# Anthropogenic induced activities on Water resource with special reference to Bhimtal and its Environ; A critical study on Kumaun Lesser Himalaya.

**Kedovikho Yhoshü**
**Department of Geography, Nagaland University- 798627**

**Abstract:** The mounting pressures of anthropogenic activities have taken its toil on nature and nature is gradually degrading in the blunt ways of man with a cost to the pristine ecology. To study the affect of anthropogenic activities on the water ecosystem in the fragile Himalayan Ecosystem, a case study has been taken by selecting Bhimtal town and eleven satellite villages surrounding it. The study region is located in Uttarakhand state under Nainital district and comes under Nagthat geologic formation. The study region has the largest lake namely- Bhimtal lake in the entire Lake region. Being a part of the Himalaya, the study region is in a fragile environment where more destruction are rising with the increase of building activities, modernisation, deforestation, pollution level, etc. Some of the anthropogenic activities especially tourism has been considered along with the anthropogenic landuse pattern system to analyse the degrading environment in Bhimtal and its Environ especially in regard to water resources. The boon of tourism in the state has led to drastic change in the economy as well as the ecology of the lake region. The once agricultural land has now being replaced by the resorts, recreational centres, etc. This crucial matter has been highlighted by pinpointing the destruction process of the environment.

**Keywords:** Ecosystem; Drainage; landuse; water resource; tourism; environmental hazard

## Introduction

The Study Region comprises of one urban centre-Bhimtal and eleven satellite villages. It is located in the Lake Region of Nainital district in Uttarakhand State. It lies 22 km East of Nainital. Bhimtal town is situated at an altitude of 1370m above mean sea level. It is located between 29°18’ N and 29°28’N latitudes and 79°32’E and 79°37’E longitudes. The total geographical area of the study region is 2156.758 ha or 21.57 sq km. The pride of Bhimtal Township and its Environ (Figure 1) is the beautiful lake located at an altitude of 1331 m above mean sea level (msl) with a catchment area of 11.4 sq km.

## Physical Milieu

Bhimtal Township and its Environ constitute a part of the Lesser Himalaya which lies between the Siwalik range in the south and the Greater Himalaya in the north. The relief topography features a series of ridges and small spurs- with valley in between streams and hills with largely varying slope conditions.

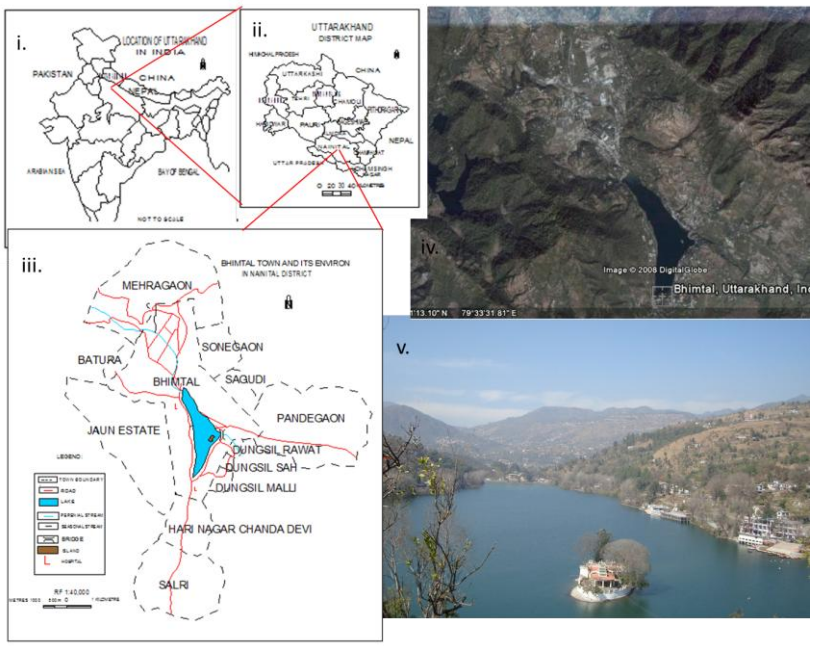


**Figure 1.** (i) India Map. (ii) Uttarakhand state. (iii) Study region. (iv) Location of the study region as seen from Google earth. (v) The picturesque Bhimtal lake and its surrounding.

Latitudinally, this area belongs to sub-tropical part of the globe but altitudinally it has the characteristics of the sub-temperate climate. The Kumaun lakes are spread in a radius of 23 km with Nainital Lake as their centre while Bhimtal Lake is one of the important lakes and the largest lake in the Kumaun region. The Township and its Environ comes under the rock strata of Nagthat Formation made up of Bhimtal Volcanics (BV) where its formation was formed during the Meso to Palaeo Proterozoic Period (Figure 2).

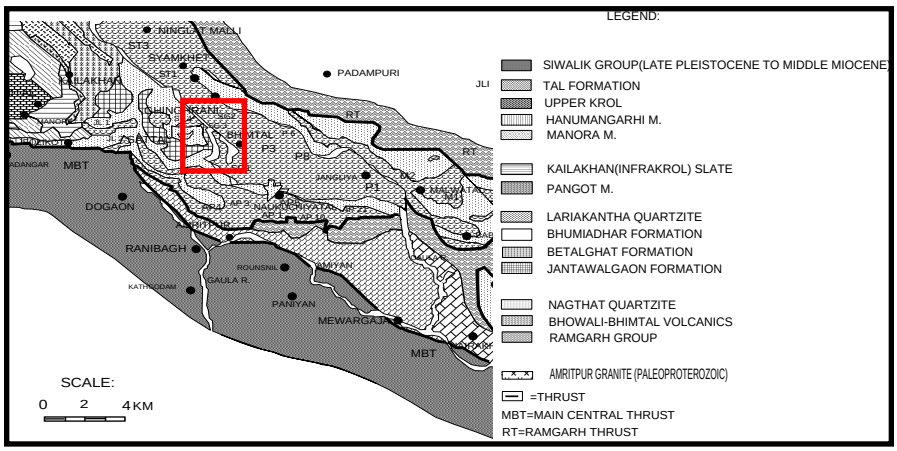


**Figure 2**. Geology map of the study area is highlighted within the Red box (source-Valdiya,1988)

The rock belt is largely composed of unfossilerous strata and is made of Crystalline and Metamorphic rocks. Being Metamorphic in nature, the Region present a massive resistance topography with sub- rounded ridges though the valley had

witness more weathering being made up of softer fragments compared to the hilly part which are made up of quartzites (Pandey, 2005). Location and physiographical factors have greatly influenced the climatic characteristic of the Region. Being a part of the Himalayan Mountain Range, the area experience and exhibit significant climatic phenomena. Though India being climatically divided by the Tropic of Cancer, due to the physiographic feature of the Himalayan Range, there is a diverse climatic system which is divided and classed by its altitudinal feature. Interestingly, though the region of Bhimtal Town and its Environ come under the Sub-Tropical part latitudinally, the region exhibit a Sub-Temperate climate because of its altitudinal location.

The mean annual Temperature is 15.7°C and the mean monthly minimum and maximum temperature range from 2°C to 15°C in the month of Jan and 18°C to 31°C in the month of May. The rainy season usually commences by the middle of June. Approximately more than 70% of the rainfall occurs in the month of June to September. Winter precipitation is caused by the western disturbances with a rainfall amount ranging from 100 to 200cm and in monsoon it ranges from 175 to 100cm.Mean annual temperature range from 8.5°C during the month of January and 23.5°C in the month of June.

**Drainage**

The drainage water of Bhimtal Lake originates from the forested zone of the Lesser Himalaya in the northern part of the Bhimtal Catchment. The streams are mainly seasonal in nature and carry small quantity of water except during the rainy season. Bhimtal Lake has only one drain opening which drains the upper northern part of the Township descending from the Gorakhal Region. Bhimtal Lake is the main water source for the study region which also forms the main drainage reservoir and it is used in domestic as well as for irrigation purposes. The Lake water drains out from its main outlet located in the SSE direction into the Bhimtal Gadhera which intersect with the Balia Nala in the lower Catchment areas and finally merged into the Gaula River which joins the Ram Ganga River (Gusai, 2004). The main drainage system (Bhimtal Lake) is form through several small seasonal stream and tributaries some of which are perennial and some seasonal, the lake also has its own subterranean water source.

**Soil**

The soils of Bhimtal Township and its Environ are classed under mountainous region soil or mountain soil. The soils largely vary in mountain soil according to parent material which differs from place to place as well as varying local conditions of climate, altitude or aspect. The soils of the study region are deluvial soils- derived from parent material and occur at specific site and are of sandy loom type of soil texture (Table 1). Being made up of Bhimtal Volcanics (BV) strata the soils have good retentive capacity for moisture due to their parent rock material- crystalline and metamorphic and are good arable land though the depth of the soil is very thin. Areas

under fertile soils are covered by Oak forest because the roots of Oak tree are fibrous and they absorb vast quantities of water which they release slowly.

| | | |
|---|---|---|
| 1. | Site | Bhimtal and Environ. |
| 2. | Depth of soil (cm) | 10-30 |
| 3. | Organic carbon (%) | 2.50 |
| 4. | pH value | 6.2 |
| 5. | Soil texture | Sandy loam |
| 6. | Nitrogen (%) | 0.16 |
| 7. | Phosphorous (kg/ha) | 18 |
| 8. | Potassium (kg/ha) | 225 |

**Table 1.** Soil profile (Source: Takuli, Pokhar Singh( 2002), Agro Ecosystem and Agro-Energy Environment Management in Gaula Watershed, Lower Kumaun Himalaya).

## Demographic profile of the region

Physical factor along with cultural factor plays an important role in demographic growth. Settlement map is shown in Figure 3. Traditions and behaviour associated with common ancestry, religion and language tend to influence population growth. Various economic factors like push and pull factor draw people from near and far off places. The total population of the Study Region according to 2001 census was 7270 where 3908 are male and 3362 are female. The percentage distribution of both male and female are 54% and 46% respectively. SC and ST population make about 1461 i.e., 20.1% of the total population in Bhimtal and its Environ.

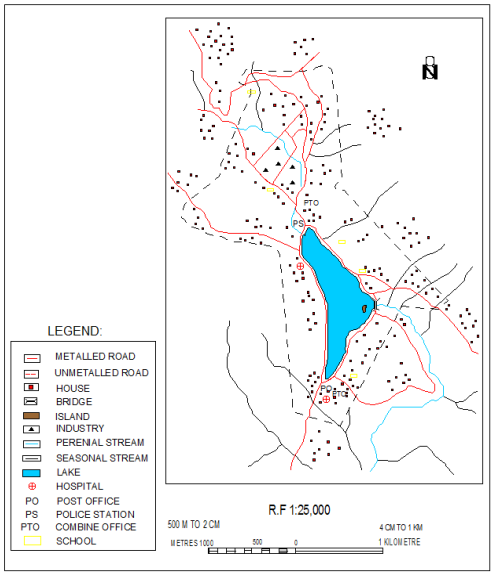


**Figure 3**. Settlement in and around Bhimtal and its Environ.

## Economy

The usage of water resources depends on the settler's livelihood. Economic activities in the study region are broadly grouped into primary, secondary, tertiary and

quaternary activities. The people in Bhimtal Town are mainly engaged in secondary, tertiary and quaternary occupation. With the growth of tourism and industrial areas more people are engaging in tertiary and quaternary activities, the demand of water has also risen. Tourism has been a major factor which has led to the rapid growth of secondary, tertiary and quaternary occupation. Unlike the Township of Bhimtal, the economy of the Environ around the town is basically engaged in primary occupation. Though agriculture is a difficult task in the mountain region, the scope for the extension of agriculture is severely limited. Agriculture is still the main backbone for economic generation in the Environ around Bhimtal Town. Primary occupation is slowly giving way to other occupation due to several reasons like limitation of expansion of cultivable land, tourism industry, building, unstable land topography, etc., despite the fact that the available cultivable land are fertile. But the future of primary occupation is very grim as more and more arable land are being used up in building houses, hotels, etc. also the fact that limitation and expansion of arable land offer less scope for primary occupation.

## Landuse classification

Land is the prime and a vital resource for man, land resource is one of the most important ecological factors (called edaphic factor) and is the most characteristic feature of terrestrial environment. A general land use pattern (Figure 5) has been presented in the Table 2 below to understand the position of Bhimtal Township and its Environ land use utilisation and scenario of water resources.

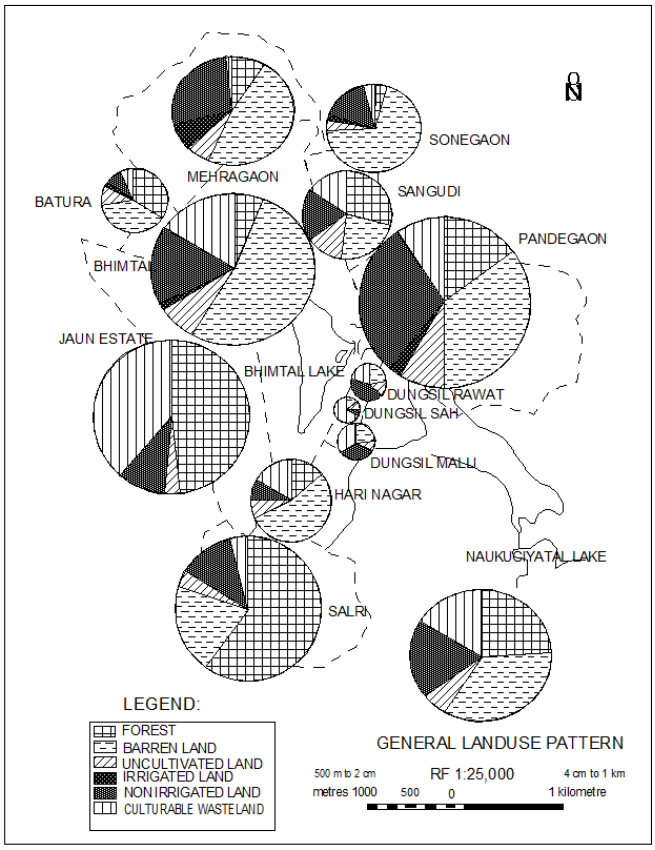


**Figure 5.** Landuse Classification in the Study region.

The distribution of forest is very unbalanced as in some sample villages the area under forest is completely absent. Out of the total physical area of the region, the area under forest comes about 24.14% of the total geographical available area. This portion constitutes 34.35% of the total geographical area. Bhimtal has the largest barren land with an area of 197.202 ha i.e., about 26.62% of the total barren land. Nearly 144.772ha or 6.71% of the total geographical area has been classed under uncultivated land. Because of presence of forest and difficult topographic condition agricultural land occupies only 20.04% of the total geographical area. Out of the cultivated land (20.04%) in respect with the total geographical land we have 18.58% under non-irrigated land and only 1.46% under irrigated land. Culturable wasteland (318.276ha) constitute 14.76% of the total reported geographical area of the study region. Out of which the maximum share is in Jaun Estate (41.91%) followed by Bhimtal(19.08%), Pandegaon (14.06%).

| Sl.no. | Village | Total area | Forest panchayat area | Barren land | Uncultivated land | Cultivated land | | Culturable wasteland |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Irrigated | Non-irrigated | |
| 1. | Pandegaon | 435.810 | 60.000 | 153.500 | 37.305 | 6.395 | 133.867 | 44.743 |
| 2. | Sagudigaon | 112.055 | 32.000 | 27.231 | 16.158 | - | 20.171 | 16.495 |
| 3. | Jaun-Estate | 346.657 | 164.951 | 0.121 | 13.361 | - | 34.847 | 133.377 |
| 4. | Bhimtal | 370.227 | 21.169 | 197.202 | 28.847 | 1.609 | 60.688 | 60.712 |
| 5. | Mehragaon | 222.321 | 17.003 | 109.204 | 13.662 | 17.7465 | 58.722 | 6.265 |
| 6. | Dungsil-Malli | 19.348 | - | 4.453 | 1.710 | - | 6.544 | 6.641 |
| 7. | Batura | 68.115 | 23.123 | 26.414 | 6.026 | 2.380 | 6.336 | 3.836 |
| 8. | Dungsil-Rawat | 18.706 | - | 4.148 | 2.475 | - | 8.006 | 4.077 |
| 9. | Dungsil-Sah | 10.200 | - | 1.470 | 1.011 | - | 0.294 | 7.425 |
| 10. | Sonegoan | 146.357 | 5.280 | 103.034 | 3.715 | 2.689 | 25.439 | 6.200 |
| 11. | Salri | 308.112 | 184.000 | 60.542 | 12.323 | - | 39.578 | 11.669 |
| 12. | Hari Nagar-Chanda-Devi | 98.850 | 13.038 | 53.588 | 8.179 | 0.995 | 6.214 | 16.836 |
| | Total | 2156.758 | 520.564 | 740.907 | 144.772 | 31.533 | 400.706 | 318.276 |

**Table 2.** Landuse classification of Bhimtal and its Environ (2007-08 Census).

The general classification of the region can be placed under the land capability classification of class IV as some of the available physical land is subjected to erosion risk and the cultivated area cover under irrigation is also less and scarce where cultivation is carried only to a limited extend.

**Water resource**

The main water source in Bhimtal Town and its Environ is derived from the lake water where it is used for domestic as well as agricultural purposes. Bhimtal lake is located at an elevation of 1331m above mean sea level and extend between 29°23'N latitude to 79°36'E longitude. The Bhimtal Lake has an estimated volume of 4.2 million $m^{-3}$ of water which is the life sustaining substance in and around Bhimtal Town. The Lake water is necessary for the sustainable development of Bhimtal as it act as fodder source as well as a financial source to the people of Bhimtal region.

As seen in Table 3, the nutrient content is increasing causing deterioration in the pristine value of the lake. Change in man's life style has induced the present degradation of the water. Increase pollution level has brought more physiochemical change which creates more curtailment for the sustainability of mankind. Besides the reduction in the pristine value of water, the water level is also diminishing in the Lake as well as the area around the Bhimtal Township.

| Sl.no | Feature | Bhimtal | | |
|---|---|---|---|---|
| | | 1980 | 1990 | 2000 |
| 1. | Secchi transparency (m) | 1.23-3.9 | 1.83-2.45 | 2.1-3.7 |
| 2. | pH value | 7.8-8.9 | 7.0-9.2 | 7.2-8.3 |
| 3. | Dissolved $O_2$ (mg/l) | 7.2-14.6 | 5.2-7.2 | 6.2-12.6 |
| 4. | Free $CO_2$ (mg/l) | 0.0-2.8 | 0.8-2.8 | 0.0-5.1 |
| 5. | Alkalinity (mg/l) | 30-160 | 72-118 | 80-182 |

**Table 3.** Time Scale Changes in certain Water quality parameters in Bhimtal Lake (after Sharma, 2002) (Source-Cold water and Fisheries research, Bhimtal)

The present dissolved oxygen level in Bhimtal Lake is 6.2-12.6 mg/l while its temperature is 10.5-26.5°C and alkalinity is 80-182 mg/l. The decomposition of organic matter and the respiratory activity of aquatic plant and animal produce carbon dioxide. Carbon dioxide influences the pH value of water where the pH value of the lake is 7.2-8.3 which shows that it is alkaline in nature.

**Environment hazard**

The ever increasing urban demands on the environment and the negative effects of tourism industry is leading to rapid exploitation of natural resources-water, forest which are resulting in the degradation and deteriorating stage of the eco-system. The study region is fast becoming a tourist region where lots of hotels and resorts are coming up consuming the already scare land. Improper disposal of waste both domestic and industrial in and around Bhimtal Town are finding its way back into the Lake causing water pollution, sedimentation process, etc. The manic of solid waste disposal is largely seen during the monsoon season when the nalas are over flown and swept the unattained waste into the drainage system which later drains into the main Lake- the reservoir.

Slopes are cut for construction of buildings and deforestation makes the land vulnerable to landslides. The process of erosion is causing siltation and sedimentation in Bhimtal Lake. The shrinking of the Lake has become a major problem not only in Bhimtal but also in other lakes like Nainital, Sat Tal, Naukuchiyatal, etc. The Bhimtal Lake had an area of 60.00ha in 1904 but is now reduced to 46.26 ha (Khanka and Jalal, 1985) and the capacity of the lake has declined by over 50,000 cubic feet. With the rise in eutrophication the transparency level of the water is degrading affecting the water ecosystem.

## Conclusion

The fact that the study region had a rich history of agriculture production was seen in the record as early as 1881 when tea plant was planted from Bhimtal to Sat Tal by the British Imperial because of its favourable climate for vegetation. Man has change the pattern of tea plantation where the previously tea plantation and Banj oak vegetation has been replaced by Chir-pines. The barren and fallow lands have given rise to the rich growth of lantana plant.


**Figure 6.** Negative effects: i. Trees dectructed-Firewood, ii. Waste disposal left unattended, iii. Landslide caused by deforestation, iv. Slope failure due to construction.


**Figure 7.** Positive effects: i. Pisciculture by DCFR, ii. Lopping of trees for fodder, iii. Renewable resources for home appliances, iv. Floriculture and reforestation.

The present existing scenario of Land Use pattern in the Region as seen in Table 2 does not hold much scope in agriculture due to limited agricultural land and irrigation. For better production of agriculture, the role of agricultural innovations and techniques, its potential and planning are the main issues which have to be directed for an efficient performance. Bio-physical as well as socio-cultural environment of these hill areas exert dominant control in the agricultural economy. To assist and gear up the efficiency of agricultural economy, it needs some prerequisite for planning.

Serious reimplementation of development and plantation of trees is needed so as to conserve the water resource which will help in the conservation of the natural eco system for a long sustainable environment. Man has induced massive changes in the environment- in the past the area surrounding the Bhimtal Lake was covered by bamboo grooves but now it has been replaced by Chir pine which reduces the water table level. The quality and quantity of the forest land is fast degrading due to man induced changes (Figure 6). All the credit however cannot be presented to man alone since nature also holds some responsibility in its own destruction- the Bana menace. Due to Bana menace, the tropical trees are slowly diminishing. Bhimtal forest was covered by temperate and tropical trees in the past but man has cut the trees down and has given a new face lift. The deforested and fallow lands have given way to the immense growth of lantana- an irritant weed. This theory is well supported as one go along the road towards Naukuchiyatal vast areas have been engulfed by this weed.

According to Vass , (2003) conservation of water resources in Bhimtal region has reach a mark for serious consideration since 'Bathymetric analysis of the Bhimtal Lake reveal that the aerial extend of the Lake has shrunk by 13.44 ha from 60 ha in 1940 to 46.26 ha in 1984 (Khanna and Jallal, 1985)'. Moreover weeds have infested a large portion of the Lake and the marshy land is expanding at a fast rate especially towards the north- Mallital. The area under culturable wasteland constitute 318.276ha (14.76%) of the total geographical area, this area if taken under plantation and afforestation, the present forest land will not only increase but the plantation will increase the water level. Besides it will help in the infiltration process- the main source to replenish the ground water source. Sustainability of an occupation depends on consistency, for livelihood through fishery, methods like 'Pens' and 'Cages' could be exploited which have a vast potential for raising and regenerating Mahseer and Snow-trout fingerlings in its onward stage, the stock should be fed with highly nutritive and efficient cheap diets. Various positive steps as shown in Figure 7 should be encouraged and undertaken for the conservation and sustainability of water resource in the region.

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