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Change in environment at Dehradun and its impact

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Abstract
Dehradun, is best described as "Valley in Shiwalik Hills", being surrounded by Shiwalik mountain range, fringed with the Ganga on the east and the Yamuna on the west. The jewels studded in Dehradun's crown are-Queen of hills-Mussoorie, Sahastradhara, Rishikesh, Haridwar, Lachiwala, Maaldevta, Bhatta falls, Tiger Falls, Robber's cave, Buddha Monastry, Shiv Temple, Tapkeshwar Cave Temple, Shenshai Ashram, Ramkrishna Mission Ashram, Malsi Deer Park, British architecture, leychee farms, resplendent weather and pristine natural beauty. Dehradun houses great institutions and schools like The Indian Military Academy, The Forest Research Institute, The Doon School, to name a few. After the formation of Uttarakhand State in November 2000, Dehradun was declared the "Capital" of Uttarakhand. This proved to be the biggest misfortune that befell on our beloved city. The city today faces huge difficulties in terms of waste management as around 300 tonnes of waste is generated every day, of which only 100 tonnes is collected and recycled. The rest stays around us in the form of roadside litter and open dumpsites. Mass migration of people from uphills to the city in search of quick bucks followed by rapid urbanization led to building of houses even on a small piece of land with roads becoming narrower for the traffic. Since 2000, over 2 lakh trees were cut officially, while unofficial estimates put the number five times. The leychee farms have been replaced by multi storeys, malls, hotels and resorts. Today the beauty of Dehradun is like of a wouded tiger at the Rajaji National Park.

Keywords: Valley in Shiwalik, Leychee, Capital of Uttarakhand, Dev Bhoomi, Ganga, Yamuna, Garhwal, Kumaon, Leopard, Rain city.

1. Introduction

India, not technologically advanced, but stands apart because of its rich cultural heritage. A multistate country (29 state), each state with its distinguishing language, local dialect, customs, traditions, food habits and dress code marks unity among diversity.

1.1 About Uttarakhand State

Uttarakhand, formerly known as Uttaranchal, the "Land of Celestial Beauty", also called as "Dev Bhoomi" or the abode of the Gods. It became the 27th state of the Indian Union on the 9th of November 2000. The charming hilly state carved out of Uttar Pradesh, comprises of two regions - Garhwal in the west and Kumaon in the east. Two of India's largest and holiest rivers, the Ganga and the Yamuna originate in the glaciers of Uttarakhand. The state is studded with stunning snow covered peaks, glorious glaciers, alpine meadows, lush green valleys, dense forests, holy rivers and exotic flora and fauna. Today, Uttarakhand has become an important destination for religious tourism, spiritual tourism, wild life tourism, adventure sports like mountaineering, trekking, skiing, skating, water sports like rafting, boating and angling. A brief overview of Uttarakhand is shown in table 1.

Table 1: Overview of Uttarakhand State

Country	**India**
Region	North India
State	Uttarakhand
Established	9 November 2000
Districts	13
Capital	Dehradun
Official Language	Bhoti, Hindi, Sanskrit
State Animal	Musk Deer
State Bird	Monal
Government	
Body Governor Chief Minister Legislature Parliamentary Constituencies High Court	Government of Uttarakhand Dr. Krishan Kant Paul Harish Rawat (INC) Unicameral (71 seats) Rajya Sabha 3 Lok Sabha 5 Uttarakhand High Court
Area	
Total Area rank	53.484 km^2 (20,650 sqmt) 18th
Population (2011)	[3,4]
Total	10,116,752 5,154,178 (Male) 4,962,574 (Female)
Rank	19th
Density	189/km^2 (490/sqmt)
Demonym	Uttarakhandi
Time zone	IST (UTC+05:30)
ISO 3166 code	IN-UT
Vehicle registration	UK 01-XX
HDI	0.515[3]
HDI rank	7th (2011) 79.63%
Literacy	88.33% (Male) 70.70% (Female)
Sex ratio	963/1000 (Female/Male)
Languages spoken	Hindi Garhwali Kumaoni Jaunsari

1.2 About Dehradun City

The study area Dehradun is the state capital of Uttarakhand. Dehradun is made up of two words: 'Dehra' is derived from the word "Dera", meaning home. 'Doon' is a term for the valley that lies between the Himalayas and the Shiwaliks [1, 2]. Present day Dehradun resembles a metro..... its like a Delhi with hills. Geographically, Dehradun is located about 270 km north of the Indian Capital New Delhi. Dehradun lies between 29°58' N and 31°2'30" north latitudes and 77°34'45" and 78°18'30" east longitudes. Doon valley extends for a length of about 80 km with its average width of 20 km occupying an area of about 2245 km^2. It is located between the rivers Yamuna and Ganga in the north western limit of state Uttar Pradesh and adjoining the state of Himachal Pradesh. Dehradun is bounded by the Himalayas in the North and the Shiwalik ranges in the Southern in the Southern part. A brief overview of Dehradun is shown in table 2. It has a temperate and humid climate, as shown in table 3. Winter season is confined mainly from mid-November to February, while summer continues upto the end of June and monsoon from July to September. Temperature ranges between 1 and 20°C in winters and 35 °C-44 °C in summers. It is referred as "The Rainy City" of India due to continuous and incessant rainfall. The average annual rainfall in the valley is about 207 mm. The year 2013 has the longest monsoon with highest ever recorded rainfall of 370 mm on 16th and 17th June 2013, leading to Kedarnath disaster. Relative humidity is high during the monsoon season; it exceeds 70% on an average. During summer season, the relative humidity becomes even less than 45%, retrieved from meteorological department [5, 6, 7].

Table 2: Overview of Dehradun City

State	Uttarakhand
City	Dehradun
Area	300 sqmt.
Elevation	432 m (1,427 ft)
Population (2011) Metropolitan Metro	[3,4] 578,420 714,223
Languages Official	Hindi, Punjabi, English, Urdu, Garhwali, Kumaoni, Nepali, Tibetan
Time zone	ST (UTC+5:30)
PIN	248001
Telephone code	91-135
Vehicle registration	UK-07, UA-07, UP-07
Food	Momo, Bun Tikki, Spring rolls, Soup, Tibetan food, Uttarakhand Thali consists of samba rice, Janghura Ki Kheer, Pahadi Alooki Sabji, Kulathki Dal and Manduaki Roti
Dress	Women wear saris with full sleeve blouses along with angora jackets. Girls wear full skirts with scarfs covering their head and shoulders. Men wear traditional dhoti, angarkha and langoti urban men wear shirts, trousers and jackets.
Vegetation	Tropical moist deciduous and himalayan moist temperate type. The main tree species are Sal and Chir. Other common species are Deodar, Jamun, Khair, Shisham, Semul, Tun, Babool (*Acacia sp.*) and Eucalyptus. The mango (*Mangifera spp.*), Lychee (*Litchi sinensis*), *citrus spp.* and rice plantations along road side add to the beauty of Doon valley.

Table 3: Climate data for Dehradun

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	28.6 (83.5)	31.2 (88.2)	37.2 (99)	40.8 (105.4)	42.8 (109)	43.9 (111)	40.6 (105.1)	37.2 (99)	36.6 (97.9)	36.1 (97)	30.6 (87.1)	27.4 (81.3)	43.9 (111)
Average high °C (°F)	19.3 (66.7)	21.5 (70.7)	26.4 (79.5)	32.1 (89.8)	35.6 (96.1)	34.8 (94.6)	30.5 (86.9)	29.4 (84.9)	29.7 (85.5)	28.5 (83.3)	25.0 (77)	21.1 (70)	27.8 (82)
Daily mean °C (°F)	12.7 (54.9)	14.7 (58.5)	19.2 (66.6)	24.4 (75.9)	28.2 (82.8)	28.9 (84)	26.7 (80.1)	25.9 (78.6)	25.3 (77.5)	22.1 (71.8)	17.7 (63.9)	14.0 (57.2)	21.6 (70.9)
Average low °C (°F)	6.0 (42.8)	7.8 (46)	12.0 (53.6)	16.7 (62.1)	20.7 (69.3)	23.0 (73.4)	22.8 (73)	22.4 (72.3)	20.8 (69.4)	15.7 (60.3)	10.4 (50.7)	6.8 (44.2)	15.4 (59.7)
Record low °C (°F)	-1.1 (30)	-1.1 (30)	2.2 (36)	7.2 (45)	11.3 (52.3)	13.1 (55.6)	13.2 (55.8)	18.0 (64.4)	14.3 (57.7)	8.4 (47.1)	2.8 (37)	0.0 (32)	-1.1 (30)
Precipitation mm (inches)	55.0 (2.165)	58.8 (2.315)	49.0 (1.929)	22.5 (0.886)	41.7 (1.642)	201.8 (7.945)	672.6 (26.48)	728.2 (28.669)	296.5 (11.673)	49.8 (1.961)	8.6 (0.339)	24.4 (0.961)	2,208.9 (86.965)
% humidity	72	66	57	46	48	66	85	86	81	69	68	71	67.9

2 Study Methodology

An extensive survey was conducted to evaluate the quality of environment in Dehradun city with respect to air pollution, vehicular pollution, land pollution, water pollution and wildlife. Authentic data from concerned departments had been retrieved during this survey. The survey helped to analyse the impact on environment due to human intrusion.

2.1 Air Pollution

The primary air pollutants recognised are Sulphur dioxide (SO_2), Oxidesof Nitrogen (NOx), Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM or PM_{10}). Every winter, thick blue smoke envelops Doon, casting a shadow on one of the most "Picturesque Valley in Asia". This gives rise to a lateral inversion that does not allow hot air to rise from the valley. As a result the smoke settles over the valley. Air quality in Dehradun is shown in table 4.Air pollution is

concentrated in the middle of the town-Clock Tower, ISBT and Raipur road. This is supported by findings of Chauhan [8]. The results of other studies by Chauhan *et al* [9], showed Saharanpur road, Gandhi road and the Railway Station areas as most polluted areas. City's annual average SPM level is more than twice the permissible limit and the maximum SPM level was more than thrice the standard. SPM levels were higher in residential areas as compared to industrial area. SPM level was high due to natural dust and particulate laden smoke from diesel fueled vehicles like vikrams, trucks, buses and four wheelers.

Table 4: Yearly Average Air Data

Year	Station	Respirable Suspended Particulate Matter (μgm^{-3})	Suspended Particulate Matter (μgm^{-3})	Sulpher Di-Oxide (μgm^{-3})	Oxides of Nitrogen (μgm^{-3})
	Clock Tower				
1993		-	613	-	-
1994		-	473	-	-
1995		-	345	25	17.92
1996		-	316	18	15.08
1997		-	361	17	16.37
1998		-	302	16	13.99
1999		-	348	17	16.22
2000		-	377	18	18.43
2001		-	443	19	24.19
2002		-	416	19	21.07
2003		-	416	19	22.28
2004		-	288	18	20.36
2005		-	343	22	26.02
2006		-	289	25	27.23
2007		-	226	26	25.87
2008		116	254	25	24.43
2009		134	290	28	29.91
2010		166	362	29	31.05
2011		188	395	24	24.71
2012		163.87	355.14	25.16	27.17
2013		138.69	330.03	24.18	27.41
	ISBT				
2012		176.72	393.37	24.75	26.89
	Raipur Road				
2013		128.92	285.79	23.60	26.10
	ISBT Road				
2013		168.12	29.62	24.73	26.95

2.2 Vehicular Pollution

In yester years, children in Doon were dropped into school in tongas (horse carriages). Due to rising living standards, number of vehicles or road have increased. Total number of vehicles registered in Dehradun between 1937-1967 was 10,000. At present more than 126,452 vehicles are plying on the roads. Number of 2-wheelers are more than 100,000 and 4-wheelers were 4212 (2011), 6292 (2012) and 10,509 by Aug 2015. This is supported by findings of Narwaria and Kushwah [10]. The number of vehicles on roads have increased, as shown in table 5, though the lengths and width of roads have increased only marginally. This adds to traffic congestion and harmful vehicular emission in air.

Table 5: Annual Registered Vehicles in Uttarakhand

Vehicle Type	Year										
	2000-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	10-11	11-12
Two Wheeler	27396	32306	40587	44467	54042	58090	67974	67850	65391	109363	981825
Cars/Jeep	4274	4539	5430	7956	9163	10323	12031	16471	16385	29367	205745
Buses	266	259	195	361	670	1096	387	544	348	650	9707
Trucks	818	570	917	1215	1042	3426	1411	1146	850	1669	21058
Four Wheeler Trucks/Delivery Van	482	533	701	1270	1401	3436	1524	2866	3066	3881	25710
Taxi/Maxi	1530	1721	1165	899	1038	2953	1824	2405	2486	3427	25265
Auto/Tempo	901	797	529	577	291	1271	949	1512	2220	2527	15463
Tractors	1692	1332	1318	1418	1686	2168	3417	2994	2372	3348	57201
Trailers	61	44	117	190	295	529	902	581	215	189	4508
Others	230	46	601	175	462	103	635	536	118	245	2538
TOTAL	37650	42144	51560	58533	70090	83395	91054	96905	93451	154666	1349020

2.3 Land Pollution

Dehradun city today faces huge difficulties in terms of waste management as around 350 metric tonne (MT) waste is generated every day, of which only 250 metric tonne (MT) is collected and recyled. The rest 100 metric tonne (MT) stays around in the form of roadside litter and open dumpsites, as shown in table 6, 7. The findings coincides with results of other studies [11]. Government has coined measures to fight waste collection by deploying more than 200 garbage bins in 60 municipal wards and 100 supervisors deputed to maintain cleanliness of wards. Door to door garbage collection at Rs. 40/- month and a fine of Rs. 500-Rs. 5000 is charged from those found littering.

Table 6: Waste collection in different years

	Year 2000	Year 2015
Ward	38	60
Waste generated	200 MT	350 MT
Waste collected	150 MT	250 MT

Table 7: Type of waste collected

Household waste	115 MT
Industrial waste	27 MT
Medical waste	23 MT
Business waste	94 MT
Slum area waste	1.05 MT

2.4 Water Pollution

The analysis of water samples collected from river Ganga and Yamuna from different sites in different years, is shown in table 8. Analysis of ground water showed that calcium (15-112 mg/l) and magnesium (14-132 mg/l) with their carbonates, sulphides and chlorides made the water hard, both temporarily and permanent, fit for domestic purpose only after special treatment. High TDS (total dissolved substances/salts) value ranging from 108-760 mg/l showed that ground water could be used with special management for salinity control in soil and plants with good salt tolerance should be selected. This coincides with other studies [12, 13, 14] pollution of ground and surface water is caused mainly by:

- Waste disposal activities - Sewage leakage from septic tanks and solid wastes carelessly disposed in landfills decomposes and produces leachate that can contaminate ground water.
- Agricultural activities - Fertilizers and pesticides percolate from the root zone and contaminate ground water.
- Industrial and commercial operation - Leakage and spills of gasoline or petroleum from pipelines contaminate ground and surface water.

Table 8: Water quality criteria

Site	Year	Quality criteria				
		Temp °C	pH	DO mg/l	BOD mg/l	Total coliform/100ml
River Ganga at Raiwala, Dehradun	2011	21.8	7.7	7.8	4.4	>1600
	2012	21.18	7.91	6.85	6.28	>1600
	2013	19.74	7.85	6.83	5.45	>1600
River Yamuna at Lakhawar Dam, Dehradun	2012-13	19.2	8.21	8.2	1.70	Nil
River Yamuna at DakPathar, Dehradun	2012-13	18.1	8.23	8.3	2.20	220

2.5 Wildlife Rajaji National Park is famous for Asian Elephants, tigers and leopards. Tiger (*Pantheratigris*), the national animal of India, showed an increase in number at the average rate of 6% per annum, as shown in table 9, 10.Today Uttarakhand second only to Karnataka in tiger density. Highest density of tigers was found at the Corbett Tiger Reserve with 170 tigers followed by Rajaji National Park as second highest, Fig. 1. The death of tigers, leopards and elephants, as shown in table 11, has alarmed forest department to take measures against poaching of endangered species like musk deer, snow leopard and, pangolins by aerial surveillance, sniffer dogs, intensive patrolling and collaborating with army and Wildlife Crime Control Bureau to bust the network of poachers. As an Barage is the country's first conservation reserve wetland. Migratory birds visit here from October to March. There is a increase in number of visiting birds from 4897 in 2014 to 5796 in 2015, as shown in table 12. The findings coincides with the results of other studies [11].

Table 9: Increase in number of tigers in different states of India

Year	Tamil Nadu	Kerala	Karnataka	All India
2006	76	46	290	1,411
2010	163	71	300	1,706
2014	229	136	406	2,226

Table 10: Total number of tigers in different states (2014)

State	Number of Tigers
Karnataka	406
U.K.	340
M.P.	308
Tamil Nadu	229
Maharashtra	190
Assam	167
U.P.	117

Table 11: Yearly count of dead animals in Uttarakhand

Year	Tiger	Leopard	Elephant
2000	00	05	04
2001	07	41	24
2002	04	33	24
2003	02	40	15
2004	05	53	16
2005	02	40	19
2006	05	55	15
2007	09	65	14
2008	03	68	26
2009	08	89	23
2010	06	67	10
2011	14	68	22
2012	05	70	24
2013	08	74	06
2014	06	40	23

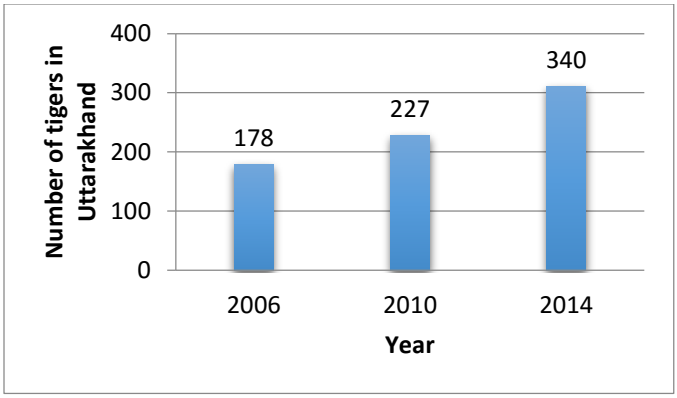


Fig 1: Increase in number of tigers in Uttarakhand

Table 12: Birds at As an Barrage in 2015

Name of Bird	Number
Pintails	250
Little grebe	08
Great crested grebe	02
Indian sage	01
Cattle egret	05
Little egret	35
Grebe intermediate egret	04
Great egret	05
Purple heron	02
Painted stork	46
Black ibis	06
Wooly necked stork	05
Bar hated goose	90
Reedy shelduck	1592
Eurasian wigeon	371
Gadewal	446
Commonteel	146
Mallard	361
Spot billed duck	290
Indian pond heron	01
Little instant	03
Famenic	01
Flash gull	01
City vixel	01
White bird	01
Little blue kingfisher	01
One stork bill	01
Mark harrier	02
Booted eagle	04
Pales fish eagle	01
Steppie eagle	01
Bon singrel	12
Plain saint martin	12
Murhangalnulaclospus	22
Common coot	579
River lapping	20
Red wetted lapping	06
Little ringed plover	13
Redshank	03
Green shank	27
Northern shovler	112
Red crested poachard	734
Common poachard	180
Seri genius duck	01
Tufted duck	74
Common duck	250
Little cormorant	61
Great cormorant	341

3 Results and Discussion

The air quality and climatic conditions of yester years was a major reason for retired people to settle in Dehradun and make it their home giving the city the sobriquet "Grey hairs and green hedges". However, due to human intrusion, the city had lost its sobriquet, as shown in table 13, 14.

Table 13: Pollution in Dehradun, India

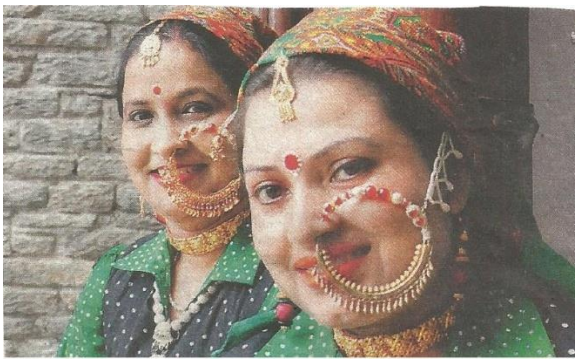
Air pollution	83.33 Very high
Drinking water pollution and inaccessibility	55.00 Moderate
Dissatisfaction with garbage disposal	55.00 Moderate
Dirty and Untidy	70.00 High
Noise and Light Pollution	45.00 Moderate
Water Pollution	65.00 High
Dissatisfaction to spend time in the city	71.43 High
Dissatisfaction with green and parks in the city	60.00 High

Table 14: Purity and Cleanliness in Dehradun, India

Air quality	16.67 Very low
Drinking water quality and accessibility	45.00 Moderate
Garbage disposal satisfaction	45.00 moderate
Clean and tidy	30.00 Low
Quiet and No problem with night lights	55.00 Moderate
Water quality	35.00 Low
Comfortable to spend time in the city	28.57 Low
Quality of green and parks	40.00 Moderate

State animal- Musk Deer

State Bird- Monal



Garhwali Dress

Uttarakhandi Thali

State Flower- Brahma Kamal

Scenic Beauty at Dehradun

4 Conclusion

This report ends with a note that excessive modernization destroys fragile natural equilibrium. In a longer run, living with technology could prove to be a bane as compared to living with nature or prakriti which could prove to be a boon.

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