate forest	22	247	6	0	0	275
Open forest	0	74	473	7	20	574
Cropland	0	0	0	1167	1	1168
Non-forest	0	0	19	340	621	980
Total 2005	232	377	543	1514	642	3308
Net change	–79	102	–31	346	–338	

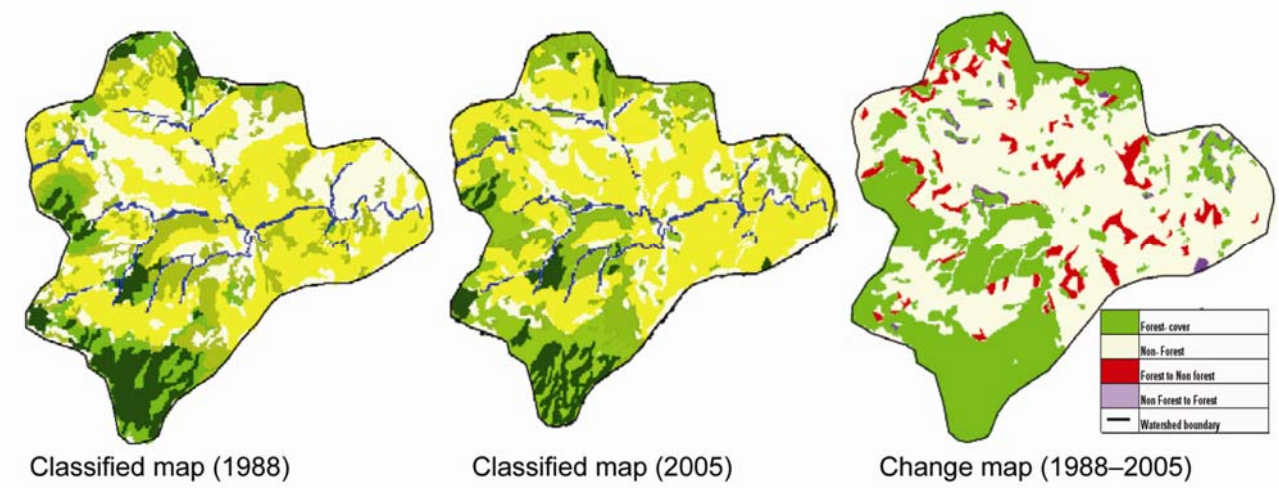
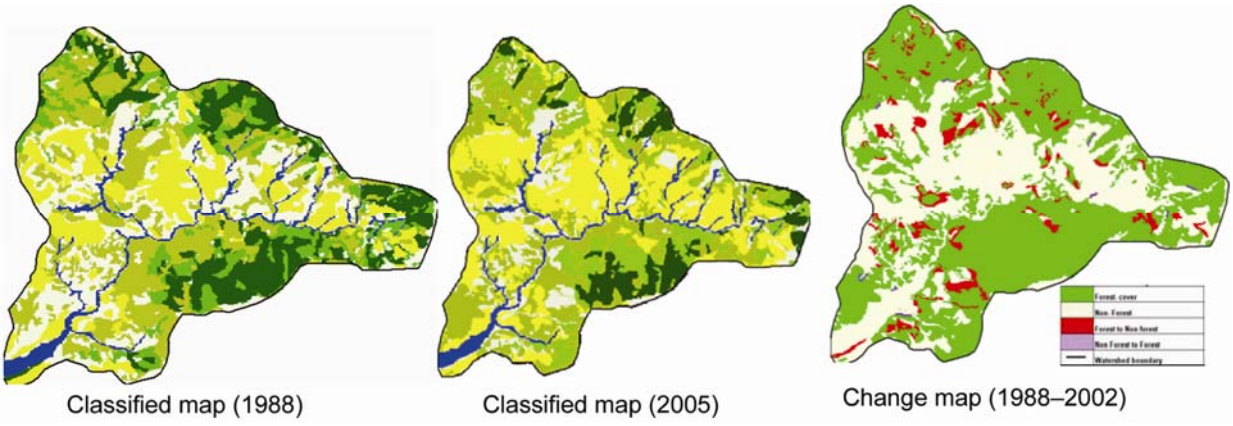


Figure 2. Temporal change analysis during 1988–2005 of Khulgad Watershed.

significant increase in MDF was observed, possibly due to the conversion of OF into MDF. Overall increase of OF between 1988 and 2005 is mainly due to increase in plantations in NF areas and conversion of dense forest to OF. As most of the NF area (barren land, grassland, scrub, settlement and water bodies) was converted to CL, the NF has shown decrease in cover due to increase in CL and settlement.

The forest cover changes that occurred within the forest density classes during 1988–2005 are also depicted graphically for both the watersheds.

Population dynamics in both watersheds: There are 33 villages in Dabka Watershed having 1818 households with a population of 10,368 as per the 1991 Census which has risen to 2244 households and a population of 12,534



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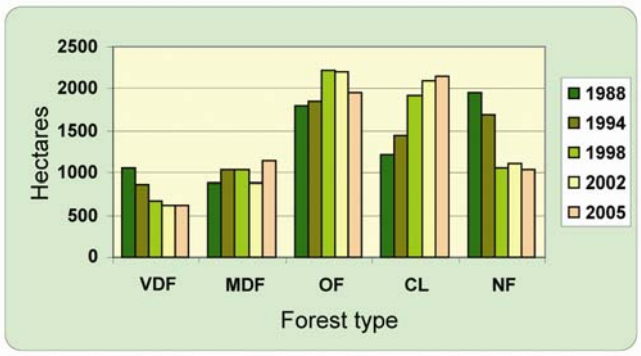

Figure 4. Forest cover change in Dabka (1988–2005).

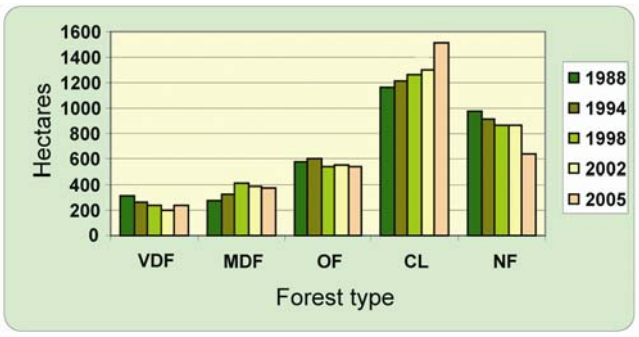

Figure 5. Forest cover change in Khulgad (1988–2005).

respectively in the 2001 Census. Using this decadal growth rate, the rise in population parameters during 1988–2005 is estimated as 39.8% for number of house holds and 35.5% for population. Similarly in Khulgad Watershed, there are 28 villages but the population growth rate was slower and increased, for the same period by 12.4% for households and 9.4% for population. It is remarkable that in both the watersheds the rate of increase for number of households was faster than the population which will definitely pose more requirements for fuelwood.

Table 4. Potential income from non-timber forest products from resource species of Khulgad Watershed

Habit	Species	Monetary potential (Rs)
Tree	*Rhododendrum arboreum*	35,109
	Cinnamomum tamala	12,730
	Juglans regia	482,220
Shrub	*Berberis aristata*	288,559
	Asparagus adscedens	118,991
Herb	*Ajuga bracteosa*	61,862
	Berginia ciliata	517,588
	Viola serpens	47,550
	Thalictrum foliolosum	697,866
Total		2,262,475

Table 5. Potential income from non-timber forest products from resource species of Dabka Watershed

Habit	Species	Monetary potential (Rs)
Tree	*Rhododendrum arboreum* (TOF)	92,142
	Rhododendrum arboreum	2,103,780
	Cassia fistula (TOF)	64,067
	Holarrhena antidysenterica (TOF)	1,797,164
Shrub	*Berberis aristata*	2,169,183
	Asparagus adscedens	126,402
	Dioscorea deltoidea	303,937
Herb	*Adiantum venustum*	1,327,437
	Hedychium spicatum	4,199,163
	Viola serpens	238,780
	Thalictrum foliolosum	7,703,947
Total		20,126,002

Impact of population on forest: In Dabka Watershed most of the forest area is regenerating but 82% of the forest area is under inadequate regeneration; in Khulgad Watershed it is 70%. Fire incidences were seen in 52% forest area in Dabka and 62% areas in Khulgad. The whole forest area of Khulgad is dominated by chir-pine and con-

sequently, more prone to fire. Most of the time, the fires were caused by humans.

Grazing incidences in Dabka occur in 75% of the forest area, out of which 27% of the area had moderate to heavy grazing. In Khulgad most of the forest was subjected to grazing, out of which 62% area had moderate to heavy grazing. Lopping for fodder was seen in 33% of forest in Dabka, and 8% in Khulgad. In Dabka, no further injuries to crops were noted which could have been caused by human. However, in Khulgad 23% of the area experienced girdling, illegal felling and scarring of trees.

Though there is hardly any change in total forest cover of both the watersheds, there is lot of change in the density classes of forest cover. In Dabka, very dense class of forest cover has reduced by 41% and MDF increased by 30%. Whereas in Khulgad, VDF has reduced by 25% and MDF increased by 37%. The per capita forest cover in Khulgad was only 0.14 ha whereas in Dabka it was 0.30 ha. The rate of growth of population parameters is higher in Dabka than in Khulgad; the higher rate of deterioration of forest cover in Dabka may be attributed to this fact.

Estimates of potential monetary gains

Khulgad Watershed: *Rhododendron arboreum* from forest area, *Cinnamomum tamala* and *Juglans regia* from outside forest area were selected for productivity estimation. Local people sell the flowers of *Rhododendron* at the local market at the rate of Rs 6 per kg. In case of *C. tamala*, leaves are used as an important spice. The dry leaves of this plant costs about Rs 20 per kg. The fruit of *J. regia* is one of the most important dry fruits. It is planted in agricultural fields. The market cost is about Rs 75 per kg.

Our observations suggested that 50% of flowers and leaves are obtained from these two species. Accordingly, a total income from flowers and leaves of *R. arboreum* and *C. tamala* would be about Rs 35,109 and Rs 10,730 respectively. However, for *J. regia* 90% of fruits can be harvested. Therefore, the total income can be estimated as Rs 482,220.

The two shrub species, namely *Berberis aristata* and *Asperagus adscendens* whose roots are of medicinal value were selected for estimation of productivity. Assuming that the harvesting can be limited to around 25%, a potential annual income of around Rs 407,550 can be generated from these species. Similar estimation for herbs, viz. *Ajuba bracteosa*, *Berginia ciliata*, *Thalictrum foliolosum* and *Viola serpens* known for medicinal value is around Rs 1,324,867. Thus from the three selected trees species, two shrub species and four herb species of forest area/TOF of Khulgad Watershed, the potential income can be estimated to be Rs 2.26 million, after considering safe harvesting limits for the sustainability of the forest/TOF resources as given in Table 4.

The total number of households in Khulgad as per Census 1991 and 2001 is 1480 and 1588 respectively. Considering this population growth rate, the number of households in 2006 was estimated as 1642. The annual potential monetary gain per household from these resources is Rs 1378.

Similarly, for Dabka, from the selected three trees species, three shrub species and four herb species of forest area/TOF of Dabka watershed, the potential annual income was estimated as Rs 20.1 million, after considering the safe harvesting limits for the sustainability of the forest/TOF resources as given in Table 5.

The total number of households in Dabka as per Census 1991 and 2001 is 1818 and 2244 respectively. Considering this population growth rate, the number of households in 2006 was estimated as 2457. The annual potential monetary gain per household from these resources is Rs 8191.

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