Conventional and Unconventional Urban Planning and Design Approach, a Way-out to Increase the Green Cover and to Reduce Temperature Variation in the Cities - Case Study Dehradun City

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Publication Date: 11 September 2017

DOI: https://doi.org/10.23953/cloud.ijarsg.307

Abstract In the last few decades, most of cities in India have seen rapid growth of industrialization and urbanization. This rapid growth in urbanization has lead to unplanned development of urban areas, by large scale cutting of trees, converting agricultural land into human habitation and deforestation. This has affected adversely on general environment and maintaining ecological balance. The escalated urbanization, associated with environmental degradation, has generated a debate on how much urban green space has been lost due to the urbanization process. Integrated means of addressing the ecological and environmental, economic and social concerns are still neglected in the framework of development. The increase in built up mass is increasing the temperature variation and UHI effect within the city & is also decreasing infiltration and evapo-transpiration of water which has directly increased the surface runoff and has lead to water logging in urban areas. Most of cities in India are now facing the problem of water logging & urban heat island effect; these problems are very common in most of the metropolitan cities like Mumbai, Delhi, Bangalore, Gurugram (Gurgaon). The unplanned development has increased water logging and flood like situation, during rainy season traffic movement gets hampered due to submersion of roads under water, the houses in low lying area of the cities get partly submerged and if not planned other cities in future are going to face the similar problems, the balance between open spaces and built up area has to be maintained. Therefore for sustainable development of any city it is important to maintain a balanced built up mass arrangement. Urban Planners, Geographers, Environmentalists have to adopt various conventional and unconventional urban planning designs and plans to increase the depleting green cover (open spaces) & to reduce temperature variation within Cities.

Keywords Environment; Geographers; Green cover; Urbanization

1. Introduction

Urbanization in India began to accelerate after independence. Population residing in urban areas in India has increased, according to 1901 census; the urban population was 11.4%. This count increased to 28.53% according to 2001 census, and crossing 30% as per 2011 census, standing at 31.16%. According to a survey by UN State of the World Population report in 2007, by 2030, 40.76% of country's population is expected to reside in urban areas. As per World Bank, India, along with China,
Indonesia, Nigeria, and the United States, will lead the world’s urban population surge by 2050 (Kavitha and Gayathri, 2017). Rapid rise in urban population, in India, is leading to many problems like increasing slums, decrease in standard of living in urban areas, also causing environmental damage water logging, UHI effect etc. When a settlement grows in any city, it goes through various interactions of its physical components such as forest, green cover, air, water bodies etc. These fast growing cities not only need to accommodate the pressure of urbanization, but they should also to measure the issues of environment arising due to fast infrastructure development. The rapid growth of cities is eating up the open spaces, green cover and is thus affecting the ecological balance of the area.

![Figure 1: Increasing built up mass and decreasing green cover](image)

Dehradun city is not different than other Indian cities in the context to urban sprawl and its negative impacts; it has undergone rapid economic development and urbanization over past decades after becoming the interim capital of Uttarakhand in the year 2000. Dehradun city is going through a phase of rapid development; the growth in population has increased urban sprawl in all possible directions of the city, as the city was not much familiar with the concept of vertical development therefore the urban sprawl has mainly been horizontal in nature. This horizontal and unplanned development of the city has led to deforestation, decreases in green, open spaces, water bodies & increased in pollution etc.

As per the records maintained by an NGO "citizen for green doon" more than 30000 trees has been cut in Urban Area of the Dehradun in last 15 years. The decreasing green cover, deforestation, decreasing open spaces, increasing temperature & pollution has degraded the environment and ecological balance of the region. A city once know for soothing climate and better environmental conditions has now turned into a 31st most polluted city in the world (wikipedia.org). This negative growth is very alarming in nature and needs deep analytical analysis and due consideration of urban planners.

The whole study is has been phased into three subdivisions:

1. To observe the reduction of forest/green cover in the city & its impacts
2. Reduction of green/open spaces and its effect on temperature variation in within city area
3. Mitigation strategies and policies to increase green cover of the city with the help of conventional and unconventional methods of urban planning and design

**1.1. Increasing Build up Mass (Concrete Jungle) and Decreasing in Green Cover of Dehradun City**

After the declaration of Dehradun city as the interim capital of the Uttarakhand state, there has been a major change in land use adding to its deforestation has increased, open and green spaces have decreased in the city. The escalated urbanization, associated with environmental degradation, has generated a debate on how much urban green space has been lost due to the urbanization process. Integrated means of addressing the ecological and environmental, economic and social concerns are still neglected in the framework of development. As a result, large areas of urban green space are
declining rapidly, and causing numerous environmental problems. However, both environmental awareness and environmental legislation (setting of standards etc.) have advanced considerably in recent years, but enforcement is lagging almost everywhere. Now, it is well recognized that urban green/open spaces plays an important role in the social and natural sustainability of a city.

Urbanization has led to unprecedented reduction in agriculture open spaces, and vegetation. Due to this unprecedented reduction in all these we have to face tremendous problems regarding to environment. The impact of reduction of green cover on air, water and society is negative. It has caused air pollution, variation in temperature, increased urban heat island effect and many other negative effects in the city. WHO has declared Dehradun city as 31st most polluted city in the world based on how much fine particulate matter (PM 2.5) they have in the air and Dehradun PM Count is beyond 100. (wikipedia.org).

About 114% growth in urban population since 1991 and 230% growth in urban buildup area have been observed since 1982 in Dehradun city (UUDP 2007). Dehradun city is highly vulnerable to urban climate change mostly due to anthropogenic activities. The annual maximum, annual minimum and annual mean temperatures at Dehradun city have positive trends of change. Overall it has warmed significantly and annual mean temperature has increased about 0.47°C during the 41 year period (1967-200). Per decade increase in annual mean temperature was found to be 0.12°C which is about four times more than the global increase in temperature. The time period during 1967-1987 has less intensity of temperature growth than the time period of 1988-2007 (UUDP-2007). Dehradun city will result into fatal effects on natural ecosystems. Below given data clearly indicates how green cover has decreased with passage of time in Dehradun city (Omvir Singh et al., 2013).

| Year | Agriculture | Tea garden | Forest | Total green cover |
|------|-------------|------------|--------|------------------|
| 1998 | 14983.32    | 1119.068   | 12238.89 | 28341.278        |
| 2003 | 13763.17    | 1126.97    | 10586.874 | 25477.014        |
| 2008 | 12469.37    | 1089.97    | 9780.908  | 23340.248        |
| 2013 | 10340.75    | 1029.43    | 9821.195  | 21191.375        |

*Urban Growth assessment using CA Markov Model: a case study of Dehradun City.*
Table 2: Data of tree felling/cutting in the urban areas of Dehradun

| Year | Private Green Trees | Private Dead Trees | Private Dangerous Trees | Public Dangerous Trees | Public Green Trees | Public Dead Trees | Total  |
|------|---------------------|--------------------|------------------------|-----------------------|-------------------|------------------|--------|
| 2000 | 297                 | 75                 | 0                      | 0                     | 51                | 0                | 423    |
| 2001 | 460                 | 191                | 26                     | 1                     | 6                 | 1                | 685    |
| 2002 | 611                 | 183                | 13                     | 0                     | 249               | 0                | 1056   |
| 2003 | 389                 | 28                 | 0                      | 2                     | 10                | 5                | 435    |
| 2004 | 489                 | 6                  | 3                      | 0                     | 6                 | 0                | 454    |
| 2005 | 333                 | 72                 | 30                     | 1                     | 148               | 0                | 689    |
| 2006 | 181                 | 72                 | 38                     | 0                     | 251               | 0                | 542    |
| 2007 | 135                 | 73                 | 66                     | 91                    | 3839              | 64               | 4268   |
| 2008 | 188                 | 99                 | 48                     | 0                     | 214               | 42               | 521    |
| 2009 | 426                 | 86                 | 326                    | 46                    | 3911              | 98               | 5779   |
| 2010 | 177                 | 196                | 276                    | 98                    | 217               | 706              | 1670   |
| 2011 | 224                 | 73                 | 383                    | 268                   | 2386              | 114              | 3458   |
| 2012 | 803                 | 198                | 940                    | 339                   | 467               | 60               | 2827   |
| 2013 | 517                 | 269                | 572                    | 74                    | 734               | 118              | 2284   |
| 2014 | 635                 | 178                | 669                    | 678                   | 2508              | 755              | 4911   |
| 2015 | 158                 | 30                 | 648                    | 84                    | 24                | 5                | 950    |
| **Total** |                |                    |                        |                       |                   |                  | **30,002** |

After becoming interim capital of Uttarakhand the buildup mass has increasing drastically as shown in images comparatively (Year 1986, 1998, 2011). With the passage of time and decreasing in the forest area, open spaces and water bodies in Dehradun city. In the images the urban sprawl is represented by red color which has increased & the water bodies which are shown by blue as well as forest which are shown by dark green and green cover which is shown by light yellow has decreased with time at an alarming pace.

Figure 1: Unplanned urbanization leading to environment degradation of Dehradun city

The analysis of the satellite imagery of Dehradun city and Its Environment for the Year 1986, 1998 and 2011 by (International Journal of Advanced Remote Sensing and GIS) clearly indicates that on the
one hand area under green cover, water bodies & forests has decreased and on the other hand built up mass has increased rapidly.

Table 3: Development of built up area in Dehradun city during 1982–2004

| Type of urban land use            | Built up area (hac) | Built up area (ha) | Growth in Built up area (%) |
|----------------------------------|--------------------|--------------------|-----------------------------|
| Residential                      | 1588.8             | 4071.8             | 156.3                       |
| Commercial                       | 81                 | 341.4              | 321.5                       |
| Industrial                       | 113.4              | 383.4              | 238.01                      |
|Govt. & semi govt. Buildings      | 267.2              | 479.6              | 79.5                        |
|Facilities & services             | 802.2              | 915.4              | 14.1                        |
|Orchards & gardens                | 205.7              | 728.4              | 254.1                       |
|Open spaces & parks               | 156                | 581.9              | 274.1                       |
|Tourism & Transportation          | 203                | 822                | 304.9                       |
|Rivers and Nalas                  | 331.5              | 1179.3             | 255.7                       |
|Undefined land use                | 55                 | 3058.8             | 5461.5                      |
|Total                             | 3802.8             | 12565              | 230.1                       |

Uttaranchal Urban Development Plan, 2007.

As of today the concrete jungle is continuously increasing and green cover and open spaces are decreasing, the unplanned growth is creating misbalance in built up mass arrangement in proportion to the green cover and open space ratio, which is effecting the overall environment and sustainable growth of the city. Dehradun city being the part of the Smart city project list has to do the interventions to enhance Sustainable environment & Health. This horizontal, unplanned and haphazard growth will affect the city in various ways, some of the factors are briefly describe below.
1.2. Effect of Decreasing Green Cover and Increasing Built up Area

Massive urbanization and land use change has decreased infiltration, green and open spaces, evaporation & has increased the surface runoff which has lead to water logging in cities. Due to the insufficient percolation or seepage of water into the ground, water table also gets affected and therefore the surface runoff has increased in most of the urban areas, which has increased the risk of floods & Water logging. In the above given figure one can easily understand that how urbanization affects various environmental parameters.

Unplanned development & urban Sprawl has also lead to increase in unwanted Population Growth, increase in migration from rural to urban areas, decrease in water quality, increase in Erosion and Sedimentation, increase in Sewage Overflows, increase in Waterborne Pathogens, increase in Pesticides content in water and soil, Decrease in air quality, Decrease in life expectancy and reducing health inequality, Decreasing levels of physical activity and health, Decreasing psychological health and mental well-being, Negative effect on land and property values Impact on local economic regeneration, Decrease habitat areas, Decrease in population of some protected species, Decreasing species movement.
Climate change is another factor which increases with the urbanization in any city. For e.g. Heat amelioration or heat island: An urban heat island (UHI) is a city that is significantly warmer than its surrounding rural areas due to human activities. UHI is most noticeable during the summer and winter. The main cause of the urban heat island effect is from the modification of land surfaces. Waste heat generated by energy usage is a secondary contributor. As the density of population in core area grows, it tends to expand its area and increase its average temperature. The less-used term heat island refers to any area, which is consistently hotter than the surrounding area.

The UHI decreases air quality by increasing the production of pollutants such as ozone, and decreases water quality as warmer waters flow into area streams and put stress on the ecosystem. There are several causes of an urban heat island (UHI); for example, dark surfaces absorb significantly more solar radiation, which causes urban concentrations of roads and buildings to heat more than suburban and rural areas during the day.

Other causes of a UHI are due to geometric effects. The tall buildings within many urban areas provide multiple surfaces for the reflection and absorption of sunlight, increasing the efficiency with which urban areas are heated. This is called the “urban canyon effect”. UHIs have the potential to directly influence the health and welfare of urban residents. Increased temperatures have been reported to cause heat stroke, heat exhaustion, heat syncope, and heat cramps.

**Figure 3: Locations**

### 1.3. Temperature Variation within the City Limits

Most of the times UHI effect is used to indicate, the temperature variation of city in comparison with surrounding rural areas, but in this case study temperature devices were used to detect temperature variation within Dehradun city limits. In this case study the variations in temperature within city limits have been studied, to confirm that there can be the temperature variation within the city limits because of unplanned built-up mass arrangement. To validate temperature variation within the city limits temperature device were installed at seven different locations randomly.
| Location | 11.5.2 016 / 3 pm | 12.5.2 016 / 1pm | 13.5.2 016 / 1pm | 14.5.2 016 / 4pm | 17.5.2 016 / 5pm | 23.05.20 16 / 1pm | 26.05.20 16 / 2pm | 01.06.20 2016 / 12.3 pm | 03.06.20 16 / 1pm | 08.06.20 16 / 12.3 pm |
|----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| House No-238 East Patel Nagar, Near Ramilia Ground, Dehradun | 35 | 36 | 36 | 39 | 39 | 37 | 37 | 36 | 37 | 34 |
| House No-243, Loharwala, Sirmour Marg, Kishan nagar Chowk, Dehradun | 35 | 35 | 34 | 38 | 38 | 35 | 35 | 35 | 35 | 33 |
| Bhimtal, Subash Nagar, Post Office, Mobhewala, Dehradun | 33 | 30 | 34 | 35 | 34 | 34 | 35 | 35 | 35 | 32 |
| Astle Hall, Near Orient Cinema, Rajpur Road, Dehradun | 34 | 34 | 36 | 37 | 39.5 | 36 | 37 | 35 | 35 | 35 |
| Kolagarh, Near Kolagarh Post Office, Near FRI, Dehradun | 33 | 35 | 36 | 37 | 37 | 37 | 36 | 35 | 33 |
| Wadia institute of Himalayan Geology, GMS Road, Dehradun | 31 | 30 | 33 | 35 | 34 | 34 | 34 | 31 | 32 | 30 |
| House no 57, Near Gurukul School, Dharampur Dhanda, Dehradun | 33 | 33 | 34 | 35 | 34 | 35 | 36 | 34 | 36 | 30 |
| Google | 32 | 33 | 35 | 37 | 38 | 36 | 38 | 34 | 34 | 31 |
| Highest | 35 | 36 | 39 | 39.5 | 37 | 38 | 36 | 37 | 35 |
| Lowest | 31 | 30 | 33 | 35 | 34 | 34 | 34 | 31 | 32 | 30 |
| Difference | 4 | 6 | 3 | 4 | 5.5 | 3 | 4 | 5 | 5 | 5 |

To collect, analyze & detect the variation in temperature at various locations within the city limits, temperature recording devices were provided free of cost to members and contact number of all persons where collected saved in the mobile. To make data collection & communication with member's easier whatsapp group under the name of "research members" was created and members were added.
in the whatsapp group. The members were instructed about the location for installation of the devices and they were trained how to check the temperature. The members were told to note down the temperature in Degree Celsius scale instead of Fahrenheit scale for easy compilation and analysis of the data. The members were also instructed not to install the devices in the rooms; all the devices were installed outside of the house because room temperature which is subjected to various factors always differs from outside temperature. Temperature data of Dehradun was also collected from internet (http://www.accuweather.com) for comparison purposes. Temperature data was collected for once in a day for approximately 10 days. The details of the recorded temperature are given below in the table.

Analysis of the table clearly indicates the following:

- There is continuous temperature variation in the city limits.
- The temperature variation is between 3 degree Celsius to 6 degree Celsius.
- The lowest temperature was usually recorded in areas like
  1) Wadia institute of Himalayan Geology, GMS Road, Dehradun.
  2) House no 57, Near Gurukul School, Dharampur Dhanda, Dehradun.
  3) Bhimtal, Subash Nagar, Post Office, Mobhewala, Dehradun.
- The highest temperature was usually recorded in areas like
  1) House No-238 East Patel Nagar, Near Ramlila Ground, Dehradun,
  2) Kolagarh, Near Kolagarh Post Office, Near FRI, Dehradun.
  3) House No- 243, Loharwala, Sirmour Marg, Kishan nagar Chowk, Dehradun &
  4) Astle Hall, Near Orient Cinema, Rajpur Road, Dehradun.
- The temperature was recorded high in the densely populated areas with more built-up mass, which clearly indicates that built up mass effects the overall environment of the area.
- Temperature variation within the city spatially confirms the UHI effect at micro level.
- The areas with less green cover spatially are comparable hotter than the areas with less green cover.
- Built up area effects the micro environment of that region, for e.g. one of the location like Kolagarh is surrounded by green area in the sides but due to higher density along with built up area in that specific area is more which leads to higher temperature. Micro level temperature variation is very much dependent on the built of mass arrangement & density of that area.

Therefore, we can say that UDI affects is different for different areas of city based on the spatial growth in specific area. In the below given figures one can understand how urban built up mass arrangement effects the temperature variation in the city.

The impact of built up mass effects the heat absorption, the area with more built up area will be warmer than the surrounding area, but if studied on the micro level one can easily calculate variation in temperature in the city.
Figure 4: Micro level temperature variation

Figure 5: Landscape planning patterns and its impacts

Warmer core and cooler surrounding (Figure 1): In this pattern the growth is mostly concentrated in the core area of the city, which effects the environment of the city core area thus leading to warmer core and cooler surroundings.

Cool core area, central warm and cool peripheral areas (Figure 2): In this pattern as the core, outer surrounding is cool and the central area is warmer. This happens when the core area is preserved, most of the development has occurred in the central part of the city.

Scattered development (Figure 3): In this pattern the built up mass percentage is different all around the city, in some part is more and in some part its less, thus the areas with more built area are
comparably warmer than the other areas. The micro level temperature difference in Dehradun city is because of the difference in buildup mass arrangement which shows that effect can be different in different parts of Dehradun city.

**Planned development** (Figure 4): (Solution) planned development is the key for balanced Built up arrangement, in the figure no 4 the Built-up mass arrangement is planned and balanced, this kind of arrangement is possible in planned area. This type of built up mass arrangement decreases the temperature variation possibilities. The green area and open spaces are spatially located. It's not only about the total area under green cover and open space; it's about spatial placement of the green and open spaces.

Urban planning and design recommendations to create balanced built up mass arrangement to decrease the UHI impact.

**Planning, design and orientation:** As almost all Indian cities are facing the common issues of increasing environmental degradation. There is need to have strong policy and regulatory framework to increase urban environment sustainability. To moderate the environmental impacts of urbanization, sustainable ways of planning are required. Urban centre's by its form play a significant role in mounting urban heat island. Green city modules such as street orientation in lines with sun direction and wind direction not only help reduce the impact, but also slow down the gas emissions from artificial cooling systems. Further green spaces within the urban set-up ensures cooling effect and better public interaction spaces, apart from psychological supports in reducing human stress levels.

**Effective land use planning:** It is essential to implement effective Land Use planning. Green cities practices and effective land use reduces the impacts of urban sprawl by encouraging compact, mixed-use developments and promotes higher urban densities without affecting the quality of life. During the formation of master plan, city development plan, zonal plans should consider the planner should consider and promote and open and green spaces.

**Landscape planning according to the recorded temperature statics:** City landscape planning has to be correlated to the temperature variation statics for remarkable results; the temperature variation can be taken a right tool for implementing landscape planning. For e.g. if we are planning to plant trees shrubs or have planned to do any kind of landscaping in the city then the right way is to plan the plantation drives etc according to the temperature statics, the landscape planning has to be done in the areas which are hotter in comparison with the other areas in the surrounding. The landscape planning will be more fruitful if it is scientifically planned to decrease the temperature variation in the Dehradun city.

**Time to adopt vertical development to save land and green spaces:** Urban sprawl should be discouraged by practicing higher development densities with green roof tops. Urban sprawl has to be restricted & the unplanned growth patterns have to be checked. The zonal plans have to be strictly enforced. As the valley lies in the highest seismic Zone IV and Zone V making it more vulnerable to earthquakes therefore. Under such circumstances high rise buildings are not advisable under normal procedures of construction techniques. But with the increase in the technological advancement like earth quake resistant building construction techniques etc high rise building can be constructed.

**Public transport:** All Cities should majorly use public transportation to reduce fossil fuel consumption & vehicular emissions. The proximities of basic transportation mode should be in walk able distance. There is need to introduce smart, sustainable and green public transport.
Subsidiary materials: As the unbalanced and unplanned growth in terms of build up mass in Dehradun city is increasing as a result of which the evapo-transpiration, infiltration is decreasing, and surface runoff in increasing, therefore there is urgent need to use to porous material like porous concrete, interlocking tiles etc to cover open space like footpath, pathways tracks etc. The Buildings should be painted with light colors to reflect more light and absorb less light for eg (light color Plastic paints, emulsion paints, white wash), concrete structures without paint absorbs more heat and increase heat island effect.

![Image](image_url)

**Figure 6:** White roofs helps in increasing the albedo effect

**White roofs:** Painting rooftops white has become a common strategy to reduce the heat island effect. In cities, there are many dark colored surfaces that absorb the heat of the sun in turn lowering the albedo. White rooftops allow high solar reflectance increasing the albedo of the city or area the effect is occurring. Therefore city dwellers should use white color to paint their roof tops

**Vinyl sheets:** Vinyl roofs provide an energy-efficient roofing option due to their inherently light coloring. While the surface of a black roof can experience a temperature increase of as much as 90 degrees under the heat of the full sun, a white reflective roof typically increases only 5–14 degrees Celsius. Vinyl membranes can also be used in waterproofing applications for roofing. This is a common technique used in association with green, or planted, roofs.

**Spatial placement of green spaces:** Open spaces have to be should be spatially distributed (Recreational space, Organized green) other common open spaces, the spaces have to be equally distributed across the city. Planned development is the key for balanced Built up arrangement, the Built-up mass arrangement is planned and balanced, This type of built up mass arrangement decreases the temperature variation possibilities and increase green cover in the city. The green area and open spaces are spatially located. It's not only about the total area under green cover and open space; it's about spatial placement of the green and open spaces.

**Two dimensional landscape planning:** The urban planner and designers have to carefully plan the green and open spaces; for long we have only concentrated on horizontal landscaping, a new
approach of vertical landscaping has also to be adopted to increase the green cover in the city. As per U&RDPFI in a green city about 25-35 % out of total area should be earmarked as recreational and open spaces within the Green City. So if we want to attain this criterion in our city and turn Dehradun into a green Doon we have to start implementing two dimensions landscape planning.

Figure 7: Vertical landscaping a way forward to increase green covers in the future cities

**Vertical Landscaping**

As we know the land resource in urban area is becoming scarce, rare and costly, therefore in future it will become difficult to keep large open space in urban area. But with vertical growth and vertical landscaping can be increased and land resource can be save.

What's the best way to deal with urban air pollution/urban smog? An intriguing solution to this problem is vertical gardens that scale up buildings. Several such projects have already sprung up around the world, in places like Italy and Mexico. Now, an Italian architecture firm called Stefano Boeri Architetti is planning to build the first one in Asia, specifically in Nanjing, China.

The firm is planning to build two towers laden with greenery, known as a Vertical Forest or the Nanjing Green Towers, in Nanjing's Pukou District. Due to be completed in 2018, the towers would be covered in 600 tall trees, 500 medium-sized trees, and 2,500 cascading plants and shrubs. In total, this would cover an area of 6,000 square meters (64,600 square feet).

**Roof gardening/green roofs:** Green roofs are another method to decrease the urban heat island effect and increases green cover in the city. Green roofery is the practice of having vegetation on a roof; such as having trees or a garden. The plants that are on the roof increase the albedo and decrease the urban heat island effect. In urban areas, due to escalating population, more land area is brought under the construction of houses; therefore there is hardly any space for landscaping. Especially in multistoried buildings, roof gardening is the only way to grow fruits and vegetables by using the pots and containers. This practice is known as container gardening. Psychiatrist recommends that working in garden refresh the body and mind by reliving harsh stresses. Gardens become the integral part of the family life benefited by the supply of toxic free fresh fruits and vegetables.
Use bonsai trees, bushes and shrubs: These types of trees or plants are very small in size and cover less space. So we can easily adopt these types of plants to cover open or small spaces effectively in our house. This will also help in increasing the green cover in the city.

Designing of housing units around the trees: The unfortunate reality of urbanization is that trees get in the way. Trees improve the air you breathe, cut your energy bills with their shade, provide homes for wildlife, and add beauty and value to your house. In fact, landscaping can add approximately 10 to 20 percent more value to a property especially landscaping that includes mature trees. Commercial areas with trees also attract more customers (and they stay longer and spend more money). The urbanization has led to tree cutting because trees are not kept as the part of the building design. Trees are usually cut to make way for construction and then unused/left over space are demarcated as the area for landscaping just to sake of building bye laws. Urban Planners, Architects & Urban designers in India have to change their mind set tree conservation has to be taken into account. The existing trees have to be agglomerated into the design. We have design the infrastructure around the trees, Existing they have to be the part of the design.
Figure 10: Designing of housing units around the trees to decrease deforestation

**Plantation on dead walls/grass paved walls:** (Vertical Greenery Systems (VGS)) A well designed and maintained Green Wall can significantly enhance a building’s appearance - whether it’s to add a new aesthetic dimension, disguise a car park, refresh a tired façade or add color and texture to a complete wall or section. A green wall in an urban area can help improve local air quality, both by absorbing carbon dioxide and releasing oxygen, and by trapping dust and other pollutants. By adding a layer of insulation (both thermal and acoustic) green walls absorb sound - making a positive impact for both the building’s occupants and the local environment. The grass paved walls look very attractive and can increase the green cover immensely. Just presume that all the walls are grass paved. The time has come when we have to think about this, thigh cost of the land in the urban areas makes it difficult to keep large chunks of land for parks and green spaces, but if we can adopt the idea of vertical plantation we will be able to increase the green cover of any city.

Figure 11: Plantation on dead walls/grass paved walls to increase green cover
Plantation on balconies: The plantation can be done in any space kept open in a building for e.g. the plantation can be done in balconies of the building. The space left for balcony can be beautifully landscaped. The addition of the soft element will enhance the beauty of the space will also enrich the view.

Other ideas for vertical landscaping and internal landscaping which if adopted can increase the green cover in the city.

Horizontal Landscaping

Planting trees in cities: Planting trees around the city can be another way of increasing albedo and decreasing the urban heat island effect. Trees absorb carbon dioxide and provide shade. It is recommended to plant deciduous trees because they can provide many benefits such as more shade in the summer and not blocking warmth of winter. trees can be installed in public area, cremation grounds, schools, median, graveyards, setback area, area left for road widening, low lying areas, low lying areas, flood prone area, plantation in the road margins, play grounds, open space, recreational spaces, etc.

Green parking lots/Green Parking lots to produce electricity: Green parking lots use surfaces other than asphalt and concrete to limit the impact urban heat island effect. In recent days there has been a huge Popularity of Solar Groves in the parking area: According to a Wall Street Journal report published in September 2012, “From Long Island to the Arizona desert, developers is covering their
parking lots with canopies of solar panels. These way parking lot owners get to double up on their use of underutilized land and to offset their utility bills at the same time. And very little stands between most parking lots and the sun, so they can produce plenty of power.

Figure 14: Revitalization car parking space for increasing green cover and energy production

Prevention of existing park and gardens: Careful planning prior to undertaking work can help prevent irrevocable damage to a cultural landscape. Professional techniques for identifying, documenting, evaluating and preserving cultural landscapes have advanced during the past 25 years and are continually being refined. Preservation planning generally involves the following steps: historical research; inventory and documentation of existing conditions; site analysis and evaluation of integrity and significance; development of a cultural landscape preservation approach and treatment plan; development of a cultural landscape management plan and management philosophy; the development of a strategy for ongoing maintenance; and preparation of a record of treatment and future research recommendations.

Figure 15: Optimum utilization and revitalization of existing park and available open spaces to increase green cover
Optimum utilization and revitalization of existing park and available open spaces: The open spaces which are not properly utilized should be redesigned for optimum utilization and beautification. There are various open spaces in the city which are not properly designed nor properly maintained. There are available spaces in the city which are either being used to through garbage or are encroached or being used for informal parking, all these spaces have to be utilized for eg the space beneath the flyovers, setbacks etc

Plantation of tree and shrubs in median and road side: Plants along median strips reduce vehicular glare and prevent accidents and also increase some green cover in the city. It is important to plant trees in road margin area available to increase the green cover of the city. Plantation on road side increases the aesthetics of the ROW and also helps in decreasing the pollution due to vehicle and also helps decreasing the temperature variation.

Plantation in setback spaces and road widening spaces: The setback spaces and area left open for road widening in future should be used optimally to install the plants, shrubs and trees, this will increase the green cover of the city and will also help in avoiding encroachment of the open spaces. The open spaces are usually encroached first. The plantation of the trees, plants, shrubs will help in curbing the menace of encroachment.

Figure 16: Plantation of tree and shrubs in median and road side

Figure 17: Plantation of shrubs and trees in setback spaces & road widening spaces to increase green cover
Figure 18: Plantation along river/streams/nalas to increase the green cover

**Plantation along river/streams/nalas:** I have always been astounded at the amazing power of trees and plants to provide so many benefits to our environment and communities. Forested stream banks act like a sponge, filtering out excessive nutrients, sediment, and other pollutants that run off from the land that would be damaging if they entered a stream. Shrubs and trees are also able to prevent stream bank erosion by anchoring the soils, keeping the banks stable and excess sediment out of the stream. Buffers can even help to mitigate flooding/water logging by absorbing and slowing down surface runoff. River front development programs should mostly include increasing the green cover and open spaces near the river banks.

As a potential two major tributaries Bindal and Ripana River are traversing through Dehradun city, unplanned vacant land which not being used and are being encroached by public has to be stopped the spaces on both sides of the river have to be utilized to increase the green cover of the city. The various tributaries and nalas which are the part of the catchment area have to be properly planned and green cover has to be increased. Encroachment along the banks has to be stopped. The banks of the both the rivers from the upfront point Anarwala of Bindal river & kailaghat ghas mandi upfront point of Rispana river till the merging/conflux point Doudwala, Mothorrowala. The River Front development of both the rivers will increase the green cover in the city; will also help in balancing build up mass arrangement & decreasing UHI effect in the city.

**Utilization of all existing open spaces:** There are various available open spaces in the Dehradun city which if properly utilized for the plantation and landscaping can increase the green cover of the city for eg plantation can be done in the periphery of cremation grounds, grave yards, school boundaries, public and semi public offices, Bus terminals, truck terminals, transport Nagar, Parade ground, factories, stone crushers, batching plants, low lying areas etc we have to identify & earmark all those open space.

**Conclusion**

GIS, GPS, and other devices should be used scientifically to analyze and figure out the various problems and potentials of any city. Scientists, Geographers, Urban planners and researchers can use the various available techniques to understand the issue and can in turn provide the best suitable scientific solutions, In this case study simple and low cost scientific devices were used to record the
temperature in various part of the Dehradun city, to validate the temperature variation within the city. Most of the times the research work is not initiated because of the cost and time factor, but if the research is properly planned then it can be executed and completed with low cost measures. With the help these studies very effective solutions can be proposed which can definitely help in reshaping the city and achievement of goals like balanced urban mass arrangement, heath benefits, environment improvement, environment sensitive development, urban sustainability & maintaining ecological balance.

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