

**IMPACT OF HUMAN INTERFERENCE AND LAND USE CHANGES ON THE  
NAINITAL LAKE REGION**

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**ABSTRACT**

Nainital lake region is one of the important lake regions of the new state of Uttaranchal. It has situated on the terminus of the lesser Himalayan ranges. The lake sprawls over an area of roughly 200 sq. Km and there ecological importance has made the district of Naini Tal as famous lake districts of Himalaya. Among the major lakes of this important area are Naini tal, Bhim tal, Sat Tal, Naukuchia tal, Saria Tal and Khurpa Tal.

For a century and a half, this region has earned its name in the international tourist map but owing to the sudden spurt in tourism in the last three decades; there has been a mad rush for the construction of new hotels and group housing complexes. The real estate developers cashing in on the great demand for new houses have scarred the lovely hillside and at times rules are being flouted for illegal construction. Even the buildings rubble has not been removed; debris is dumped on the drains and slopes, which ultimately flows into the lake during the rains. The whole land use pattern has thus changed.

Besides garnishing to the aesthetics of the region, these lakes are the source of potable water and of irrigation to the nearby plains. The sedimentations in the lake and pollution are a matter of serious concern. The very existence of the lake endangered and without the lakes, the ecology of the whole regions will be disturbed. In this paper we have tried to show that how land use change has led to a decline in forest cover and environmental degradation of the lake region.

**INTRODUCTION**

Nestling snugly at the brink of the Kumaun Lesser Himalaya, the crescent shaped region of the Lake District of Nainital not only contributes valuable natural reserves of water but has also carved a niche for itself in international tourism. For over a century and a half, the scenic grandeur of its mountain ranges, the sylvan surroundings, endowed with a rich biodiversity and salubrious climate has attracted tourists. The British developed this region with a two-pronged strategy. They projected Nainital as a tourist resort and as an educational centre. But in other areas of the lake region, their focus was to develop them as a retreat for the weekends and holidays. To be away from the maddening crowds, these places served as a refuge from them, where they spent their time in bird watching, angling and swimming in the crystal clean waters of the lakes.

In the British period the region was famous as the land of sixty lakes and it sprawled over an area of roughly 200sq.kms. But to day with the drying up of several lakes, formation of new revenue boundaries and unremitting anthropogenic pressure in the form of deforestation, increasing habitations and land use changes have reduced the area of the lake region. The sizeable lakes that are now in existence are the Naini-Lake as the nucleuses around which in close proximity are situated the lakes of Bhimtal, Nakuachiatal, Sattal and Khurpatal. The tourist activity in Nainital township has a direct bearing on the other centres and lakes of the region. The tourists who come to Nainital go on a lake tour to these lakes and facilitate in accentuating their economic activities.

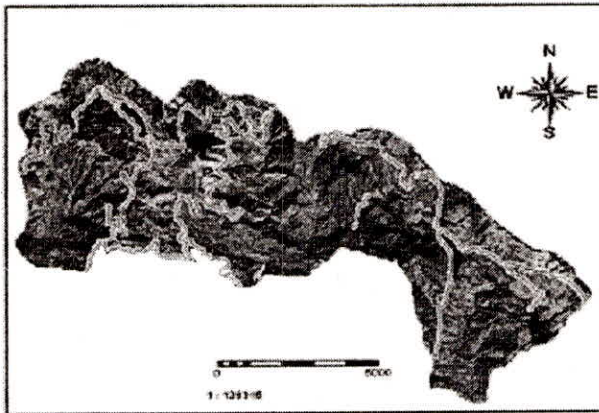
### **STUDY AREA AND ITS GEOGRAPHICAL SETTING**

The study area of the present paper is geographically demarcated with lake catchments in general and Nainital lake basin in particular. The lake region stretches between 79° 24' E to 79° 37'E Longitudes and 29° 17' N to 29° 25' N Latitudes in District Nainital of Uttaranchal. The major part of the lake region can be considered as a western sub-basin of river Gaula (one of the prominent rivers which originates from the district; it also includes a small SW part, of the headwaters of Nihal Nadi, an important stream of river Dabka. The whole region thus encompasses the lake basins namely, Khurpa Tal-Saria Tal, Naini Tal-Sukha Tal, SatTal and Bhim Tal-Naukhutia Tal respectively and drained by Nihal Nadi in the west, Ballia in the centre and Bhimtal Gadhera in the east. Within the domain of Lesser Himalaya, the region covers an area of about 80 square kms., with an altitudinal variation of 700m to 2610m. The region is one of the densely populated part of the Kumaun Himalaya. The existing permanent population of the region is about 70,000 that is inhabited in 3 urban centres and 39 villages dotted in the vicinity of these lakes. The climate of Lake Region is governed by the diversity of topographical features and the presence of lakes. The entire headwater region experiences exceedingly diversified climatic conditions. Climatic variations at short spatial distances are one of the important characteristics of the mountain environment, which result into climatic complexities at micro-levels in the region. Micro-climatic variations are mainly generated by the altitude and aspect of slope. The topographic and climatic complexities of the region have favoured the growth of a variety of natural vegetation. Forest in the lake catchments is predominantly composed of temperate genera; such as oaks, cypress, rhododendron, maple and ash but in the lower areas of the catchments sub-tropical plants such as species of Bauhinia, Butea and Chir Pine occur. Banj oak on drier aspect and Tilonj oak on moist slopes is important forest species at and around 2000m. In fact Nainital is the part of region where population of these oaks are centred. Chir pine forms almost pure crops on hill slopes, above 1000m, replacing oaks where fire, harvest of biomass and erosion are frequent. All these broad-leaved species and pine are evergreen with one-year leaf life span and constitute more than 70% of the tree importance. Such broad-leaved evergreen forests do not show extensive domination anywhere else in the world (Bargali & Singh, 1999).

### **POPULATION GROWTH AND LAND-USE CHANGE**

Land is surprisingly difficult to define. But one of the good definitions of land is "any part of the earth surface which can be owned as property, and every thing annexed to it whether by nature or by hand of man" (The Random House Dictionary of the English Language, 1996). Land utilization is a comprehensive expression connoting the use of land resource for carrying out various human activities, and also the set of geo-environmental and socio-cultural factors,





**Fig. 1 Study Area**

which control and regulate the process of such utilization in a geographical region. Land use is the result of practices, processes, techniques, customs and traditions adopted and acquired by the people after inhabiting a part of the earth for developing its natural resources. The land use system is highly dynamic, which undergoes significant changes according to the changing socio-economic parameters as well as natural environmental conditions. The human transformation process of the biophysical components has brought about drastic changes in the traditional land use pattern of the region. The process of rapid land transformation has not only created several environmental and ecological problems in the region but has also threatened the agricultural economy of the watershed through accelerated soil erosion, deforestation and reduction in ground water recharge etc. (Bisht, 1997). The study of land and its utilization is therefore of much significance in the planning and management of natural resources, particularly, land. Further, the understanding of land use is of considerable significance and importance not only from the view point of better knowledge of land use practices but also for the scientific interpretation of the various environmental processes operative in a region. Land use reflects the pattern of anthropogenic processes operating in a geographical region. It provides information regarding processes and factors under which the land and other natural resources of an area are utilized. The process of land utilization becomes more complex and intricate in mountainous environment, which need to be properly and scientifically analysed and interpreted.

In order to monitor the dynamics of land transformation process, land use interpretation was carried out in the study area for the years 1965 and 2002 respectively using Survey of India (SOI) Topographical Maps at scale 1:50000 and also, the available remote sensing merged data with intensive ground verifications. Table 1 shows the area statistics of the region and its different catchments.

**Table1. Area under different micro watersheds in lake region**

| Micro-watersheds   | Area (km <sup>2</sup> ) | Percent of Total Area | Altitude (m) |             |
|--------------------|-------------------------|-----------------------|--------------|-------------|
|                    |                         |                       | Min.         | Max.        |
| Nihal Nadi         | 7.4                     | 9.4                   | 1100         | 2400        |
| Ballia Nadi        | 42.0                    | 53.0                  | 1000         | 2610        |
| Bhimtal Gadhera    | 29.8                    | 37.6                  | 700          | 1700        |
| <b>Lake Region</b> | <b>79.2</b>             | <b>100</b>            | <b>700</b>   | <b>2610</b> |

The land use study revealed that in 1965, the average forest cover of the study region was about 72%. The Ballia and the Nihal watersheds were thickly forested with an average of 85%. In Bhimtal watershed the situation was not encouraging as compared to the vibrant forests of both Ballia and Nihal. The average forest cover of Bhimtal area was only 52%. The main reason that can be attributed for this dismal situation in Bhimtal was the high percentage of area under cultivation. In Bhimtal Gadhera watershed the cultivated area for agricultural pursuits was 35.9% whereas in Ballia and Nihal it was only 5.5% and 3.78% respectively. In Bhimtal, fertility of land, moderate climate, and being an old rural settlement, the area under cultivation was high as compared to mountain standards. Another reason that facilitated agricultural activities is its close proximity to the township of Haldwani and Naini Tal where there was a ready market for its vegetables and fruit etc. During that period, the built up area in Bhim Tal was also high, about 3%, though it had not evolved as an urban settlement or as a popular tourist resort by then. However, as early as 19<sup>th</sup> century, Bhimtal was a halting site for roving businessmen from the interior of Naini Tal and Almora districts as well as the foothills.

In both Naini Tal and Ballia the area under cultivation was only 4.5%. The reason behind this is that human concentration was negligible in Nihal and Ballia the fringe areas of Naini Tal township. Moreover the lake basin of Naini Tal had negligible area under cultivation. The ruggedness of the terrain in Ballia also entrapped agricultural activities.. Table No. 2 depicts the pattern of land use of the area in 1965.

In the present scenario of the existing land use, the forest cover in Nihal and Ballia is almost 68%, which conforms to the normal standard of 66%. But in Bhim Tal area the situation is dismal. The forests have been decimated and the forest cover is reduced to 22%. Table No. 3 illustrates the existing (2002) land use pattern of the lake region with its micro-basins.

The built-up area of Ballia has also increased from 80 ha. in 1965 to 181 ha. in 2002. Similarly in Bhimtal catchment the area under settlement has recorded an increase from 84 ha. to 150 ha. The reasons which are responsible for this accelerated growth are the increase in population, a sudden spurt in tourism in the last two decades, expansion of economic activities together with enhancement of infrastructural facilities and floating population of neo-rich settlers etc. These phenomena can be testified with tables 4a and 4b, which shows the over-all increase in population of the study region during the last two census years along with the trends of urban population growth of Nainital, Bhowali and Bhimtal townships.

The seasonal variation of population due to tourist influx and floating population dynamics has great bearing on the overall patterns of natural resource use particularly land utilization



Table-2. Broad land use pattern of lake region (1965)

| Micro-watershed | Total Geographical Area |                 | Forest Land  |              | Cultivated Land |              | Waste Land   |             | Pastures/Fallow Land |             | Water Bodies |             | Built-up Land |             |
|-----------------|-------------------------|-----------------|--------------|--------------|-----------------|--------------|--------------|-------------|----------------------|-------------|--------------|-------------|---------------|-------------|
|                 | Area (ha)               | % of total area | Area In (ha) | Area in %    | Area in (ha)    | Area in %    | Area in (ha) | Area in %   | Area In (ha)         | Area in %   | Area in (ha) | Area in %   | Area in (ha)  | Area in %   |
| Nihal Nadi      | 740.0                   | 9.4             | 613          | 82.84        | 28              | 3.78         | 09           | 1.22        | 42                   | 5.67        | 45.0         | 6.09        | 03            | 0.40        |
| Balia Nadi      | 4200.0                  | 53.00           | 3561         | 84.79        | 231             | 5.50         | 93           | 2.21        | 146                  | 3.48        | 89.0         | 2.12        | 80            | 1.90        |
| Bhimtal Gadhera | 2980.0                  | 37.6            | 1545         | 51.90        | 1070            | 35.91        | 89           | 3.00        | 98                   | 3.22        | 94.0         | 3.15        | 84            | 2.82        |
| <b>TOTAL</b>    | <b>7920.0</b>           | <b>100.0</b>    | <b>5719</b>  | <b>72.21</b> | <b>1329</b>     | <b>16.78</b> | <b>191</b>   | <b>2.41</b> | <b>286</b>           | <b>3.60</b> | <b>228.0</b> | <b>2.88</b> | <b>167</b>    | <b>2.11</b> |

Source: Land Record Office, Nainital

Table 3. Broad Land Use Pattern of Lake Region (Existing) 2002

| Micro-watershed | Total Geographical Area |                 | Forest Land   |              | Cultivated Land |              | Waste Land    |              | Pastures/Fallow Land |             | Water Bodies |             | Built-up Land |             |
|-----------------|-------------------------|-----------------|---------------|--------------|-----------------|--------------|---------------|--------------|----------------------|-------------|--------------|-------------|---------------|-------------|
|                 | Area (in ha)            | % of total area | Area (ha)     | Area %       | Area (ha)       | Area %       | Area (ha)     | Area %       | Area (ha)            | Area %      | Area (ha)    | Area %      | Area (ha)     | Area %      |
| Nihal Nadi      | 740.0                   | 9.4             | 506.0         | 68.37        | 38.0            | 5.13         | 33.0          | 4.46         | 112.0                | 15.14       | 45.0         | 6.09        | 6.0           | 0.81        |
| Balia Nadi      | 4200.0                  | 53.00           | 2808          | 66.86        | 323             | 7.69         | 483.0         | 11.50        | 316.0                | 7.52        | 89.0         | 2.12        | 181.0         | 4.31        |
| Bhimtal Gadhera | 2980.0                  | 37.6            | 660.0         | 22.15        | 1257            | 42.18        | 646.0         | 21.68        | 173.0                | 5.81        | 94.0         | 3.15        | 150.0         | 5.03        |
| <b>TOTAL</b>    | <b>7920.0</b>           | <b>100.0</b>    | <b>3974.0</b> | <b>50.18</b> | <b>1618</b>     | <b>20.43</b> | <b>1162.0</b> | <b>14.67</b> | <b>601.0</b>         | <b>7.59</b> | <b>228.0</b> | <b>2.88</b> | <b>337.0</b>  | <b>4.25</b> |

Table 4a. Population growth in lake region

| Water sheds       | No. of Villages | Population (1991) |              |              | Population (2001) |              |              | Growth of Pop. (1991-2001) |
|-------------------|-----------------|-------------------|--------------|--------------|-------------------|--------------|--------------|----------------------------|
|                   |                 | Rural             | Urban        | Total        | Rural             | Urban        | Total        |                            |
| Nihal Nadi        | 5               | 3615              | -            | 3615         | 4414              | -            | 4414         | 22.10                      |
| Ballia Nadi       | 9               | 5347              | 35315        | 40562        | 6601              | 5142         | 51743        | 25.09                      |
| Bhimalta Gadhera  | 25              | 6932              | 4225         | 11157        | 8650              | 5875         | 14525        | 30.19                      |
| <b>Total Area</b> | <b>39</b>       | <b>5894</b>       | <b>39540</b> | <b>55334</b> | <b>19665</b>      | <b>51017</b> | <b>70682</b> | <b>27.74</b>               |

Source: Census of India, 1991 & PCA. 2001, vol-4

Table 4b. Urban population and its growth trends in lake region

| Urban Centres    | Area Km      | Population             |                        |                       |                        |                        | Density Km (2001) |
|------------------|--------------|------------------------|------------------------|-----------------------|------------------------|------------------------|-------------------|
|                  |              | 1961                   | 1971                   | 1981                  | 1991                   | 2001                   |                   |
| Nainital (U.A.)  | 14.42        | 16080<br><b>+22.8</b>  | 25167<br><b>+56.51</b> | 26093<br><b>+3.68</b> | 30951<br><b>+18.62</b> | 39840<br><b>+28.72</b> | 2763              |
| Naini Tal (M.B.) | 11.73        | 14995<br><b>+21.42</b> | 23986<br><b>+59.96</b> | 24835<br><b>+3.54</b> | 29837<br><b>20.14</b>  | 38559<br><b>+29.23</b> | 3294              |
| Nainital (C.B.)  | 2.59         | 1085<br><b>+46.03</b>  | 1181<br><b>+8.85</b>   | 1258<br><b>+6.52</b>  | 1144<br><b>-11.45</b>  | 1281<br><b>+11.97</b>  | 495               |
| Bhowali          | 1.32         | 1457<br><b>-23.11</b>  | 2193<br><b>+50.51</b>  | 3212<br><b>+46.47</b> | 4364<br><b>+35.87</b>  | 5302<br><b>+21.49</b>  | 2047              |
| Bhim Tal         | 3.95         | -                      | -                      | 2871<br><b>-</b>      | 4225<br><b>+47.16</b>  | 5875<br><b>+39.05</b>  | 1487              |
| <b>Total</b>     | <b>19.69</b> | <b>17537</b>           | <b>27360</b>           | <b>32176</b>          | <b>39540</b>           | <b>51017</b>           | <b>2591</b>       |

*Small bold numerals indicate percentage growth.*

Source: Census of India, 1991, Series-25, Part ix-A, & PCA. 2001, vol-4

changes. In the last 35 years, the increasing practices of unproductive use of land in the form of commercial and residential construction of houses has extended over the large areas of the lake region and is leading to degradation of the fragile eco-system and depletion of bio-physical resources.

The land under forest has drastically reduced from 5719 ha (1965) to 3974 ha (2002). This is the result of increasing demand for fuel, fodder, and cultivated land in the area. The study revealed that proportion of degraded forests has been increasing in the periphery of settlements and agricultural lands due to human encroachment and other biotic interference. As a result, the wasteland has increased from 191 ha to 1162 ha during the period. The direct impact of the change in the land use patterns in the study region is seen in the forests that are reduced by

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more than 22%. Table-5 indicates the percentage of diminishing forest area along with the changes in different land use categories. There is also an increase in waste and pasture and fallow land area at the cost of depletion of forest cover. These changes in land use patterns provide a grim picture of the region which is eco-fragile, sensitive and a part of the catchment area of the great Gangetic plain.

**Table 5. Land Use Status and Changes in Lake Region (1965-2002)**

| Broad Land use type  | 1965      |          | 2002      |          | Changes (1965-2002) |          |
|----------------------|-----------|----------|-----------|----------|---------------------|----------|
|                      | Area (ha) | Area (%) | Area (ha) | Area (%) | Area (ha)           | Area (%) |
| Forest Area          | 5719      | 72.21    | 3974      | 50.18    | -1745               | - 22.03  |
| Cultivated Land      | 1329      | 16.80    | 1618      | 20.43    | +289                | + 3.65   |
| Waste Land           | 191       | 2.41     | 1162      | 14.67    | +971                | +12.26   |
| Pastures/Fallow Land | 286       | 3.60     | 601       | 7.59     | +315                | + 3.98   |
| Water Bodies         | 228       | 2.88     | 228       | 2.88     | 00                  | 00       |
| Built-Up/Settlements | 167       | 2.11     | 337       | 4.25     | +170                | + 2.14   |

### THREATS AND THEIR IMPACTS

The lake systems of the region have served as centres of population. They provide a range of ecosystem services: supporting services, provisioning services, regulating services and cultural services. Changes in these services affect human well-being through impacts on security, the basic material for a good life, health and social and cultural relations (Rebecca D Cruz-2004).

The threat posed to the lake region is owing to the eco-disturbances caused in the nucleus of the area i.e. Nainital town and its lake basin. Whatever happens in Nainital, whether it is increase in tourism or construction activity, it triggers a chain reaction elsewhere. It is disturbing that the very existence of Nainital is threatened. The sudden spurt in tourism has led to a mad rush for constructing new hotels, guest houses, resorts and farm houses in Nainital as well as in the neighbouring lake catchments. In some cases, rules were being flouted in a brazen manner for illegal construction. According to data available from the Municipal Board in the 1950, there were only 15 hotels in Nainital. Their number soared up to 102 in 1981-82 and 134 in 1987-88 (Rawat & Singhal-1998). At present the number of licensed/unlicensed hotels and guest houses, huge resorts claiming star facilities in Naini Lake Basin and in lake region has reached around 200. The real-estate developers cashing in on the great demand for new houses have scarred the tender and lovely hill side and have constructed houses and huge hotels in localities which were declared unsafe and where such activities are strictly prohibited by the British and Municipal Bye-laws. Rubble from this work was not removed but dumped into the lake during the rains, which accelerate the rate of sedimentation.

Lakes of this region are at present threatened by pollution. Table 6 that describes the physical and chemical properties of lake water along with their geographical profiles indicates the poor



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quality of this life supporting eco-system service. Most of the population of lake basin is dependent on these lakes for drinking water. During the last few decades, organic pollution in Naini Lake has been increasing at a rate that even preliminary limnological studies show unmistakable symptoms. The luxurious growth of *potamogeton pectinatus*, a plant always associated with organic pollution in the littoral zones of the lake, is sufficient to indicate how heavily the water is polluted. Certain toxic substances such as ammonia, hydrogen sulphide and methane, evolve round the year in the bottom layers and have affected fish population to a great extent. Fish mortality which was a casual phenomenon in early has become a regular feature now, especially in winter. The situation in other lakes is no better. It is high time that group housing in the catchment areas of other lakes should be regulated and construction should be in consonance with the rules framed by the Special Lake Area Development Authority, Nainital.

The natural resources in this lake region are being used erratically and ruthlessly due to increasing population pressure and resultant increase in demand for shelter, arable land, grazing areas, fodder, fuel wood etc. along with growing needs of tourism. It is, therefore, increasingly realized that the formulation and implementation of the process of developmental planning in the region must be consistent with the natural resource base and its ecological productive potential. The goal of ecologically sustainable development with economically viable growth Since land is the primary and fundamental natural resource and it is the basis of the genesis, management and sustainable development of all other natural resources, land management has acquired critical importance in this fragile region. The region, therefore, deserves specific attention and priority conservation measures for protecting the lakes and their environment.

**Table 6. Geographical, Morphometric, physical & chemical Profile of the Lakes**

| Lakes Parameters                  | Naini Tal | Bhim Tal    | Naukuchia Tal | Sat Tal      | Khurpa Tal   |
|-----------------------------------|-----------|-------------|---------------|--------------|--------------|
| Altitude (m)                      | 1936      | 1372        | 1219          | 1347         | 1600         |
| Length (m)                        | 1442      | 1974        | 950.9         | 1300         | 495          |
| Breadth (m)                       | 423       | 457         | 691.8         | 190          | 266          |
| Depth (m) max.                    | 27.3      | 25.8        | 40.8          | 20           | 12           |
| Depth (m) mean                    | 16.2      | 11.5        | -             | 8            | 5            |
| Basin Area (ha.)                  | 470       | 1140        | 280           | 428          | -            |
| Lake Circumference                | 3630      | 4023        | 3560          | 3750         | 874          |
| Ratio Between Basin And Lake area | 10.1:1    | 13.1:1      | -             | 10.7:1       | 0.97:1       |
| Secchi Transparency (m)           | 0.36-2.01 | 1.23-3.40   | 3.3-9.4       | 1-3          | 1.2-3.5      |
| Alkalinity (mg/l)                 | 20-560    | 43.5-290    | 15-52         | 6-31         | 50-263       |
| Dissolved Oxygen (mg/l)           | 4.0-23    | 9.7-13.4    | 8-14.8        | 4.2-12.8     | 5.5-13       |
| NO <sub>3</sub> -N (mg/l)         | 0.06-0.8  | 0.0-0.75    | 0.6-1.6       | 0.07-1.23    | 0.06-0.78    |
| PO <sub>4</sub> -P (mg/l)         | 3-30      | 1-28        | 20-60         | 0.2-3.0      | 1.16-14.6    |
| Trophic status                    | Eutrophic | Mesotrophic | Oligotrophic  | Oligotrophic | Oligotrophic |

Sources: Joshi, S.C. *et al.*, & Gupta, P. K. *et al.*



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