

Application of Remote Sensing and GIS in Demographic and Socio-Economic Analysis of Dehradun City

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1. Introduction

A nation's strength depends not only on the quantity of population, but also on its quality. A perusal of the demographic and socio-economic structure of population reflects this quality. The pressure of population in Dehradun City, expressed both in terms of absolute number of additional people every year, their distributional pattern and the decadal growth rate of population, have resulted in several constraints in the development process, and have also resulted in unsustainable exploitation of the existing resource base. The process of urbanization in Dehradun in terms of net accretion of population, has been faster in recent decades, and coupled with changes in economic activities, have resulted in certain changes in the socio-

economic structure of the population. Migration from the suburban and rural areas to the city in search of jobs has also been an important factor in shaping the socio-economic profile of the city's population. A continuous influx of population results in changes in the socio-economic characteristics of the city's population. It has its impact felt on the sex ratio, which mostly show declining trends due to male selective migration into the city. Moreover it has its impact felt on the social parameters like literacy and education. The occupational structure also undergoes changes and most of the migrants usually find employment in the urban informal sector. Again, a pressure on housing often turns out to be a major constraint, as the city is often not geared to incorporate all the immigrants most of whom are often from lower economic groups. As a result we find that slums proliferate in urban areas, marked by deteriorating living conditions and environment problems.

The state of Uttaranchal had come into being on November 9, 2000, from the erstwhile Uttarkhand region of Uttar Pradesh. Dehradun is the capital of the newly formed state. Situated amidst the Siwalik range, the flat-floored structural valley of Dehradun has long since acted as the break-of-bulk town between the Himalayan region in the north and the Ganga plains of Uttar Pradesh in the south. In general the district has the second highest population of 1,279,083 according to 2001 census, preceded only by Haridwar district. Out of this, 496,871 persons belong to the Dehradun city in 2001. Moreover this figure represents a near doubling of the population noted in the earlier census. The application of remote sensing and GIS technologies has enabled the conventional cartographer to work with vast quantities of spatial and non-spatial data which was previously impossible. This paper tries to demonstrate the many ways of mapping socio-economic data and also the possible lines of deriving additional inferences by using GIS.

2. Objectives

The primary objective of the study is to explore the mapping techniques of social indicators using GIS, which would help in the analysis of

- Spatial distribution, density and growth of population in Dehradun city
- Distribution pattern of slum population
- Biological, social and economic characteristics of

population

- Areas of population pressure vis-à-vis land use pattern of the city; and also to propose probable areas for the location of certain services and welfare measures
- Prepare a three dimensional surface model for demonstrating population pressure on available land.

3. Overview of Dehradun City

3.1 Physical Background: The city of Dehradun is situated in the south central part of Dehradun district. Dehradun city lies at 30° 19' N and 78° 20' E. The area under the administrative control of the Dehradun municipal board is 38.04 sq. km. The Dehradun municipal board was divided into 34 wards according to the 1991 Census. Two intermittent streams viz. Rispana river and Bindal river, on the east and west respectively marks the physical limits of Dehradun municipality. The city is located at an altitude of 640 m above MSL. The lowest altitude is 600 m in the southern part and the highest altitude is 1000 m in the northern part. The site where the city is located slopes gently from north to south and south west and is heavily dissected by a number of seasonal streams and nallas. The drainage of the city is borne by the rivers Bindal and Rispana.

The average temperature of the city is $36 \pm 6^\circ \text{C}$ and the minimum is $5 \pm 2^\circ \text{C}$. In summer, the maximum temperature is $36 \pm 6^\circ \text{C}$, and the minimum temperature is $16 \pm 7^\circ$ whereas in winter it varies from $23 \pm 4^\circ \text{C}$ and $5 \pm 2^\circ \text{C}$ respectively. In summer the heat is often so intense that the temperature on a particular day may rise to over 42°C . January is the coldest month and the minimum temperature occasionally falls down to a degree below the freezing point. Inversion of temperature is a conspicuous phenomenon, due to the location of the city in the valley. The average annual rainfall of Dehradun is 2183.5 mm. About 87 percent of the rainfall is through monsoons and is received through the months from June to September, July and August being the heaviest. The relative humidity is the highest during the monsoons normally exceeding 70 percent on an average. The driest part of the year is usually during the summer season, when the relative humidity becomes less than 45 percent.

3.2 Settlement Structure and Urban Form: The settlement structure of Dehradun depicts morphological expansion over a colonial structure. The Eastern Rajpur canal was the most important feature in Dehradun during the British period that had served the needs of water for drinking and agricultural purposes. The central part, consists of the old city, i.e. the colonial vestiges, and private residential areas. The prestigious educational and research institutions are situated outside the core city. The western side houses the Cantonment, Oil and Natural Gas Corporation, Forest Research Institute, and Wadia Institute of Himalayan Geology. The eastern part of the city is largely residential. The southern part of the city is

designated as an industrial area.

3.3 Demographic Aspects: As a part of the past heritage, concentration of national and regional level institutions, and economic activities, availability of infrastructure, and the emergence of Dehradun as the state capital on November 2000, would further invite the influx of population from the rest of the valley as well as from outside. This would further increase the growth rate in addition to the natural increase of population within the city itself. Favourable climate, good regional linkages by rail and road, and feasibility of spatial expansion of Dehradun would be therefore instrumental for further migration. However whether the city would support this population expansion on a sustainable basis also calls for a detailed insight into the socio-economic characteristics of population that in turn decides the quality of population as well as certain aspects of urban planning and urban environment.

3.4 Socio-Economic Functions of Dehradun City: Cities come into existence due to the functions they perform as central places. A harmonious integration of functions and activities can lead to a healthy and orderly development of the city.

The major town functions of Dehradun can be grouped under:

- **Administrative:** Dehradun is the capital of the newly formed state of Uttaranchal.
- **Educational and Institutional:** The city besides being the seat for prestigious educational institutions, and other technical institutes, is also famous for national level institutes as already stated.
- **Commercial:** Dehradun is the largest service center within the hilly region of Uttaranchal. It meets the trade and commerce requirements of its region. With the expansion of national level institutes and offices, and the expansion of the cantonment area, the commercial activity had gained momentum.
- **Industrial:** Establishment of industries based mainly on limestone and forests, have attracted ancillary industrial units and other industries. Development of industries is likely to play a vital role in building a sound economic base of the city.
- **Tourism:** Dehradun is endowed with immense potentialities for tourism industry besides being gateway to Mussoorie, the "Queen of Hill Stations". There are a number of tourist places and recreation spots within a short distance of the city that can be developed adequately.
- **Defence:** Dehradun is the headquarters of Indian Military Academy. A number of other defence establishments also are in Dehradun. The defence function has played a vital role in shaping the development and economy of the town.

3.5 Impact of Population Growth on Dehradun City:

Growth of human numbers and human activity in Dehradun city has resulted in large scale ecological degradation. Improper use of surrounding forest resources and environmental pollution due to air, water, and land pollution within the city itself are posing serious constraints leading to unsustainable development. All these are resulting in a fast transformation of Dehradun, which is known as the "green lung" to "black lung". Therefore during the last few decades, there has been an appalling increase in various stress related disorders, hypertension, coronary artery disease, duodenal ulcer etc. Gastro-intestinal diseases are on the rise. There is an ever-increasing incidence of throat irritation, infection, allergy, bronchial asthma and bronchitis with emphysema. The incidence rate of enteric fever and jaundice are also high.

4. Data Used

The following data sources had been consulted by the authors:

4.1 IKONOS Imagery of Dehradun City of April 19, 2001: IKONOS is a new source of GIS data. IKONOS has the following properties: IKONOS is characterized by its sharpness, with the help of which earth features such as trees, buildings, road network, houses and automobiles can be easily identified. It is a unique database for urban studies. IKONOS acquires panchromatic imagery with one meter spatial resolution and multispectral imagery at four metres. With ground control, the imagery is said to have a two meter horizontal and three meter vertical accuracy, equivalent to 1:2400 scale map standards. The IKONOS multispectral imagery has four bands of blue (1), green (2), red (3), and NIR (4). The accuracy is 50 m CE 90. It is based on Universal Transverse Mercator, horizontal units being metres, datum being WGS84 and pixel size ranging from 3.2 to 4.8 m GSD resampled to 4.0 m map increment.

4.2 Toposheet: Survey of India toposheet No. 53 J/3 of Dehradun and Tehri Garhwal districts of Uttar Pradesh has been used. The map is at a scale of 1:50,000 and has been published in 1972.

4.3 Guide Map of Dehradun City: Survey of India Guide Map of Dehradun city has also been consulted. The map has been reproduced in 1982 and the scale is 1:20,000.

4.4 Data on Socio-Economic parameters: had been collected from village and town directory of Dehradun, 1991, Census of India; Municipal Corporation of Dehradun, and voluntary organizations at Dehradun like Peoples Science Institute and Academy for Mountain Environics.

5. Methodology and Software Used

It has been noted that GIS packages are utilized as an instrument for applying demographic and related statistics for the analysis and planning of socio-economic

development. The softwares that have been used in this study include image processing software i.e. ERDAS 8.4 and ARC View 3.2a.

The steps that have been incorporated are:

- Georeferencing the toposheet with the already referenced IKONOS imagery in the UTM grid system, datum WGS 84.
- The next step involved visual interpretation of the panchromatic image of the IKONOS and on-screen digitization using ARC View.
- Creation of a polygon theme consisting of the Ward map of Dehradun city and creating a Ward attribute table.
- Preparation of socio-economic database in Excel and then converting the same into a common database file.
- Joining of the ward attribute table and the data base file.
- Creation of the thematic maps based on demographic and socio-economic parameters
- Creation of analytical maps (superimposing one layer on the other),
- Creation of maps based on certain queries and finally
- Creation of 3D map based on TIN (Triangulated Irregular Network), utilizing population densities and ward map.

6. Application of GIS in Mapping Demographic and Socio-economics Structure Dehradun City

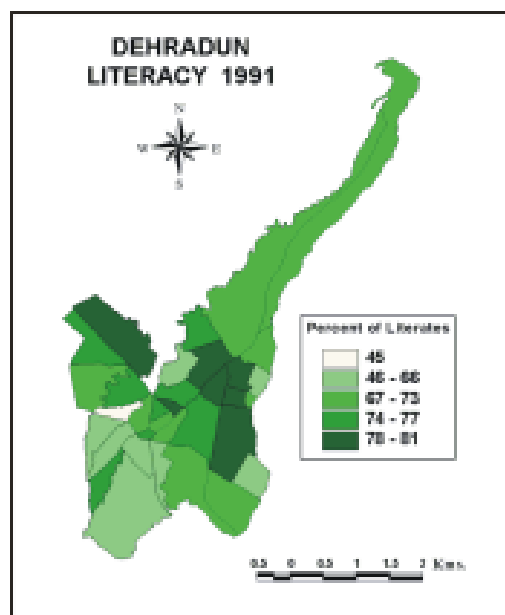
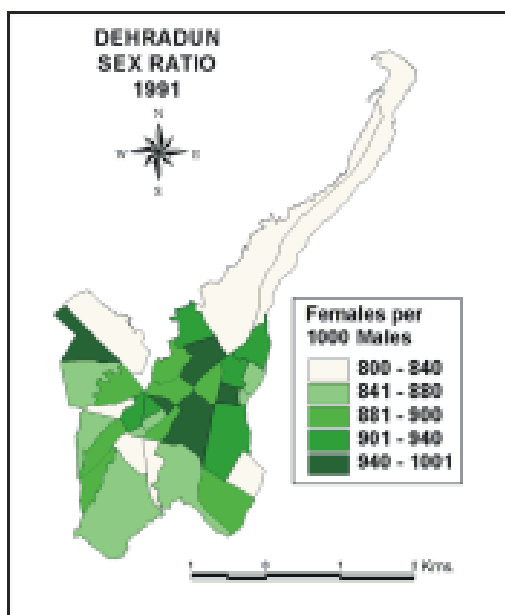
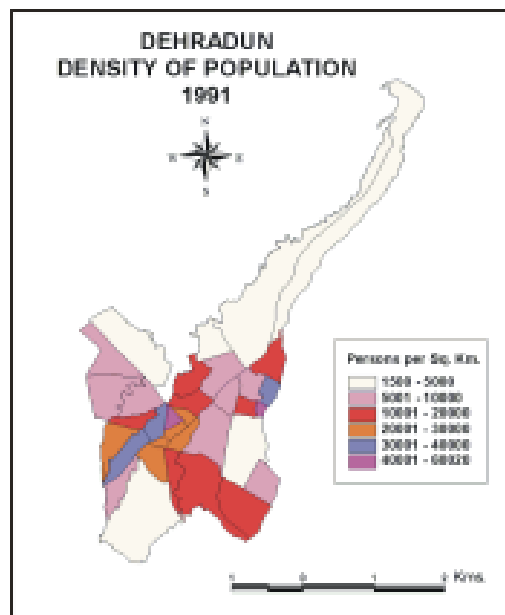
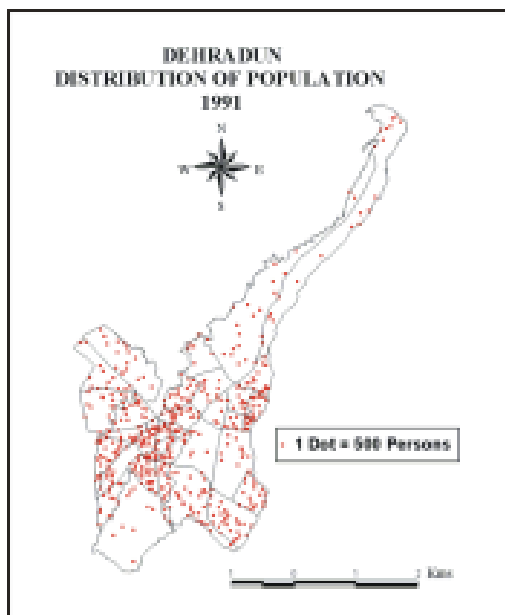
6.1 Growth of Population: Dehradun in 1991 was the twelfth largest city of Uttar Pradesh, according to the size of population. The total urban population of Dehradun urban agglomeration had grown from 2,53,628 persons in 1981 to 3,68,053 in 1991. The population of the U.A. had further increased to 4,96,871 in 2001. The percent decadal growth had been showing an increase from 32.84 percent in 1981 to 35.00 percent to 2001. However, in terms of absolute numbers, the total population has also grown in the Municipal Corporation from 2,11,416 in 1981 to 2,70,159 in 1991 and 3,28,902 in 2001. But here the percent decadal growth had shown a decline from 24.49 percent to 21.74 percent.

6.2 Population Distribution and Density: Population distribution has been depicted by the dot method in the thirty-four wards of Dehradun according to 1991 Census. Most of the population had been concentrated in the central, south-eastern and western parts of the city. The highest population had been noticed in Nehru colony, followed by Race Course, Laxman Chowk, Lakhbagh and Dungwal Marg. The density of the Dehradun M.C. was 7268 persons per sq. km. in 1991. A ward wise distribution of the population density had revealed that the density is highest in the central, eastern, south eastern and western parts of the city. Tilak road followed by Old Dalanwala and Khurbura were the areas with the highest densities.

The number of occupied residential houses was highest in the south-eastern part. Race Course, Laxman Chowk, Lakhibagh, Dungal Marg and Yamuna Nagar had the highest number of occupied residential houses. The number of persons per household in the city had varied from 4-6. Six persons per household were seen in the wards of Dalanwala West, Mahadevi Kanya Pathshala, Dhammawala, Mannuganj, etc.

One of the striking facts about the population of the Dehradun city is the marked growth of slum population in the recent decades. Higher number of slums lead to various social problems. Slum population were concentrated around the highly populated core area of the city, particularly in Race Course, Dhamaawala west and east, Aryanagar, Lakhibagh, Chukoo Wala and Dungal Marg.

6.3 Biological Characteristics of Population: The sex ratio of Dehradun city had revealed a variation from 803 to 1001 females per thousand males. The average sex ratio of the city was 879 in 1991, which had revealed a paucity of females as against the state of Uttaranchal, which is not a female deficit state. Spatially the east central part of the city had higher sex ratios in 1991. The highest sex ratio had been noticed in Ballupur. The other wards having higher sex ratios were Mahadevi Kanya Pathshala, Ansari Marg, Bakrawala, Karanpur etc. The juvenile sex ratio is not influenced by male selective immigration into the city, and hence the figures were usually in favour of the girl child. Though the average was 936, many wards had revealed much higher juvenile sex ratios than this.



6.4 Social Characteristics of Population: In 1991, about 70.26 percent of the total population of the city were literates. The highest proportion of literates (78-81 percent) to the total population had been noticed in Ballapur, Ansari Marg, Dalanwala West, Karanpur etc. The male literacy figures were much higher than that of the females. The average figure for the city had been 57 in case of the males and 43 in case of the females.

About 12 percent of the population of the city comprised of the scheduled caste population. The highest population had been found in Dungwal Marg, Aryanagar and Rispana. The number of scheduled tribes were though negligible, had been mostly found in Hathibarkala and Dungwal Marg in 1991.

6.5 Economic Characteristics of Population: During the recent decades, there has been a considerable increase in the economic activities of the city. About 28 percent of the population was main workers in 1991, and a negligible proportion was marginal workers. About 71 percent were non-workers that basically exhibit the pressure on the bread earners in the city.

7. Socio-economic Analysis of Dehradun and Mapping Through GIS

In this section an attempt has been to prepare analytical maps through the ArcView GIS. The analytical tool of the Query Builder in ARC View GIS has been also used. Overlay analysis by superimposing two themes has also been used to bring out the existing relationship between two variables.

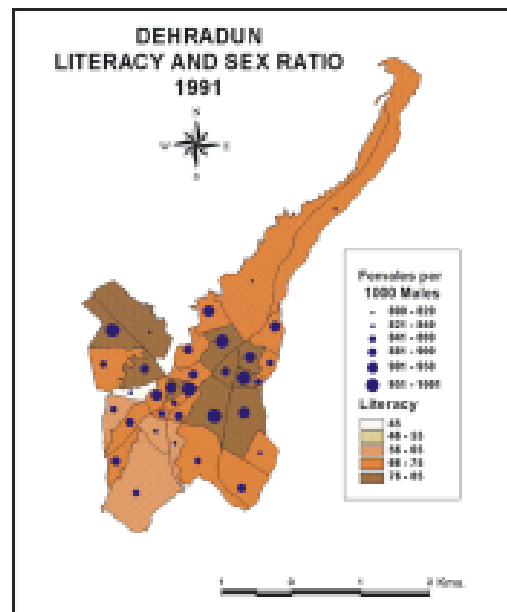
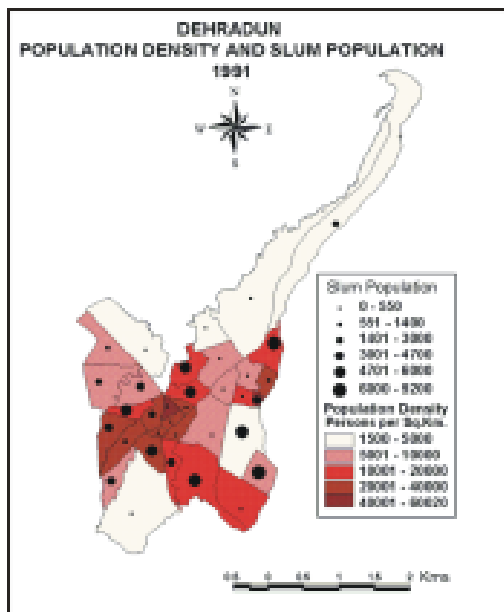
7.1 Mapping of Two Variables to Bring out the Existing Relationship: The relationship between two variables has been brought out in this paper through GIS mapping techniques. Mapping of population density (graduated colour), along with the slum population (proportional symbols) had revealed that highest slum population were also associated with the areas having medium to high

population densities particularly in the wards surrounding the inner core of the city; whereas lowest slum population were noticed in the wards having the lowest population densities, more towards the periphery of the city.

A similar method of analysis has been adopted for the map on literacy and sex ratio. Literacy rates of the wards have been clubbed into five groups. Sex ratio has been represented by proportional symbols. The map had revealed that higher sex ratios pertain to those classes that have also higher literacy figures as for example in the wards of Mahadevi Kanya Pathshala, Ansari Marg, Ballapur ward etc. Lowest literates were associated with the lowest sex ratio as for example in Shivaji ward. This shows that literacy may have some influence on the sex ratio in an area.

Map on literacy and scheduled caste population had pointed out that higher proportions of scheduled castes were associated with lower literacy as for example in Faltu Line, Man Singh Wala, Karanpur Bakral Wala etc. Mapping of literacy and child population had revealed that there is an inverse relationship between the two. The wards having lowest literates to total population also had the highest number of child population, as for example in Chander Nagar, Bhandari Bagh, and Lakhi Bagh. The inverse relationship had been also marked in the map on Female Literacy and Child Population. For example the wards having higher female literacy also had lower child population as for example in Dalanwala West, Bakrawala, Man Singh Wala etc. On the other hand, lower female literacy was associated with higher child population as in Dalanwala East, Dungal Marg, Rispana, Chander Nager etc.

Buffer analysis along the major routes of communication, with buffers situated at distances of 100 and 200 m had revealed that population densities were highest in all those wards specially in the central part of the city that are nearly fully covered by the buffer zones of 200 m.

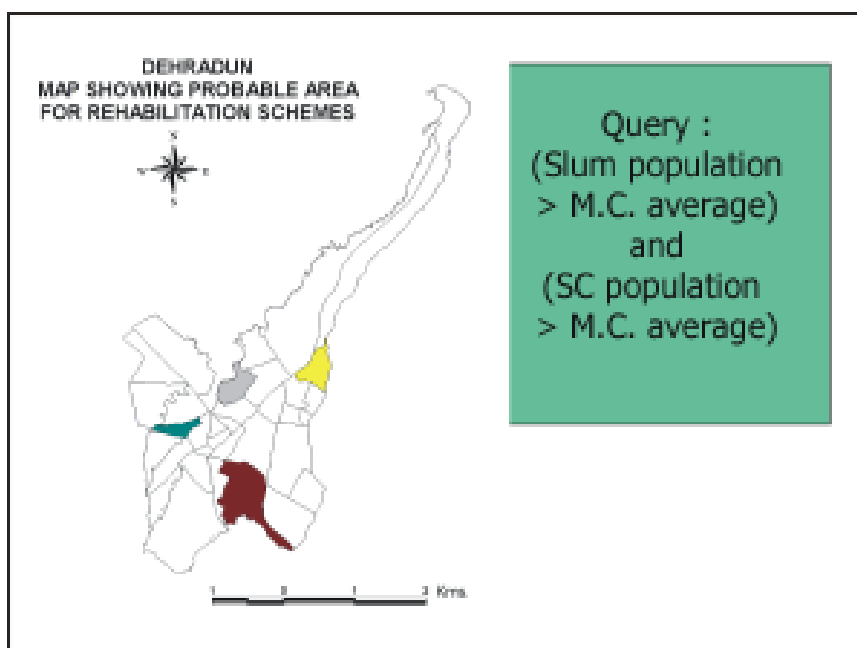
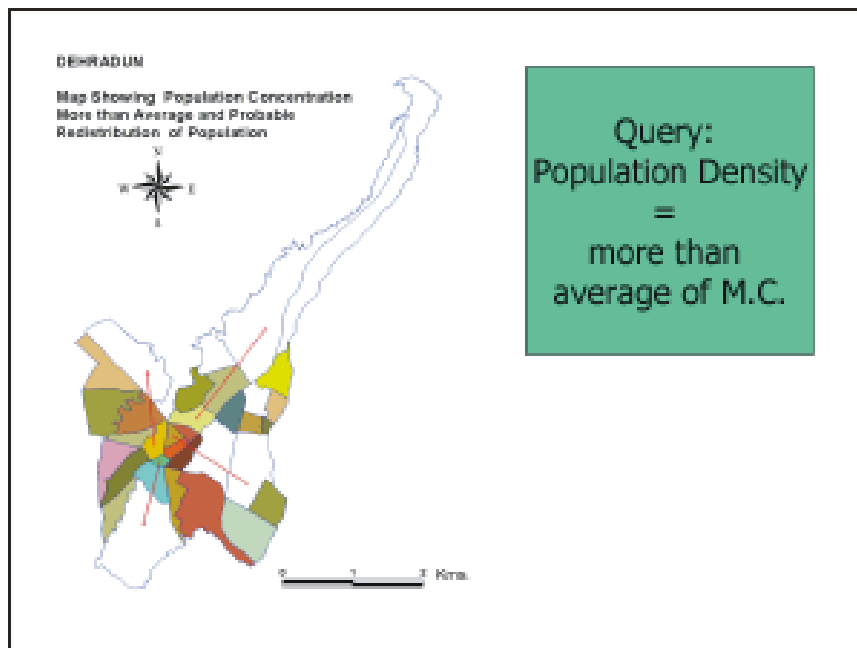


The relationship between population density and the built-up area, as proportion to the total area has been also mapped. This represents that the highest proportion of the built-up area occurs in the city centre. According to secondary data sources, the land use pattern of the central built-up area is of mixed type with commercial and residential areas lying in close juxtaposition with each other. Both higher population densities and high proportion of built-up area had been noticeable in the wards of Shivaji Ward, Chukku Wala, Faltu Line, Tilak Road, Ansari Road etc.

7.2 Mapping based on Query Building: The map on probable redistribution of population had exhibited wards

that have population more than M.C.s average, and the probable areas to which this population can be redistributed. The wards of the the city to which the population can probably redistributed include Vijay Colony, Rajpur, Hathibarkala, Rajendra Nagar, Dalanwala West, Mahadevi Kanya Pathshala and Bhandari Bagh.

The map on probable areas for literacy improvement had shown wards where literacy was less than the average and Scheduled caste population more than the average. Four wards were found fulfilling this criteria, and hence it was proposed that the wards Rispana, Dungal Marg, Indresh Nagar, and Shivaji Marg are the probable areas where literacy should be strengthened.

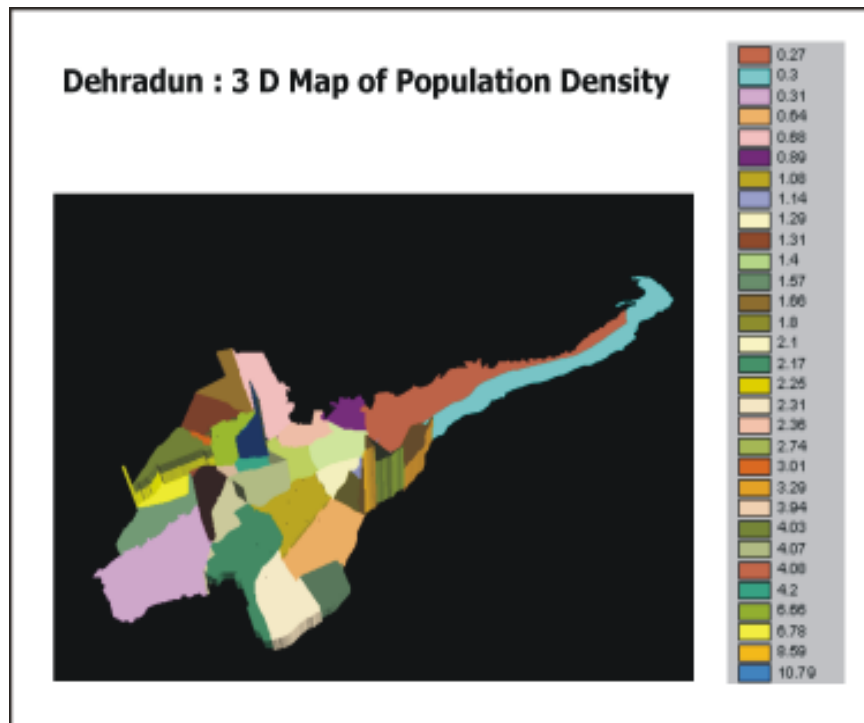


The map on probable areas for welfare schemes for women was based on the query to identify the wards where the proportion of the females was more than the average and also where female scheduled caste population was also more than the average. The wards that had fulfilled these criteria were Indresh nagar and Dungal Marg. It has been suggested, therefore that these are the areas where welfare schemes for women could be implemented.

Based on query building, map showing the probable areas for rehabilitation schemes for the downtrodden had also been worked out, that had shown the wards that require such welfare measures were Race Course, Shivaji

Marg and Dungal Marg; where there was a concentration of slum population as well as scheduled caste population.

7.3 3D Model of Population Density: A three dimensional model of ward-wise density of population had been also attempted through the ARC View 3D Analyst, in order to gauge the pressure of population on land in Dehradun city. This exercise is basically a surface representation to elevate the wards according to their population size. This map helps in an easy comparison of the problem of the population pressure in the various wards particularly in and around the C.B.D (Central Business District).



8. Conclusions

The conclusions that can be drawn include:

- Considering the early history of settlement, the population of the city has been experiencing a continuous influx of migrants, due to non-availability of economic opportunities in Uttaranchal. A policy directed towards regional development, by allowing some urban settlements to come up as growth centres in Uttaranchal may solve this problem.
- The above-mentioned factor may also help in raising the sex ratio in favour of females.
- At the same time low-income group housing facilities should be extended by the government to provide some relief to the proliferation of the slum population within the city; thereby checking unhygienic living conditions.
- Population growth in the marginal areas is placing pressure on land resources, thereby resulting in environmental problems. Agriculture, the mainstay of

the surrounding areas is also adversely affected. Housing schemes should also take this factor into account.

- Both male and female literacy is moderate in the city. Increasing literacy particularly female literacy should form part of government initiatives aiming at qualitative development of population.

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