Urban Regeneration using Geo-spatial Techniques

Thesis submitted to the Andhra University, Visakhapatnam
in partial fulfilment of requirement for the
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Disclaimer:

This work has been carried out in partial fulfilment of Masters of Technology program in Remote Sensing and Geographic Information System at Indian Institute of Remote Sensing, Dehradun, India. The author is solely responsible for the contents of the thesis.

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CERTIFICATE

This is to certify that the project entitled '***Urban Regeneration using Geo-spatial Techniques*'** is a bona-fide record of work carried out by **Mr. Amit Singh**. The report has been submitted in partial fulfilment of requirement for the award of **Master of Technology in Remote Sensing and GIS** carried out at Indian Institute of Remote Sensing, Dehradun. The work has been carried out under supervision of **Ms. Kshama Gupta**, Scientist- 'SE' Urban and Regional Studies Department, Indian Institute of Remote Sensing.

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Declaration

I, ***Amit Singh,*** hereby declare that this dissertation entitled ***"Urban Regeneration using Geospatial Techniques"*** submitted to Andhra University, Visakhapatnam in partial fulfilment of the requirements for the award of ***M.Tech in Remote Sensing and GIS***, is my own work and that to the best of my knowledge and belief. It is a record of original research carried out be me under the guidance and supervision of **Ms. Kshama Gupta**, Scientist- 'SE' Urban and Regional Studies Department, Indian Institute of Remote Sensing, ISRO, Dehradun. It contains no material previously published or written by another person nor material which to a substantial extent nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgement has been made in the text.

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Date:

Abstract

The regeneration of core area in cities is essential strategy which involves various aspects of social, economic, physical and environmental developmental process. The degradation of the infrastructure is a natural process if it is not maintain on time to time basis. The changes in life style and the usage pattern of the spaces may cause further degradation in the already existing spaces. The core areas are severely affected by the degeneration phenomena as these spaces are changing their role in society. The changing pattern of land uses and space uses results in further degradation of already affected infrastructure. The cores are primarily residential setups with mixed use. Over period of time, these residential setups are transformed into commercial spaces and expended in the vertical direction. The transformation takes place at cost of neighbouring open spaces; and results in excessive use of essential services. The per capita spaces are reducing at faster rates. The increased vehicular traffic on road networks in the city results in lower usage of these roads by pedestrians due to non-conducive walking conditions. The regeneration is an approach to improve these degraded conditions in city core areas

In present study, the different administrative setups (wards) are compared depending upon type and amount of data availability using indicator based approach. The indicators depict current situation and condition of the city core area. The certain class of indicators also measure qualitative aspects in quantitative manner.

The multi criteria evaluation of the indicators for respective wards reduces the subjectivity in the approach. This type of analysis is data demanding and the applicability of indicator based approach is subject to availability of uniform data samples. The geospatial techniques are useful in indicator based urban regeneration approach.

The highlight of the study was the generation of 3D space use maps prepared using Esri CityEngine software which is till now mostly done through 2D cartographic mapping. For vertically growing cities 3 dimensional space use maps are much needed instead of 2 dimensional maps having insufficient information.

The analysis of the study area reveals that there is a huge deficit of open green spaces which is important for natural ventilation as well as to maintain the micro climate. The analysis of space use in the study area reveals that there is a high percentage of commercial activity in the study area which attracts vehicular traffic as well as pedestrian population and needs parking spaces and urban furniture. There is lack of community spaces and the educational facilities in terms of their spatial distribution. The generated regeneration index and the space use index can be utilized for prioritizing the potential areas which requires intervention for regeneration.

Key words: Regeneration, Esri CityEngine, 3D Space use maps, Indicator.

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List of Abbreviations

SAI – Service Accessibility Index

PAI – Parking Accessibility Index

PCRA – Per Capita Road Area

PCTG – Per Capita Total Green

PCPG – Per Capita Public Green

15 Ex – Ward 15 excluding city level green

$A_{Ri} = Area\ of\ Road\ in\ ith\ ward$

$L_{Ri} = Length\ Road\ in\ ith\ ward$

$A_{wi} = Area\ of\ ith\ ward$

$P_{wi} = Population\ of\ ith\ ward$

$A_{gti} = Area\ of\ total\ green\ in\ ith\ ward$

1 INTRODUCTION

1.1 Introduction to Urbanization in India

Urbanization is a phenomena taking place due to our expectations and concerns for better livable conditions. The growth of cities is an ancient and continuous phenomena. During Vedic period there are many Nagar (towns) came into existence; these towns are the business & political centers and flourished by the nearby agrarian settlements and the rivers. The towns are denser than the villages, per area population is more and the quality of life is little higher. These densely populated magnets attracts more and more people towards themselves, resulting excessive use of natural resources.

After 1950's the population growth rate of cities in India and abroad became manifold, hence requiring sustainable planning and management. Many cities and other hierarchical urban centers grow continuously in a centripetal fashion around the regional core resulting in rapid urbanisation. According to UN report over half the population started living in the urban areas by 2011and by 2045 every region will be predominantly urban (Figure 1.1).

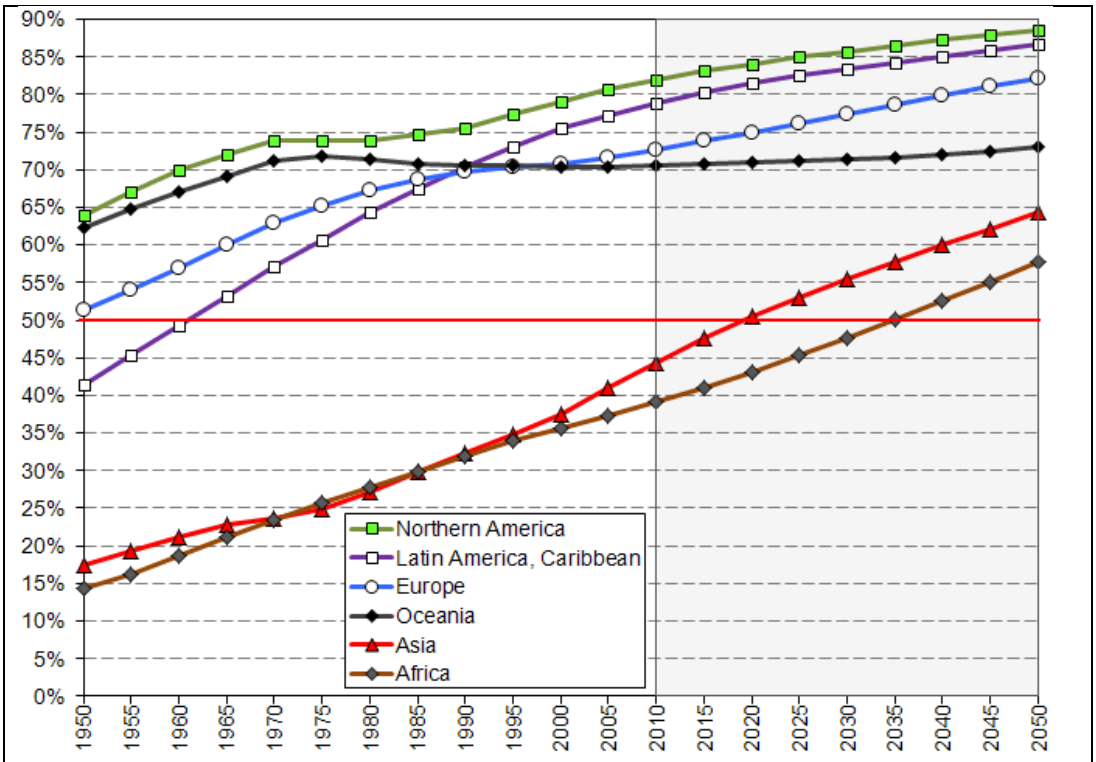


Figure 1.1. World Urban Population ("World Urbanization Prospects, the 2011 Revision,".)

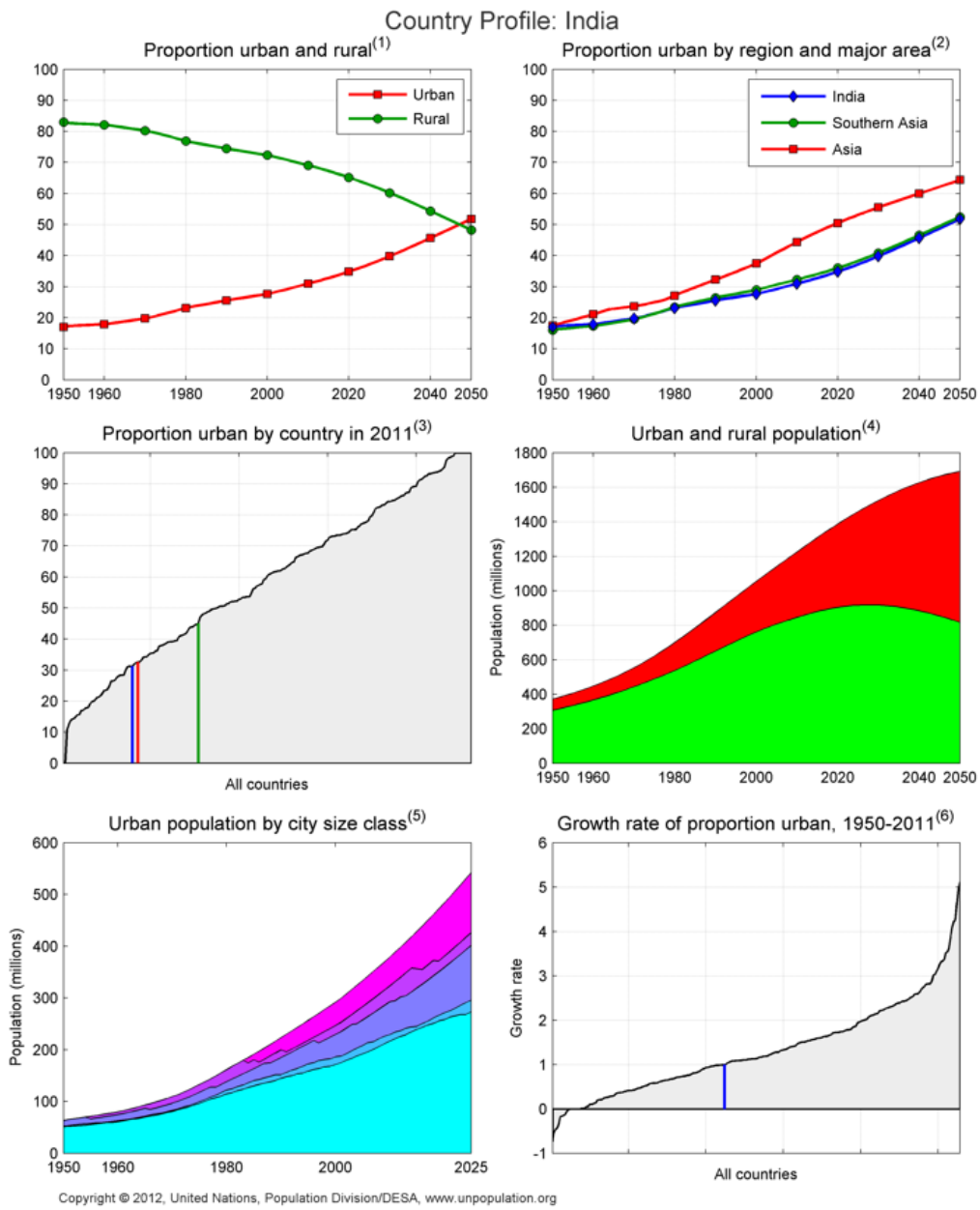


Figure 1.2. UN Country Profile: India 2011 ("World Urbanization Prospects, the 2011 Revision,")

The rapid urbanization causing enhance load on infrastructure due to natural increase in population as well as migration towards cities. The excessive use of infrastructure results in its deterioration. Some facilities and services that are sufficient at a particular time becomes insufficient. This increased load causes more deterioration in the city core, as these areas are of prime interest and acts as main commercial centre or central business district. The over

grown traffic on the roads causes traffic jams and increase the travel time. This rapid growth in population creates more energy demand and environmental problems. According to UN country profile, if India continues with the same pace of the population growth and then by 2050 it will become urbanized country.("World Urbanization Prospects, the 2011 Revision,")Urbanisation in India become many fold during last century and growing continuously, hence the demand of infrastructure.

The changing land use patterns abandon the old structures and cause the demolition of these structures. The land resources reduces the number and area of the open playing spaces as well as parks and green spaces of recreational nature. Per capita green spaces are rapidly reducing in the cities especially in the core areas. Increasing population density and vehicle density in the core areas also results in rise of demand for more number of parking spaces.

The city planning is required to tackle the problem of resource distribution, public health in order to maintain the quality of life. As a human being we are not only concern with planned cities having better roads, infrastructures and better housing colonies, but we are also concerned with beautiful and functional cities. The need of beautiful and functional cities requires regeneration of degrading parts of the (concerned) cities. If cities are overlooked they will start degrading naturally. Enhanced load of change in various space use patterns spoil the image of city.

1.2 Urban Regeneration

When regeneration is considered in the context of "urban," it involves the rebirth or renewal of urban areas and settlements. Urban regeneration is primarily concerned with regenerating cities and inner ring suburbs which are facing periods of decline due to compounding and intersecting pressures.("Metropolitan Institute » Urban Regeneration,"). The city cores are mostly affected by the process of degeneration. The city core is not only accessed by the permanent dwellers but also by high number of floating population that comes only at some particular time of the day. Most of the inner cities came in to existence in 19th and early 20th century which are now 100 or more years old. The designed dimensions of the road were according to the vehicular as well as pedestrian density of that time. Now the vehicular density gone many fold has created problems of traffic jams and parking spaces. These vehicular population also interfering with the pedestrian population on road at particular time. This conflict demoralise pedestrians to using these areas. So the pedestrian services has to be examined and better environment for the pedestrians has to be provided. There are requirement of better footpaths, vehicle restricted areas and place for hawkers. The walking experience along these roads and streets in a vehicle free environment is very relaxing.

Regeneration is the holistic process of reversing the economic, physical and social decline of places where market forces alone won't suffice. This holistic theme runs throughout this

Strategy and forms the basis for the regeneration. The balance between all the aspects of physical, social, economic as well as environmental and holistic approach towards growth are the key for a city to sustain. Growth based on market forces, may help some aspects of society and social life but not holistic, in long run as it creates social and environmental problems. Enforcement of social and environmental concerns over the economic forces bring the right results. The regeneration is the process standing on the balance between all such concerns. Infrastructure represents the image of the city, quality of life and connectivity, social unity and social mixing within the society. Physical infrastructure is representation of what society needs or requirement of society sometimes it enforced to society as well. Infrastructure, transport and housing is important in driving developmental processes, delivering opportunities for sustainable economic growth, job creation, and connectivity.

Regeneration processes are futuristic. It organise the city for current as well as future needs; so futuristic vision and action should also be integrated. Urban regeneration implies an integrated perspective on problems, potentials, strategies and projects within the social, environmental, cultural and economic sphere. Urban regeneration programs dealing with issues of spatial and social integration, in the effort of preventing segregation and slum creation. (Mitrojorgji, 2003) It respects and protects our environment.

"*Urban regeneration thereby moves beyond urban renewal (a process of essentially physical change), urban development (general mission) and urban revitalisation (no precise method of approach). Urban regeneration implies that all approaches should be constructed with a longer-term, more strategic purpose in mind*"(Roberts and Sykes, 2000)(Lang, 2005).

Regeneration will also contribute to the drivers of growth: Productivity, Competitiveness and Resource Efficiency; Participation in the Labour Market and Population Growth, by helping to realise the potential of our most disadvantaged communities.(Scotland and Scottish Government, 2011)Public services are part of the bedrock on which our society and future prosperity depends and they have a vital role to play in supporting economic development and regeneration.

Planning, or plan-making, for urban space in a city is a comprehensive activity to define goals, policies and implementation measures to shape urban space based on the current and the future conditions of the city and the demands of various actors on urban space. Therefore, in order to tackle the issues of urban regeneration, there are high expectations toward plan making.(Murayama, 2009) Plan making defines the way forward how the space is going to be, so carefully planning or plan preparation can be done. The basic plans for the cities are master plan and the city development plans as well as the authorities can also prepare the regeneration plans based on detailed study of the concern areas as well as the spatial setting of the area. As cities are not only growing horizontally but as well as vertically. Various land use and space use plans are the key for regeneration planning.

Urban regeneration is a supervised process of identification of problems, their analysis and finding out adequate design solutions. As this process needs the knowledge of all sorts of areas associated with the earth, land, land forms, water, air, food needs, and the sociology of the concerned society, hence a multi-disciplinary approach is required for desired development and considering requisite recommendations during design process.

An urban shape of city is determined by organization of its space elements. These elements fall into two categories: active and passive elements. The active elements are the different networks which guarantee the city's operation; networks which do not define the objects they are comprised of, since they are functional systems which can share components with other networks at the same time. There are four networks we could differentiate: information network, mobility network, services network and connection network. The passive elements are non-connective elements which can form part of a network or sub network, but which usually do not.

Urban regeneration research aims to build new knowledge and shape policy confronting the pressures from major short- or long-term economic problems, deindustrialization, demographic changes, underinvestment, structural or cyclical employment issues, political disenfranchisement, racial or social tensions, physical deterioration, and physical changes to urban areas.("Metropolitan Institute » Urban Regeneration,".)

1.3 Definition of urban regeneration

"Urban regeneration can be defined as a comprehensive and integrated vision and action which leads to the resolution of urban problems and which seeks to bring about a lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change"(Roberts and Sykes, 2000)(Mehta, 2008).

Need for urban regeneration

The overall aim of the regeneration is to achieve high quality well designed, sustainable places for people to live, work and enjoy. So when the degradation of infrastructure and services going to happen the regeneration is needed. As long as the degradation is a continuous process the regeneration to be a continuous process. Degrading environment of the city may consist

- Degraded core areas
- Poor environment
- Degrading infrastructure
- Poor and / or insufficient housing
- Diminishing architectural characteristics
- Very few open, green and recreational spaces

- Slums

The regeneration process involve preservation utilisation, enhancement of old buildings and public spaces, as well as it may go for partial or whole demolition and new construction or may be internal and partial modification based on the situation.

One of the major issues of sustainable urban regeneration is to shape attractive urban space through renovation of existing urban space, thus contributing to the enhancement of people's quality of life. It is expected that in each area there should be a plan for a future vision of urban space which will be implemented effectively and creatively with various measures such as preservation and utilization of historic buildings, reconstruction and repair of old structures, creation of a safe and comfortable pedestrian and bicycle environment, development of parks and open space, creation of a beautiful landscape, supply of community facilities, consideration for the environment and maintenance of safe and clean public spaces.(Murayama, 2009)

Regeneration Activities must take account of permanent public arts and account the conservation of historical monuments (Haveli's, Temples), memorials (Statues, Sculptures) and built environment and Aesthetic values as well. Regeneration process also account for urban furniture (pavements, benches, signalling systems, lights, urban tolls, street lamps etc.), basic services (lavatories, clocks, fountains, kiosks, Waste disposal containers etc.) and ordered landscape elements (Plants, trees, grass, open public spaces, spaces for pets etc.).

Urban regeneration is an operation of renovation guided by strategic objectives of urban development. It offers a comprehensive, integrated and acceptable design solutions combined with interventions of a social & economic nature. Because of its nature regeneration become the need to solve the complex urban problems. This process is not only the problem solving technique, but concern with the design and development of green breathing spaces, plazas, parks public and community built masses and the cultural areas and hubs. As regeneration respects the opinion of all the stack-holders and local users it acts as catalyst in further management of regenerated areas.

Regeneration studies are complex spatial studies involve many parameters. Spatial and field based attribute information are easily integrated, utilized and analysed over GIS platform. GIS analysis of parameters eliminate or minimize subjectivity of analysis. The remote sensing data easily provide a base layer for urban regeneration studies i.e. information of built masses, open areas their number and size, the width of roads and connectivity networks. It also acts as base layer for amenities and services analysis. The complex urban areas need regeneration processes that are based on the accurate and fast geospatial techniques. This easy to maintain data sets prepared during the regeneration study used for further monitoring of areas, change detection. It also used to check unauthorised developments and encroachments. Multiple level information can be extracted through geospatial data sets and their GIS analysis.

To calculate the indices that are of spatial nature geospatial technique is very useful. This minimizes the efforts to check the results and scenario generation. When multiple scenario available it's easy to opt for best possible option of regeneration. The high resolution and accurate data sets and GIS platforms for analysis are much needed in current highly changing and complex urban areas regeneration.

1.4 Geospatial techniques for urban regeneration

The urban regeneration is a spatial and continuous process requires vast database and information that are spatial and temporal in nature too. Remote sensing techniques provide the spatial and temporal data, which is very useful for regeneration. The traditional data collection techniques are subjective, so remote sensing data eliminate subjectivity. It also simplifies the temporal monitoring process. The GIS analyze the spatial as well as attribute data sets. GIS and Remote Sensing provides a platform over which regeneration studies are easily undertaken.

Remote sensing techniques not only the aerial or satellite photogrammetry but LiDAR and Microwave remote sensing opens door to analyse the vulnerable spaces; building heights and skylines. These techniques help in 3D creation that is a visualisation tool and easily involve all the stakeholders. GIS act as a tool for analysis and scenario generation and helps in finding out the holistic solutions.

More Choices More Chances. Remote sensing and GIS provide more choices of data acquisition and analysis so the city planners come up with all the possible holistic solutions; test and discussions of the possible consequences of all the scenario's and go for the best regeneration solutions. If many possible solutions tested it enhance efficiency and widens the vision and involvement of all the stakeholders and resulting in best possible holistic solutions. It involves young people in education, employment and training and comes up with a framework that include a focus on prevention, intervention and sustainability.

1.5 Aim and objective of research:

Planning and managing the complex urban areas no more based on imperial techniques. Complexity of urban processes need advanced technological support to analyze and monitor the system. The city core are even more complex and degraded parts at the heart of the city. So to regenerate these areas, all the causes and aspects of degradation along with futuristic needs should be analyzed. When the number of factors involve in the evaluation process the modern geospatial techniques are very helpful. This study aims to analyze geospatial techniques for regeneration of the core areas of city.

1.6 Research Objectives:

- To identify geo-spatial indicators for analyzing the physical problems in the city core area.
- To study and analyze the physical conditions in the delineated study area using identified geo-spatial indicators.
- To provide planning recommendation as per guidelines.

1.7 Research Question:

- How Remote Sensing, GIS and Visualization tools are useful for Urban Regeneration?
- What are the indicators relevant to study physical and environmental conditions in the study area?
- What are the logical criterion for the analysis?
- How regeneration index (composite index) is important in identification of areas needs regeneration?

2 LITERATURE REVIEW

2.1 Approaches for urban regeneration

The regeneration is a local phenomenon as it differs in approach from place to place and with the specific nature of the problems. Some of the approaches identified are

- Property led urban regeneration - private sector and economic development approaches are used for regeneration.
- SRB (Single regeneration budget) - a regional development agency co-ordinate and monitor all the regeneration projects and project funding so that redundancy of services reduced. It promote the reclamation and development of derelict, vacant and underused land and buildings. (Roberts & Sykes, 2000).
- Design led regeneration- regeneration through urban design of the areas
- Policy led regeneration- development regulations induced regeneration
- Conservation based regeneration – conservation of important city fabric is main theme of the regeneration. It deals with buildings and street fabric conservation during revitalisation process.
- Culture led regeneration – cultural activities leads to regeneration of the area. It is associated with the religious and cultural city fabrics.

The regeneration provides facilities and services to community. These services may include meeting places, sitting and resting spaces, play areas community spaces for public events and happenings, better accessibility for children, women and old persons. Well ventilated and sunlit spaces. It also protects and enhance green spaces, heritage fabric as well futuristic buildings state of art technologies with various renewable energy choices. It also proposes the transit oriented development and decentralisation of goods and services to prevent the high land values and generation of slums which leads to degeneration of the area. The regeneration also works in favour of mixed land and space uses, multi-purpose uses of the buildings and increased residential density so that load on the traffic and transportation network is minimised to provide fuel efficiency leading to less carbon emission. Regeneration promotes street activities, culture and markets. It also provides the sense of safety, security, intimacy and connectedness or belongingness. Regeneration provide opportunity for variable scale and flexible land uses, diverse cultural context, creative and artistic expressions as well as heritage conservation and connection to history of place in its daily working and leisure. Regeneration acts as breeding ground for mixed use with simultaneous work, live and play environment. It also incorporates resource and waste management, local as well as basic needs, public health, pollution, better access and biodiversity of the area. These facilities may work as indicators for the regeneration. Some other qualities of the regeneration processes are empowerment of

the local economy and markets, satisfying working environments culture and aesthetic led development, better access and a big picture for the motivation of the society.

2.2 Urban Regeneration

The regeneration process is balanced revitalization approach between socio-economic, physical and environmental infrastructure of the area. Revitalisation of existing centre by enhancing amenity, attractiveness, socio-economic and cultural vitality should be ensured in the process. Place specific regeneration phenomena helps to develop sense of place and associated identity and pride. 'Regenerating people rather than a place' ("Metropolitan Institute » Urban Regeneration,").To develop sense of place and to improve employment access education, training of users is also a part of regeneration activities. Slum clearance is a major task associated with regeneration activities. Revitalization of existing infrastructure and built setups, along with conserving the relevant structures is central theme of revitalization process. Some of the priority actions are

- Mix use development, flexibility, integration, safety and multidisciplinary approaches are encouraged. Mixing of uses reduce need for travel between residence, employment centre and recreation spots. (Land use and space use mix ratio ensure better mixing).
- Sustainability - all three aspects of social, economic and environmental sustainability become priority of modern development or redevelopment.
- Good design - Respect human scale, walkability, access, open and public space while developing urban form/s within complex environments e.g. density, sprawl, heritage constraints.
- Decision making – futuristic vision, better approval processes, transparency, Community – planning, and community buildings are space specific as our country having so much diversity. Affordable housing and land values should be a concern during Implementation of planning and development policies.

2.3 Factors/ indicators relevant for urban regeneration

For sustainable urban regeneration, indicator based approaches are the most widely used and most effective. Indicator based methodologies ensure easy and accountable regeneration process. An indicator based methodology developed by(Hemphill et al., 2004) is commonly used with certain modifications which provide a wide range of indicators that covers all the aspects of the regeneration called as Hemphill framework. This framework attempts the benchmarking and indicator based approaches. Hemphill identified 34 indicators and has given the bench marking based on points to each indicator that is between 2 and 10. These indicators are grouped under six performance categories

2.3.1 Economy and work**:-**

- Employment Density: Employment density in regeneration area (employees/ Ha)
- Workplace Occupancy: percentage of workplaces already occupied & active (%) Employment for local people

1. **Building and land use structure:-**
   - Green space Ratio: Percentage of green spaces with in regeneration area.
   - Green Space availability: Amount of public green space per capita in regeneration area (m2)
   - Unsealed Surface Ratio: Percentage of real vegetation in public green spaces
   - Reclamation Potential: Percentage of contaminated area and underutilized lands reclaimed (%)
   - Net Residential Density: Number of dwellings per land area devoted to residential purposes (dwellings/ Ha)
   - Mixed use Structure: Mixed- use combinations
   - Residential occupancy: Share of houses occupied (%)
   - Climate friendly buildings 1: Percentage of buildings with green roof or façade
   - Climate friendly buildings 2: Percentage of buildings generating/ consuming renewable energy
   - Climate friendly building 3: percentage of buildings assessed by green building certification programs
2. **Transportation and mobility:-**
   - Land devoted to roads: Percentage of site area occupied by roads (excluding pedestrian and bicycle) (%)
   - Land devoted to walking and cycling: percentage of roads designed to pedestrian & cycling
   - Work Travel habits: most common mode of transport for work commutes in regeneration area
   - Leisure Travel habits: most common mode of transport among visitors to project areas.
   - Public Transportation coverage: Average distance to major facilities from public transport stations
   - Passenger on public transport: ratio of annual public transport passengers in project area to that of city
3. **Infrastructure and resource efficiency**
4. **Energy consumption and efficiency**
5. **Community based issues and benefits**

- Community participation 1: involvement of community in preparation of regeneration project
- Community participation 2: involvement of community in management of project area

The framework attempts to measure sustainable regeneration by allocating a point score to various indicators within indicator sets. A point score is given to each indicator ranging from 1-10 (10 indicating the 'maximum' or 'optimum' contribution to sustainability). The points are totalled for each of the indicator sets and a total point score can then be allocated. The model allocates a varying degree of importance to each indicator. The weightings are subsequently applied to the scores obtained from the indicators in each set to calculate the index value.

Selection of indicators is crucial for a study. Sometimes some indicators are more important than others, sometimes some indicators are irrelevant or some other indicators are more important based on time and the location of study area. Some of the questions the researcher should answer before selecting the indicators

1. What indicators should one select?
2. Who selects them?
3. Why are they selected?
4. What are they meant to help achieve?
5. What about balance between the various elements of Urban Regeneration?
6. How are the indicators to be measured?
7. How are the indicators to be interpreted and by whom?
8. How are the results to be communicated, to whom and for what purpose?
9. How are the indicators to be used?

Indicator Development: UNU-IAS Working Paper No. 167(Balaban, 2011)describes Steps of Indicator Development and Application

1. Review of the literature and current indicator frameworks
2. Identification of potential indicators
3. Preliminary interviews to evaluate the potential indicators
4. Revision of the initial set of potential indicators
5. Definition of benchmarks for indicators
6. Finalizing the set of indicators to be applied to the case study
7. Data collection
8. Data analysis to calculate the indicators
9. Dissemination of the research results

The number of indicators should be as small as possible, but not smaller than necessary. That is, the indicator set must be comprehensive and compact, covering all relevant

aspects.(Bossel, 1999)The researcher should ensure how many indicators need to be adopted for the study based on the questions asked above.

Once indicators are finalised, the second step is to integrate the indicators so that they may be viewed together to provide a holistic view of regeneration(Bell and Morse, 2013). There are two main approaches; visual integration, which keeps individual indicators separate but presents them together in a single table or diagram, and numerical integration, which combines the indicators to generate a single index value for SD(Bell and Morse, 2013). Many approaches consider integration of multiple indices to single indices based on weight In order to formulate a framework of indicators with sustainable regeneration index. Some indicators may be allocated a greater weighting than others, this weighting issue is highly contentious and is driven mostly by value judgement (Langstraat, 2006).

Visual integration can be used in conjunction with an index. In general, a radar diagram is used for visual representation of sustainable regeneration indicators. The method employed is often dependent on the intended end user(Bell and Morse, 2008). Single index value or a simple diagram is easy to understand.

Couch and Dennemann, (2000) have stated Urban Regeneration as ‘recycling derelict buildings, reducing demand for peripheral development and facilitating the development of more compact cities’

2.4 Local urban body and their initiative

2.4.1 Government programs in co-operation with Urban Local Bodies:

In India, the urban renewal mission (JNNURM) is responsible for infrastructure management of the cities. It motivates and involves local municipal and government as well as private agencies and stakeholders. The renewal projects aim to improve sewage, road, waste management facilities and urban water supply demands. The other government schemes in India (Rajiv Awas Yojana) are providing better housing facilities for slum dwellers and urban poor. These redevelopment schemes are working with a unique goal in sight and long term visions. These schemes are required to be comprehensive and holistic for particular place as the redevelopment and regeneration is a place specific phenomena.

2.5 Relevant work in the direction of urban regeneration:

'Urban Regeneration of Commercial Stretch in Aligarh' (Farooq, 2012) describes the strategies for the regeneration of Morris road the busiest commercial stretch in the city. The author has prepared built space map (Figure-Ground) and two Dimensional Building height map with colour coding for up to 4 storied buildings. The author has also composed broad land use map at the cluster level. In this study, the axonometric space use types were defined and every particular building was given a particular type code. The Street sections at junctions was prepared to show the different sections used by different mode of traffic and transportation and the width height ratio of the street at a particular stretch. The connectivity and linkages maps show in study locate the parking slots, bus stand, railway station and routes of different modes of transportation and Point of congestion was marked based on visual observation.

The major recommendations were

1. Road widening
2. Creation of pedestrian linkages to neighbourhood amenities and facilities.
3. Proposal for segregated parking based on the duration of the parking.
4. The major market areas recommended to pedestrianize.
5. Redeveloping some commercial buildings with provision of parking.
6. Proper crossing at intersections of road.
7. Maintaining the road section in terms of width and surface quality.
8. Provision of walkable pavements on either side of road
9. Plantation on either side of road to shade the pedestrian
10. Barrier free design.

Urban Revitalization of Old City, Rampur (U.P.)(Kausar, 2012) describe the regeneration of part of city with conservation as one of the approach. Author has described the historical fabric of the city and identified the intervention street. Further describes the road network, the width of road and showing the sections at different points. Through images author showing the encroachment and the activities on and around the road in the specified section. Author prepared the built open relationship and land use map of the area. Author also showing the heritage or historical importance of the area with the help of images of the built form. Two dimensional colour coded building height map is prepared along with the building ownership and building condition. Map of activities and the images of activities are prepared. The map of social infrastructure showing post office, guest houses, institutional and religious structures. Architectural character of the area shown with the help of images. Further highlighted the issues of road network with no hierarchy, narrow width and lack of organised parking. Issues shown are encroachment by informal sector. The other issues are of electricity and power supply and drainage and sewerage issues. The study not utilising any modern technological approaches of remote sensing and GIS. The study concern more of visual information and field data.

'Revitalization of chowk Lucknow' (Ahsan, 2012) describes historical background of the city through maps. The geography, climate, regional linkages and importance as cultural and architectural heritage, art, craft, cousin. Administrative structure of the city discussed. Further showing the evolution of chowk, strategic importance of the chowk, the cultural significance and religious buildings. The study area is the main spine of the chowk Akbari Gate to Gol Darwaza. The author prepared the land use map of the area and also commented on design of streets. The typology of open spaces are identified as household level and community level. A building height map with colour coding is shown in the report. The typology of activities are described and a map showing historical buildings identified and shown in form of images, mixed use buildings, and madrasa. Loss of historicity and the degraded street façade shown through images. The issues highlighted in the report are congestion, encroachment, multiple ownership of buildings, and lack of physical infrastructure. The other issues highlighted are loss of cultural identity, uncontrolled signage, high population and built-up density, no space for further development and lack of parking spaces.

2.6 Space use map:

Compared to the urban development in history, nowadays the three-dimensional development of urban space influences the urban configuration intensively and its effects should not be ignored.(Wang et al.)

The master plans describe their goals and objectives in 2 dimensional maps that are generalised due to merging of different space uses. The city level development plans and the municipal taxation plans are not capable enough to legally enforce the rules and regulations as the 2 dimensional physical maps having very limited information. This issue can be addressed by detailed digital maps integrated with databases in a geographic information system (GIS), as ancillary information is provided by additional GIS layers.(Erba, 2012) The space use maps are opening a new window in urban governance.

The cities are not only expending horizontally but also in vertical direction. Space use maps are the parametric maps that describe 3D information in detail. It shows no. of stories in buildings, prominent use of the floor space in each and every floor, building height and the built-up in every floor. It helps to monitor the growth of city and its constituent parts in other words buildings and open spaces.

It is required to rethink on legal and economic aspects of urban society by shifting from the traditional 2D vision to a 3D approach in order to develop, implement, and control urban land policies.(Erba, 2012)

The complexity in the land use preparation has led to space use mapping. Space use maps are prepared with the help of satellite imageries and the other ancillary data collected from the ground. Satellite images provide the property boundaries, built size, plot size and other

information is obtained from ground based data. The space use maps are the realistic and rigorous system of modern cadastre.

A modern cadastre is an integrated database system that holds information on land registration and ownership, physical characteristics, econometric modelling for property valuation, zoning, geographic information, transportation networks, infrastructure and services, and environmental attributes, all of which are linked to socioeconomic and demographic information on property owners.(Erba, 2012) . As the ownership and uses of the land or built form are changing in 3rd dimension the space use maps are getting more and more importance. These digital maps not only providing cadastre information but also representing the uses and primary physical dimension of the space or built mass. The use of oblique maps showing reliefs and height of the buildings and aerial utility networks relate user more than the plane metric maps. 3- Dimensional maps are used for visualisation and identification of under developed spaces, slums and building heights spatial relationships of buildings and the orientation of the streets and the duration of the shade in the streets that is important for pedestrian movements. It is also useful for the city professionals and the administrators to visualise the spaces and problems as well as opportunities in a better way with the help of space use maps.

The regulatory bodies can use 3 dimensional space use maps to calculate maximum and Actual floor area ratio (FAR) and to impose the land development regulations on the built parcels.

Space use maps created over the digital elevation models are useful in analysis of disaster impact calculation and compensation assessment. The space use maps are used to determine extent of traffic due to space uses and its management. It is also useful to locate efficient parking's and to control the pedestrian movement patterns as well segregation of pedestrian and vehicular traffic. Space use maps are also useful to locate community services.

2.7 Why space Use Maps:

The space use maps are the 3 dimensional maps or the representation of 3 dimensional maps with the help of colour coded system of representation. The present scenario of vertical growth is monitored only through the mapping in that direction. The 2 dimensional land use maps are insufficient in the present context to convey the real information. Not only the uses but the ownership changes along the vertical dimension.

The FAR restrictions and the uses restriction imposed by the authorities are violated in the obvious fashion without a proper monitoring system or 3D maps. The taxation of the different classes of uses patterns are different so for the proper taxation and monitoring the collected taxes is becoming for more easy with the help of 3 dimensional space use maps. In the absence of proper maps, haphazard growth in the vertical dimension is not checked properly. The right

to air and ventilation of some dwellers are not encroached by others if the 3 dimensional monitoring system is in place.

The space use maps are come through the GIS environment as the Geodatabase or the shape file is the basis of these maps. The actual condition on ground and the horizontal encroachments are also easily monitored with these maps. The name of owner taxation records of past and present are easily maintained with the space use of a particular floor. Authorities in case of disasters such as fire, flood and earth quake easily able to estimate the loss to property and the compensation may decide on the basis of space use maps.

The power consumption of each floor also recorded on the GIS environment with the space use maps and the charges or surcharges may be decided easily. The number of vehicles per family in a particular neighbourhood and their parking demand may be estimated through space use maps.

The service provider agencies such as water supply, waste management and traffic and transport management practices benefited with the use of 3 dimensional space use maps because the actual percentage or share of uses as per floor and accordingly waste generated or traffic generated is better estimated as the uses of the floors are known.

As for as the mixed use developments are preferred the land use mix or space use mix indices are calculated in area and based on the level of mixing authorities impose the rules and regulations to make a proper mixing instead of one particular use is dominating the area and causes the extra load on infrastructure i.e. traffic.

2.8 3D GIS and Urban Regeneration

The ability to easily create 3D urban scenes based on existing GIS data is one of the key strengths of CityEngine. The software allows you to create high-quality 3D content using combination of 2D data, attributes, and procedurally defined rules. It is possible for particular GIS organization to create visually appealing 3D urban environments using cadastre information .(“3D urban content creation and design using CityEngine | ArcGIS Resource Center,”)

The new development in Urban planning specially, climatological orientation analysis including noise, air and urban climate can be managed using 3D environment. 3 Dimensional GIS model are used in efficient visualization for 3D objects neighbourhood and environment. There were certain 3D Urban-GIS prototypes reported in literature which were deployed in development and monitoring of areas.

3D Urban-GIS= 3D city Model + thematic information+ effective data storage and administration + Planning analysis functionality

The City Engine provides a platform for creating rule based 3D-city models, having thematic information as attributes, with effective data storage analysis functionality. This technique is

quite different from the popularising Remote Sensing and photogrammetric approach of 3D content creation the photogrammetric approach does not provide the usage information of the different built masses. This 3D space use technique is very useful to visualise and analyse new planned cities along with organic settlements.

3 STUDY AREA AND DATA USED

3.1 Background of the City

Dehradun is the Capital city of the state of Uttarakhand. Located in the Garhwal region, it is 236 km north of India's capital New Delhi and is one of the "Counter Magnets" of the National Capital Region (NCR) being developed as an alternative centre of growth to help ease the migration and population explosion in the Delhi metropolitan area.(Bhushan, 2009). Dehradun is in the Doon Valley on the foothills of the Himalayas nestled between two of India's mightiest rivers — the Ganges on the east and the Yamuna on the west. The city is famous for its picturesque landscape and slightly milder climate and provides a gateway to the surrounding region.("Dehradun - Wikipedia, the free encyclopedia,") It is the part of the tourist circuit of Dehradun-Musoorie-Dhanaulti-Kanatal-Rishikesh-Haridwar-Dehradun. The famous tourist sites in the city and around include the Tibetan temple, Santaula Devi temple, Lachchhiwala, Rajaji National Park and Dakpathar.

According to census 2011 the total population of Dehradun municipality is 569,578 of which 298,638 male and 270,940 female out of which 449,950 persons are literate with literacy rate of 79%. The total population of the district is 800309.("Census of India," 2011) Most inhabitants of the district living with in the municipal boundaries. The city of Dehradun is well connected via rail, road and air transport networks. Dehradun railway station located at the central part of the city. The main bus terminus ISBT is located on Haridwar bypass and well connected to the other parts of the city via local autos. The other bus terminus is known as Musoorie bus stand. Jolly Grant is the airport for the city of Dehradun

Figure 3.1 Administrative boundary of Uttarakhand

3.2 Historical background

According to Skanda Purana, Dun formed part of the region called Kedar Khand. It was included in the kingdom of Ashoka by the end of the 3rd century B.C. It is revealed by history that for centuries the region formed part of the Garhwal kingdom with some interruption from Rohillas. For about two decades till 1815 it was under the occupation of the Gorkhas. In April 1815 Gorkhas were ousted from Garhwal region and Garhwal was annexed by the British. In that year the area now comprising tehsil Dehra Dun was added to district Saharanpur. In 1825, however, it was transferred to the Kumaon Division. In 1828, Dehra Dun and JaunsarBhabar were placed under the charge of a separate Deputy Commissioner and in 1829, the Dehra Dun district was transferred from the Kumaon Division to the Meerut Division. In 1842, Dun was attached to Saharanpur district and placed under an officer subordinate to the Collector of the district but since 1871 it is being administered as separate district. In 1968 the district was taken out from Meerut division and included in the Garhwal Division.("History: District of Dehradun, Uttarakhand, India,".).

3.3 Topography

Dehra Dun can be divided into two distinct tracts i.e. the montane tract and the sub-montane tract. The montane tract covers whole Chakrata tehsil of the district and consists entirely of a succession of mountains and gorges and comprises Jaunsar Bhabar. The mountains are very rough with steep slopes. The most important features of the tract is the ridge which separates the drainage are of Tons on the west from that of Yamuna on the east. Below the montane tract follows the sub-montane tract, which is the famous Dun valley bounded by Shivalik hills in the south and outer scarp of the Himalayas in the north.

3.4 City Profile

Dehradun manifests its position as an important city in the most fertile region of Doon Valley between rivers Yamuna and Ganga. It's infect, the most developed city in the Shiwalik foothills and the gateway to the far-flung hill areas of Uttaranchal. Dehradun is blessed with many state and central government institutions for which it maintain its position in the country. It is the most vital service centre, which meets the trade and commerce requirements of its hinterland.

During the post-independence period, Dehradun as a city has registered an unprecedented growth in its population as well as physical expansion. Till the seventies there was no serious effort to channelize the haphazard growth of the city. However with a view to check the

haphazard growth of Dehradun the State government declared it as a Regulated area in 1963 under UP regulation of Building and Building Operation Act 1958 but the desired objectives could not be achieved as it performed only regulatory functions.

Consequently, before MDDA came into existence in 1984, the city was confronted with a number of problems of uncontrolled and haphazard development.

3.4.1 **Municipal Corporation of Dehradun (MCD):**

The Dehradun city comprises 4 municipal areas, Dehradun Municipal Corporation, cantonment board, Clementown municipal area and Vikas Nagar municipal area. Dehradun municipal areas consist of 60 wards, which are very diverse in terms of area, population density and topography.

The municipal corporation collects the property taxes and is responsible for the maintenance works, waste management, and for other community services, land and building permissions and records. The road side vendors and the encroachment problems are also tackled by the municipal corporation.

3.4.2 Mussoorie Dehradun Development Authority (MDDA):

The MDDA was established in 1984 for monitoring of haphazard development and degradation of natural environment. MDDA is a local self-efficient decision making agency capable of undertaking all sorts of activities for systematic planning of urban development. MDDA's another important job is to provide good quality, planned infrastructure with provision of sites and services, and the housing needs of growing population An underlying integrated development process must be inexpensive, functionally utilitarian, environmentally healthy, recreationally adequate and aesthetically appealing. MDDA also works hand in hand with town planning department of Uttarakhand, which is mostly responsible for preparation and implementation of master plan 2025. Its other concerns are prevention of encroachments on river rain lands going for decongestion of business and transport centres, Earthquake proof vertical urban expansion, rehabilitation of areas that are degenerated and Encourage micro level non-conventional energy generation methods.

3.4.3 Initiatives of MDDA

- Chakrata road widening: from existing 9 metre to 24 metre on both side from Ghantaghar to Prabhat Cinema. (figure 3.2, figure 3.3)
- Relocation of affected people at 3 floor Shopping Complex and Double basement + stilt parking of around 600 Cars at RFC Go down/PWD Guest House place.

- Residential Block of 96 residential houses on MDDA land near ISBT for the residents of Chakrata road, who will be rehabilitated after demolition of their houses due to Chakrata Road Widening.
- Dispensary Road Parking and Commercial Complex.
- Parking lot at the previous Veterinary Hospital place.
- Rajpur Road Beautification in Association with ONGC
    - Project Components: -Road widening, Construction of drains, Street Lights, Shifting of Electric and Telephonic poles for planned arrangement and alignment, Shifting of central verge with its landscaping is being proposed, Beautification of Cross sections, Traffic lightening systems, Street furniture, Bus stoppages, Toilets, Muriel's.

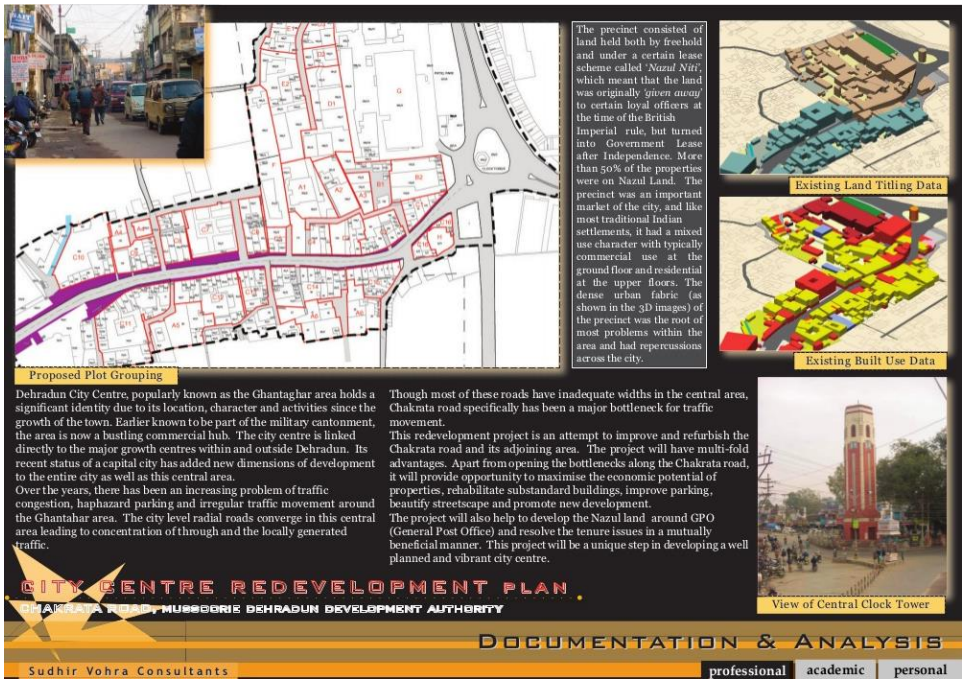


Figure 3.2 City Centre Redevelopment plan of Dehradun (source: Sudhir Vohra Consultants)

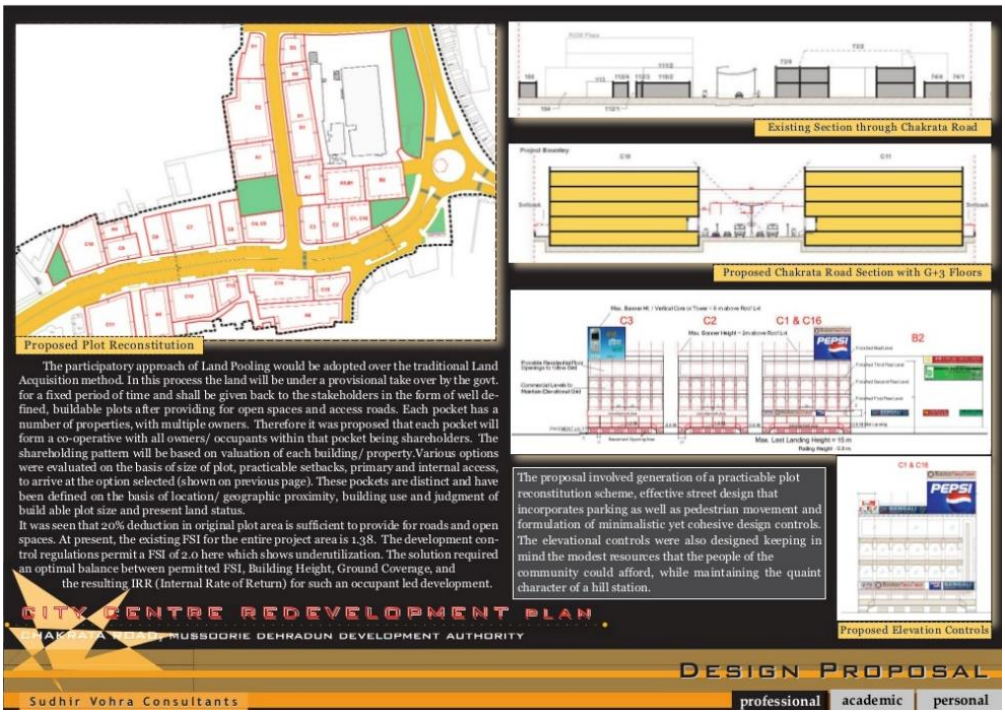


Figure 3.3 Design Solutions for city centre Redevelopment plan

- MDDA has also amended the building byelaws to achieve sustainable development in this ecologically fragile zone.
    - Provisions in the byelaws for structure safety measures to protect the build environment from natural disasters like earthquake & landslides; as this area falls under the sensitive seismic zone on the Vulnerable Atlas of India.
    - The consideration for conservation of natural resources have also been taken care of in the byelaws with the previous to promote rainwater-harvesting, use of non- conventional energy sources and providing more open spaces for water recharge and plantation.
- Dehradun is facing problem like housing shortage; tremendous pressure on the existing urban infrastructure and problem of traffic and congestion. MDDA has taken up various short term & long term planning proposals to tackle the existing problem and to cope with future requirements of the city.
- To minimize the problem of traffic jams, congestion and pollution in the city, MDDA has established Transport Nagar at Saharanpur road, an Inter State Bus Terminal near Hardware Bypass-Saharanpur Road, Warehousing complex & Whole Sale areas near Transport Nagar and proposed to develop public parking in the congested areas.
- With a view to adopt immediate measures for easy traffic movement in the city, MDDA has also carried out a study of traffic management for Dehradun/Mussoorie through traffic experts of RITES and implementing its suggestions.

3.5 Data used

S.N.	Data	Year	Use in Study	Remark
1	QuickBird Image	2007 (Dec. 6)	Base map creation	
2	Google Earth Image	2013	Updation of base map	
3	Master Plan 2025	2005	Study area delineation	Land use map of master plan
4	City Development Plan (CDP)		Study area delineation	Traffic at Important Junction
5	Census data	2011	Used to formulate Indices	
6	GPS points (Trimble juno)	2014 (Jan., Feb.)	Spatial information of amenities, services, Road network, Religious setups.	Collects attribute information of Points
7	Ground survey data	2014 (Jan., Feb.)	Information collected for land use and space use maps	

During survey the major land use patterns, amenities and major uses of the different floors on building to building basis identified. Every floor given a particular colour based on the major use of the floor. The height of the buildings are generic (3 metres per floor).

3.6 Study area

The Clock Tower and adjacent markets acts as core area of the Dehradun municipal corporation area and city. These highly dense areas consist of residential to mix to highly commercial, institutional and religious built forms.

The study area based on the administrative boundaries as ward. The identification process incorporates the dense market areas highly populated residential areas the major road with high traffic nodes as boundary on one side and the river Bindal on other side.

Primarily this area lacking in amount and distribution of open space, high traffic volume and narrow roads causing traffic jams. This Areas also vulnerable to fire causing hazards lacking the street furniture and public services so seems suitable site for regeneration study. Based on the master plan of Dehradun the main retail and commercial and dense residential settlement identification taken place. The traffic at nodes taken from the city development plan (CDP).

3.7 Delineation of study area

The area between the landmarks Ghantaghar and railway station and eastern side of the river bindal is densely populated compared to other parts of the city. The described area is also highly commercial based on initial stydies of the master plan 2025 map of dehradun. The study area comprises dense urban settlement as well as the main commercial area of the city. The population Intensity map showing the highest concentration between the landmarks Clock Tower and the railway station.

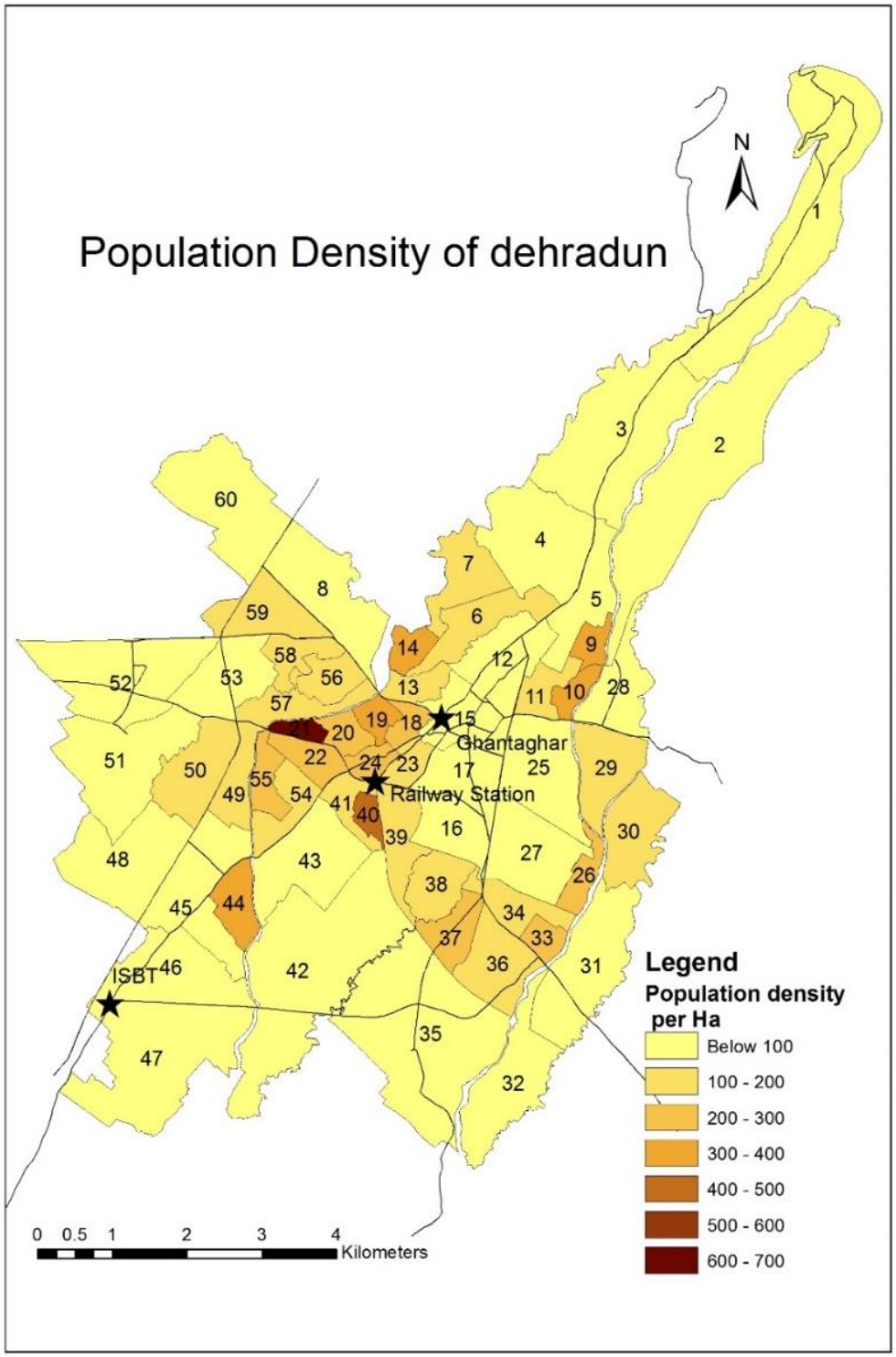


Figure 3.4. Population Density Map Of Dehradun

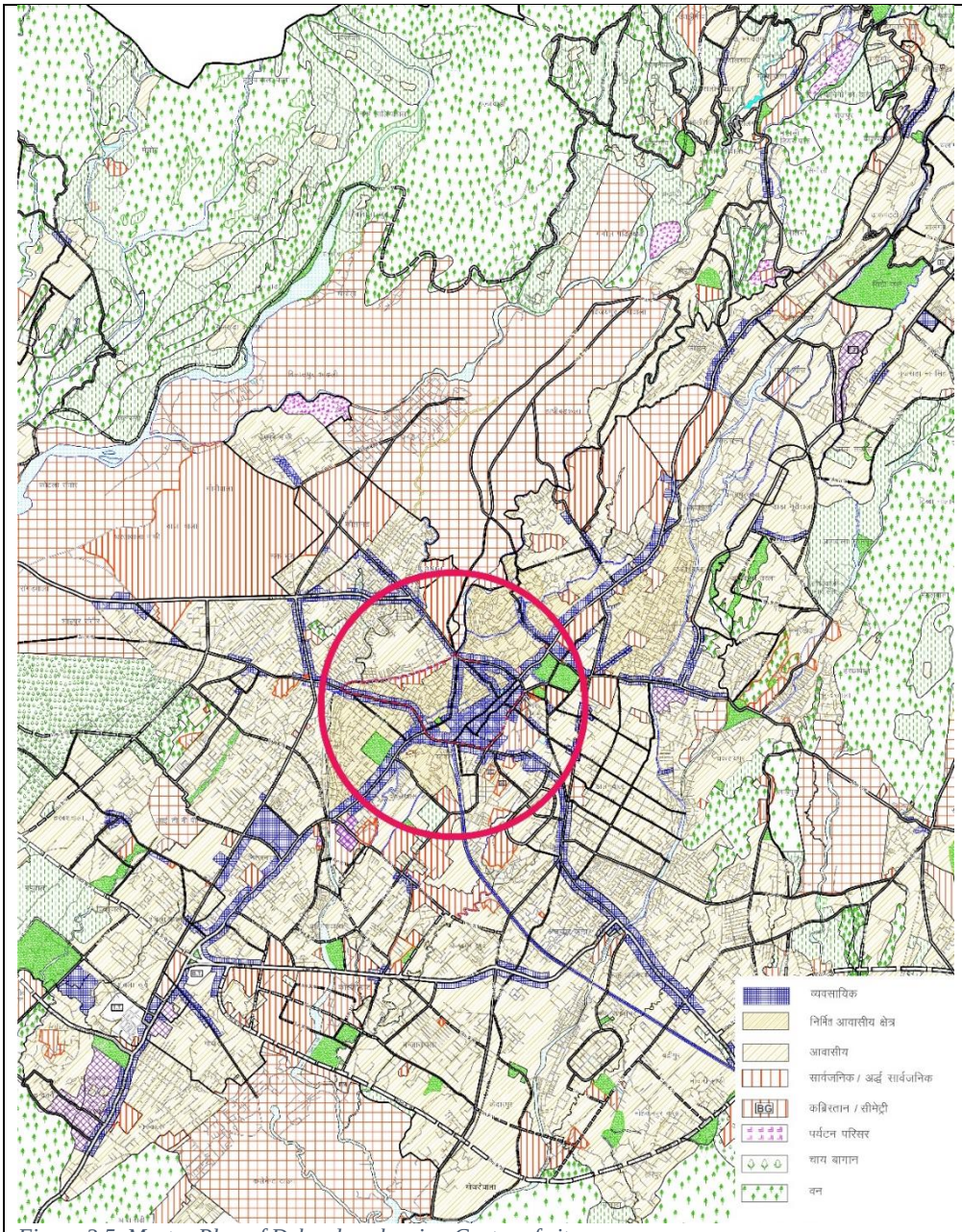


Figure 3.5. Master Plan of Dehradun showing Centre of city

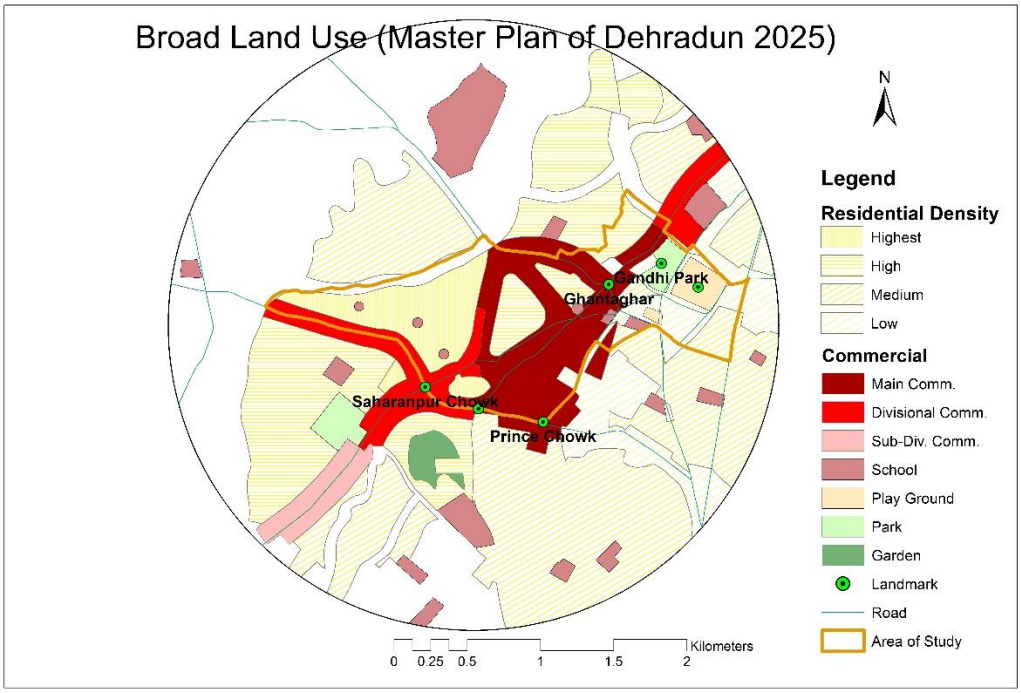


Figure 3.6. High density City core of Dehradun

The study area comprise of seven wards of different land and space use patterns, the clock tower ward primary hosts the daily needs and hosiery market, the Dhamawala contributes as grocery market and lots of go-downs are exists there, the Tilak Road primarily institutional area, jhanda Mohalla known for its religious identity and the Khurbura and Shivaji Marge are the predominantly residential setups. Some wards such as Clock Tower having low residential density on the other hand the Shivaji Marg having highest residential density in the city of Dehradun.

Table 3-1 Study Area Wards

Ward No.	Ward Name	Area (Ha)	Pop.	Pop. Den.	No. HH	Predominant land use	Remark
15	Clock Tower	82.23	5341	64.95	1240	City level Green	
18	KalikaMandir Marg	24.12	5326	220.81	1190	Mixed Development	
19	Tilak Road	23.92	8687	363.17	1926	Institutional is more	

						compared to other wards	
20	Khurbura	29.44	7374	250.48	1612	Residential	
21	Shivaji Marg	17.10	10237	598.65	2044	Residential	
23	Dhamawala	29.89	5295	177.15	1111	Commercial	
24	JhandaMohalla	24.31	6727	276.72	1472	Commercial	Prominent Religious structures present in the ward

The QuickBird image of the year 2007 used for the base layer preparation and google earth 2013 image for updating the information.

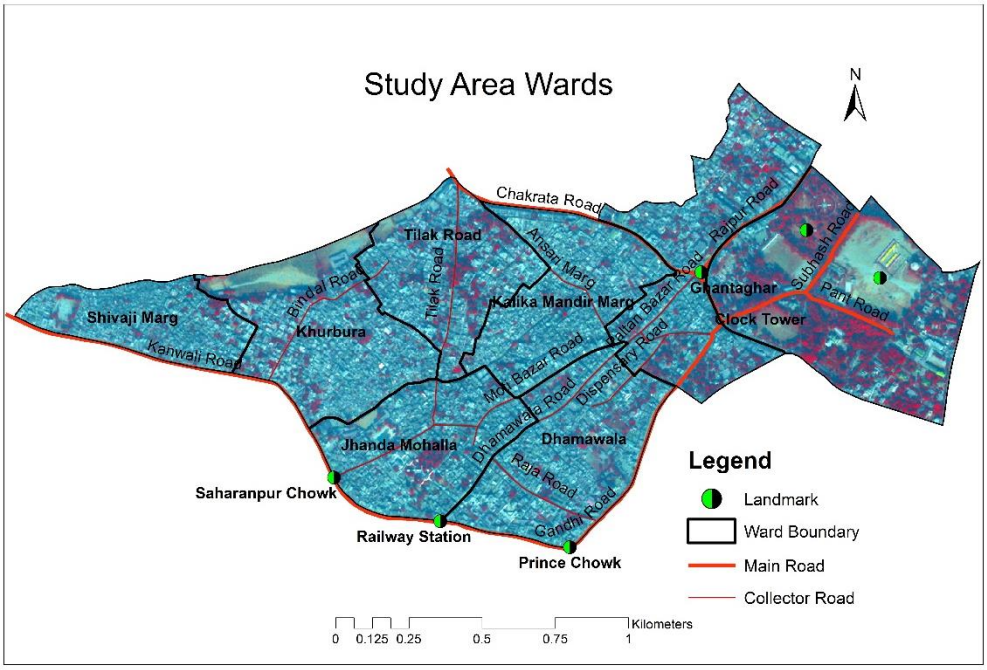


Figure 3.7. QuickBird Image (Dec 2007) Showing Study Area

4 METHODOLOGY

4.1 Introduction

The approach of urban regeneration study based on geospatial techniques of satellite image base map production and GIS based study of the degenerated areas in the core is the major basis of the study.

Remote sensing data provides road network, width of road, length of road and their interrelationship that helps in the study of traffic jams and alternate patterns of the traffic movement. On the other hand remote sensing data provides the area, number and spatial location of the green spaces, which are crucial for the health of the locals.

The great observation based on the remote sensing data is the percentage of areas either built-up or hard paved vs. the areas soft paved, which shows the pattern and tendency of runoff in the area and with the help of GIS and ground based data it is useful to study the water conservation scenario in the area. Per capita green space is a measure to study the sustainability of growth pattern.

The space use map provide the actual scenario of complex situation as it able to describe the actual share of the land uses (floor uses) in 3 dimensional complex space. The space use helps in the study of movement pattern, the traffic generated, due to land uses (in 3 D) and need for infrastructure, safety measures and social infrastructure simultaneously the environmental impact of the growth pattern. It also describe the relevance of space for different age groups.

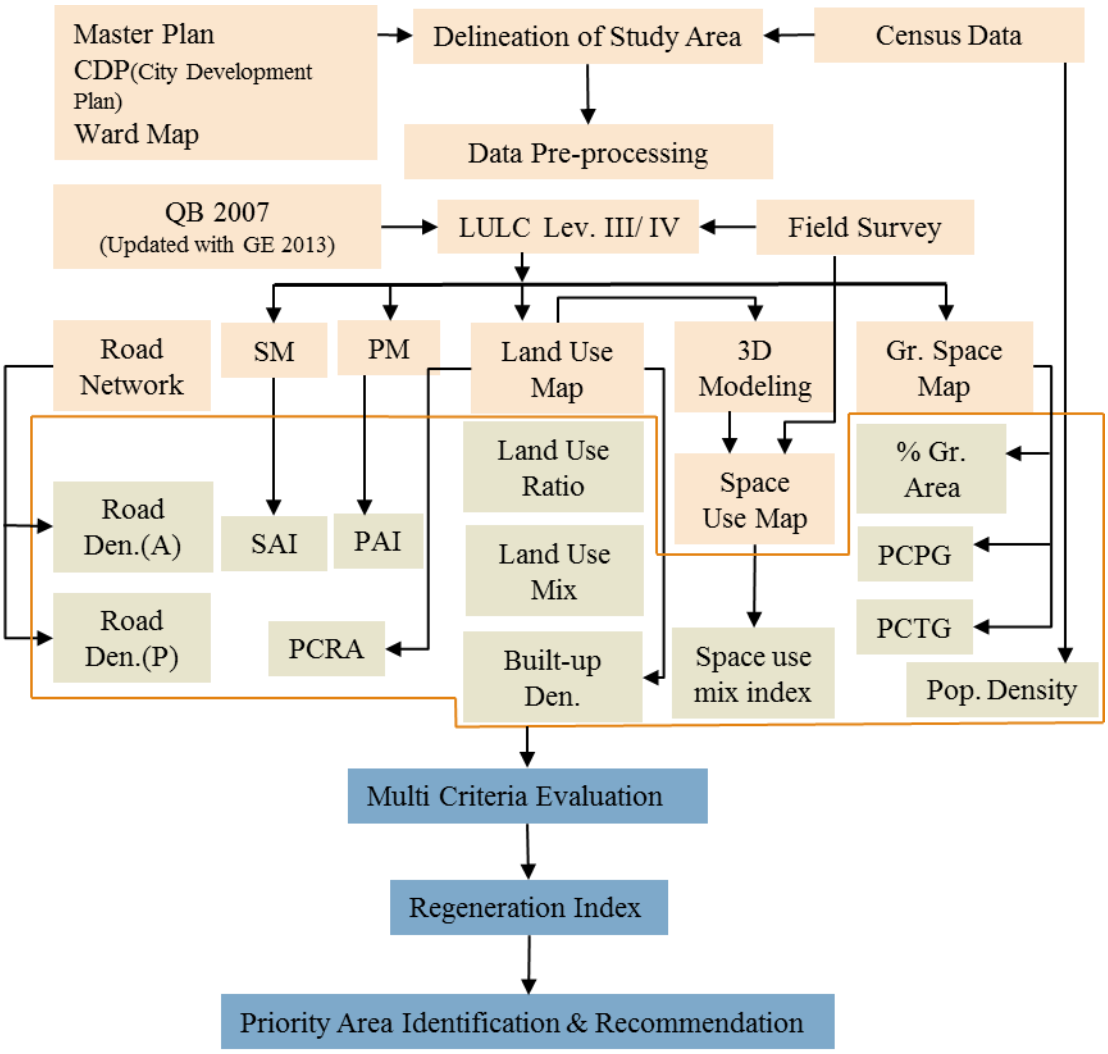
The study of urban furniture in the concern area describes the social adequacy of the area; either area is supportive for pedestrian movement or not, location of trees and open play areas represents the market oriented development is able to fulfil the need of children and elderly persons or not.

The indices based study is used. Indices based on knowledge or based on some sets of rules or observations of similar cities that undergone through the similar kind of changes. These indicators although similar for most of the city studies but their nature or number or parameters differs place to place basis.

The remote sensing data sets of QuickBird 2007 image and the google earth imagery of year 2013used for the study. The study area delineation adopted is based on the dense settlement pattern and traffic load on nodes. Saharanpur chowk, prince chowk, gantaghar chowk and survey of India chowk are the busiest chowk among the thirteen busiest chowk studied earlier. Paltan bazar, Pipalmandi, Arhat bazar, Jhandawala bazar are the main commercial streets in the city, which lies in the area of study. The 7 wards under study are highly populated areas, so this part of the city defines the core of the city. This delineation of the area based on the

land use map from the master plan 2025 of Dehradun, census data of year 2011 and the traffic volume survey of year 2003 described in city development plan.

4.2 Methodology Flow Diagram



(SAI – Service Accessibility Index, PAI – Parking Accessibility Index, PCRA – Per Capita Road Area, PCTG – Per Capita Total Green)

Figure 4.1 Methodology Flow Digram

4.3 Data collection

The ground based enhanced data collection done during the project for the preparation of land use and space use map creation. The services and amenities are marked with the help of vector data created over google earth 2013 image and the GPS device Trimble Juno SD during the project work. The paper sheets printed with the object ID's and having columns for G, G+1, G+2, G+3, and G+ 4 and above. Most of the buildings are up to G+2 level only. The space uses of floors marked on the sheet as 'C' for commercial, 'R' for residential, 'E' for educational, 'O' for office, 'Re' for religious etc. this collected data transformed over GIS and the errors in the digitisation or during the data collection verified on same day. If any dis-cremenancy than that are verified on next day during the visit of the area.

4.4 Preparation of Base Layer

QuickBird image of Dehradun of the year 2007 is earlier used as base layer. After digitization of the image the built, open green and the road network with the road width extracted from it. As the regeneration studies are always real time studies with futuristic goals in mind. The updation of all the information based on the google earth image has been carried out. The further densification of area in the following years seen as the result of it. The major task to identification of the land uses as well as the space uses with the number of floors in built masses is very necessary for the study. The urban amenities location and number on spatial context marking is based on the ground survey. The Trimble zuno D is used for the updation process as the line and point file. The line file marked as the major land uses on a particular stretch with the name of the street as for as possible and the landmarks on that particular road network. On the other hand the point file marked the land use information based on GPS location. The information collected are the location of schools primary and secondary, hospitals, offices government and private, religious structures as Temple, Mosque, Gurudwara, Church and Buddhist temples in the area collected and marked as attribute in GIS environment. Other information is the location of police stations and police chawki, fire station, petrol pumps, industrial setups are collected and marked on GIS. Cultural centres and public open and green areas are identified out of the total open and green areas digitised over the google earth image. The green spaces are the breathing spaces of the settlement. The road layer extracted as polygon used for per-capita calculations using the ward wise information of population provided by census of India in the form of CD by the census of India office at Dehradun. The per-capita green calculated ward wise.

One table with object id's marked with the space use information as columns for G, G+1, G+2, and G+ 3. Some buildings with more than G+3 height are marked separately against the point id and serial no on the sheet. The height information is based on the no of floors only. Actual building heights are not measured but generic height for floor as 3 metre per floor is

assigned during the preparation of space use map.

4.5 Preparation of Space use map on Esri CityEngine:

The space use map provide the actual scenario of complex situation as it able to describe the actual share of the land uses (floor uses) in 3 dimensional complex space. The space use helps in the study of movement pattern, the traffic generated, due to land uses (in 3 D) and need for infrastructure, safety measures and social infrastructure simultaneously the environmental impact of the growth pattern. It also describe the relevance of space for different age groups.

Space use map and City Engine

Step1: Create the location of the City Engine project. Simply it's a folder in a specified location. This folder called the City Engine workspace.

Step2: Creation of City Engine project, to create the project FILE—New—City Engine Project

In the project folder window either use the default location or browse for the location of workspace one created earlier. Provide the project name and finish. It creates the project along with set of folders.

Step3: Importing the Shapefile or geodatabase: to import the shape file or geodatabase go to the file menu → import a selection window appers. There are many import options come there.In the specified window choose Filegeodatabase import or shapefile import according to the file one have. If the computer system configuration is lower than frefferd to choose shape file insteed of geodatabase as goedatabase import all the layers and it bacome a large file size. In this project shape file of land uses with detailed to building level utilised. As the extrusion in the CityEngine take the building footprint as lot. The shapefile having attribute data of the different floors say G,G+1, G+2 and G+3 and above with the space use of that particular floor. CityEngine also extrct the building height from the attribute table itself if measured and feeded in the Arcmap during the creation of the shape file. In the present work as the number of buildings are very high so the building heights are given as generic values of 3metres each. This become the limitation of the project.

Step 4: Creation of the scene: First in the scene folder a scene with no 3 dimensional content appers. To crate the scene first go for the creation of rule file. The CityEngine is a rule based software platfom. To create the rule file go to the folder name rule→ CGA Rule. Choose the name of the rule based on your relevent requirement or convinience. The specified CGA rule appers in the rule folder.Step 5: Writing the rule file: Clicking on the rule file opens a window on the left lower bottom corner of the screen, having file name date of creation, computer name and the version of the CityEngine. Than based on the specified annotations one can write the required rule file. A sample rule file shown below.

```
/**
 * File:    CRR.cga
 * Created: 6 Apr 2014 06:49:11 GMT
 * Author:  AMIT
 */

version "2013.1"
attr height = 9
Lot --> extrude(height) Building
Building --> split(y){3:color("#21409a")ground|
3:color("#ffff73")first|3:color("#ffff73")second}
```

Figure 4.2 CGA Rule file

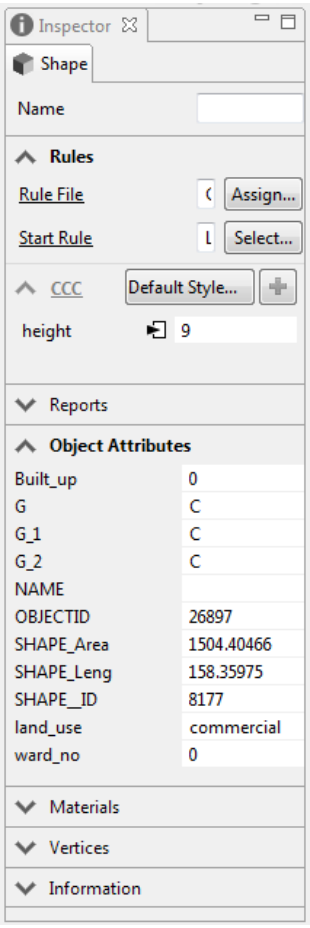


Figure 4.3. Attribute of Space Use Block

The specified rule file having attribute height of 9 metres as the rule CRR showing three floors with commercial at ground, and the residential at above two levels. The lot defined as the base in the CityEngine taking the building footprints. The operation extrude (height) extrudes the lot in the vertical direction. The extruded shape defined as the Building (a name for that object or group of objects). The object building is further divided in to three levels of equal heights i.e. 3 metres with the help of split command. As for as the space use is concerned the colour is given to that particular space use. The CityEngine works with the hex colour codes 24-bit colour using the whole six-digit form (2^{24} =16,777,216 colours)("Web colors - Wikipedia, the free encyclopedia,") It provide a vast range of colours. The colours are chosen according to the specified colour codes for land uses.

Step 6 Assigning rule to a lot: first open the inspector window by clicking the Window tab. When one can click on the building foot print or lot the attributes of that lot appears in the inspector window. According to that specified space uses the rule file just drag and drop on that lot and it will come with the particular space use pattern on that lot. Different rules are prepared based on the space use patterns in the study area.

Step7 Visualisation and inquiry: visualisation of the area in context of the space use is very easy and informative to everyone either a person is city professional or administrator with no

knowledge of the tools in back ground. The City engine scene and the model exported to the web based format and with the help of small utilities one can able to see rotate zoom in the simple web browsers like Mozilla or google chrome. This 3 dimensional space use model help in formation of new rule as the administrators are able to visualise the situation on and along every street in the city.

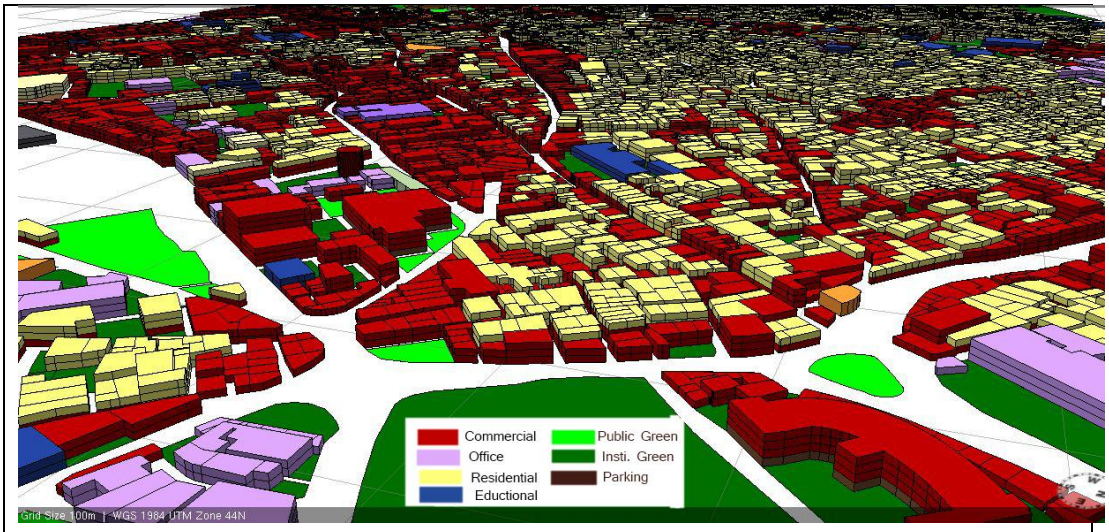


Figure 4.4 Space use map of area near Clock tower, Dehradun

4.6 Selection and definition of Indicators:

Indices based analysis is more appropriate and less subjective method for regeneration study of the area. The selected indicators based on the major concern of the area i.e. lack of green areas, high density of built-up, less availability of parking and services, land use and space use changes and their consequences. The other indices are based on mixing of land uses and space uses to analyze the area in terms of better access to daily goods and services. Sometimes green areas, accessibility and services are looking appropriate in primary observation but that are not sufficient for high density areas. These areas area highly dense to per capita basis analysis is important criteria so some indices are chosen on the basis of per capita availability. The selection of indices is such that it uses more and more remote sensing data. So the indices that are spatial in nature and quantitative selected for the study instead of qualitative indices such as architectural characteristics, need of retrofitting in the area, need of rejuvenation of river and river front development, universal accessibility and other social elements as urban

fixtures and furniture's i.e. dust bins, public toilets, benches or spill outs for children and elderly persons etc. The condition of some buildings are not good and they need retrofitting. The building condition is an important parameter but this study need appropriate and rigorous field survey with civil engineering equipment. Due to lack of time and the scope of study this parameter is not considered.

Day time visitors of the area of study who are responsible for traffic jam and need more urban services are not considered during indicator selection as the data of this floating population is not available. Although it is very important aspect of the concern study. Appropriate estimation is not made for floating population as it differs in every part of the study area. Commercial areas attract more floating population instead of residential areas. Traffic data at different junctions are unavailable during the course of study so this important regeneration parameter is not considered. The selected indices are related to physical, environmental and social considerations, although not directly related to economic consideration of the area. The selected indices are mentioned below

4.6.1 Per-capita Green:

Green or breathing spaces are require for everyone. The vibrant and healthy communities have a fair amount of green spaces per person, these spaces are for recreation, parks, functions and play areas for children's as well as young generation of the locality. The growth of younger working population as well as the developing size of the Indian cities and the concern of public health require the enhanced per-capita green or open spaces. The enhancement of urban green spaces or urban forests is one of the ways, which has the potential to mitigate the adverse effects of urbanization in a sustainable manner, making cities more attractive and comfortable to live in.(De Ridder et al., 2004). The central and state governments in India as well as international organisations realising the importance of the per-capita green in the cities and towns. Urban open and green spaces having community benefits i.e. physiological, sociological economic aesthetic and public health benefits. Urban parks, gardens and natural landscapes are better known for their non-market or intangible benefits than market or tangible benefits(Chaudhry et al.,).

Some of the Indian cities are rich in case of per-capita green spaces on the other hand some are very poor too. 20% of total geographical area of Delhi comes under green cover making per capita green space around 22m2. The Gandhinagar and Chandigarh as the post independent cities are well performing with per capita open spaces. Gandhinagar having more than 160m2 per-capita green or open spaces available.(Chaudhry et al.) The Chandigarh has per-capita green availability around 55 m2. The Bangalore city is another greener city in India the per-capita green space availability is 17m2. At the global perspective the cities renowned for its urban green spaces having 20 to 40 percent total green cover of their geographical area. And the per-capita green is 25 to 100 m2. The minimum standard set by WHO is 9 m2 of open/green area per person.("Asia-Pacific Forestry Sector Outlook Study: Urban Forestry in

the Asia-Pacific Region - Situation and Prospects,"). On the other hand most of the Indian cities like Jaipur having very low per-capita green around 2.4 m2.

These open and green spaces are used for the recreational purposes stress reliving and for walking and exercises. The per-capita green or open spaces are directly related to the

Cities public health and so the effective working days in the year and the working hours in a day. The urban greens act as capacity building and strengthening element in the society. In most of the cases the per-capita green are calculated on city level instead of neighbourhood level, it may be because of the intensive need of concern data. The neighbourhood level per-capita green analysis is more important as one can use the open spaces nearby. In the present study due to ward wise population data availability the per-capita open/ green spaces calculated at ward level.

$$\text{Per} - \text{Capita Public Green} = \frac{Area\ of\ Public\ Green}{\text{Area of ward}}$$

4.6.2 Per-capita Total Green

The total green considers not only the accessible green areas but also green areas that are either institutional or private green areas. This indicates the actual green ness of the area and directly related to microclimate of the area. The total green although directly not used by the persons living in the area but it effects the ventilation of the houses in the area.

$$\text{Population Density} = \frac{\text{Area of Total Green}}{\text{Area of ward}}$$

4.6.3 Percentage Green

The relationship of green spaces with the urbanity and health is significant. The percentage area of the green with respect to the total area is measure of openness in the particular settlement. It is important for the ventilation and cooling. The overall green space with respect to the total area shows the built open relationship and it is regulated by the laws and guidelines of different urban local bodies. It is also a measure of the capability of Natural rain water penetration to the ground, these green areas mostly used by the children as play areas in their contest.

If the percentage green area is more the Urban Heat Island effect is minimal. The percentage green spaces is very much different from the per capita green, as the same amount of green spaces may act less or more according to the population utilizing it. But the environmental concern like Urban Heat Island correction or the Natural Harvesting of water, the water table, the Ventilation Capabilities of buildings as whole, directly and indirectly connected to the percentage of green instead of this per capita green more concerned to direct health benefits.

The percentage of open/green $= \frac{\text{Total amount of green}}{\text{Concerned area}}$

$$P_g = \frac{A_{gi}}{A_{wi}}$$

4.6.4 Land Use Index

The land use index defined on the basic of land use percentage. This defines the ratio of different land uses existing in study area. The priority of the uses or ranking decided on the fact less commercialisation is good for the local residents. As more commercialisation leads to the extra load on all the amenities and services.

4.6.5 Land use mix Index:

This is an entropy measure reflecting the evenness of distribution of several land-use types within the region.(Frank et al., 2004) The LAND_MIX index is calculated as follows using the 'n' categories of land in each region:

Land use mix ratio = - ∑i (1n Pi * (ln Pi/ln n))("Land Use Mix | GeoDaCenter,")

The values of the land use mix index varies from 0 to 1. Higher the mix index shows higher mixing of different land uses. Better mix of land use ensure minimum distances to availability of products and services. As for as the products and services are available in walking distances the walkability and the tendency of walkability improves. This diminishes the use of vehicles and prevent some amount of energy consumption and pollution. Understanding the relationship between urban design and physical activity is now a high priority for the prevention of chronic disease.(Christian et al., 2011) the obesity is one of them. As enhanced walkability the obesity and other diseases depending on obesity minimised.

The walkability ensured when a person has to walk minimum possible distance for their needs. Usually if amenities located not to for or with in the walking limits 300 to 400 meters. So the location and number of parking and spaces is such so that one can park their vehicles and walk across the streets to access the desired services.

The mixing of land uses ensures the movement through the day, it also ensures the use of the public open spaces and play areas and other recreational activities. The streets full of dwellers ensures women and children safety and security as well social security of elderly peoples.

4.6.6 Space Use Index

The space use index describes the actual uses pattern of 3 dimensional space. This is different from the 2 dimensional land use that describes the prominent land use of the ground floor. It

helps in estimation of traffic generated due to space use and requirement of public facilities. Ranking is based on less commercialisation is highly prioritise.

4.6.7 Space use mix ratio

In the complex urban scenario different uses and ownerships of buildings typically exists. To determine the actual uses in the ward the space use maps are need of the time. The better mixing of the broad uses in the space is provide better facilities and it is the key of sustainable more energy efficient communities. The space use mix determine in the same way as the land use mix. Same entropy formula applied for space use mix ratio.

Space use mix ratio = - ∑i (1n Pi * (ln Pi/ln n))

4.6.8 Road Density (Area wise)

Road density defined as the total length of Road divided by Geographical area of the vehicular access and the type for settlement average plot size and approach to every house hold is defined by the Road density per geographical area.

The Road Density = $\frac{L_{Ri}}{A_{wi}}$; where L is the length of the road network in the ward and A is the area of the ward.

4.6.9 Road Density (Population wise)

The Road density according to World Bank defined as the Road length (km)/ 1000 population. The higher the road length per population ensure less traffic and pedestrians on the road it sometimes also depicts low density sub urban settlements on the other hand low density of roads mean higher the pedestrian and or the population on the Road, and less speed. Too less or too higher road density is not preferable, as previous shows congestion, the late depicts very spars settlement. As far as the study area is concerned its high density area. So the possibility of second case is not there so in this case the higher the road density per population is good.

Road Density =$\frac{L_{Ri}}{P_{wi}}$ where l is the length of the road in a ward and the p is the population of the concerned ward.

4.6.10 Per capita Road Area

Per-capita road area describes the congestion parameter of the road for pedestrian movement. Either roads are full of pedestrians or it’s open for free movement. If per-capita road area is

more than less hindrance occurs during walking. Walking speed directly depends on this parameter and so the distances in terms of time.

$$\text{Per} - \text{capita Road Area} = \frac{\text{Area of Road in ward}}{\text{Area of ward}}$$

4.6.11 Population Density

The population density defined as the number of persons living per unit of area. Population density directly influence the development and regeneration parameters of area under consideration as number of services and infrastructure i.e. housing, parking and economic setups are directly related to population density of area. The amount of built-up and green areas are also related to the population.

$$\text{Population Density} = \frac{\text{Population of ward}}{\text{Total Area of ward}}$$

4.6.12 Built-up Density

It depicts the solid void ration in the urban setup. It signifies the scope of further development in the area or where the current development taking place. Very high built up density minimizes the community and recreation spaces. It is apparently related to the Economic condition of the dwellers and social health issues.

Higher built-up density minimizes the pervious surface and acts as reason for decline water table.

$$\text{Builtup Density} = \frac{\text{Total Area Covered under built mass}}{\text{Total Area of ward}}$$

4.6.13 Service Ratio Index

The service ratio is defined as the percentage area of the ward covered under the walkable distance from the services. Based on coverage the rankings area assigned to the wards. The wards having more reach to these services gets higher ranking. Reach to the services is an indictor of quality of life and its direct impact over the development of area.

4.6.14 Parking accessibility ratio

The parking accessibility is a broad concern as the area act as central business district for the city. The walkable distances from a parking is marked (Figure 4.1) and the percentage of area of the ward covered under these buffer is marked. According to percentage area covered per ward rankings are decided to the ward. For the concern study 400 m is taken as walkable distance.

Table 4-1. Walkable Distance in different condition ("Walking Distance Research," 1982)

	Minutes	Meters
In a highly attractive, completely weather- protected and artificially climatized environment	20	1600
In a highly attractive environment in which sidewalks are protected from sunshine and rain	10	800
In an attractive but not weather-protected area during periods of inclement weather	5	400
In an unattractive environment (parking lot, garage, traffic-congested streets)	2	200

4.7 Multi Criteria Evaluation (MCE) Assigning Weights

The pairwise comparison method developed by saaty, is used for the evaluation of weights to indices. The method involves the pairwise comparison to create a ratio matrix. It take as input the pairwise comparison and give relative weights as output. The weights are determined by normalising the eigenvector associated with the maximum eigenvalue of ratio matrix.

4.7.1 Development of the pairwise comparison matrix.

The method determine the relative preference on the scale of 1 to 9 to rate the relative preference of the two criteria. (Table 4.1)

Table 4-2 Relative Prefernces by Satty

Intensity of importance	Definition
1	Equal Importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance

6	Strong to very strong importance
7	Very strong importance
8	Very to extremely strong importance
9	Extreme importance

The comparison values are placed on horizontal line and the reciprocals at vertical direction.
Computation of criteria weights
Steps involve

- Sum the values in each column of the pairwise comparison matrix.
- Divide each element in the matrix by its column total (Normalized pairwise comparison matrix)
- Compute the average of the elements in each in each row of the normalized matrix.

4.7.2 Estimation of the consistency ratio

In this step we determine the consistency of our comparison.

- Determine the weighted sum vector by multiplying the weight for the first criterion times the first column of original pairwise comparison matrix, than second weight times the second criteria, and finally sum these values over the rows;
- Determine the consistency vector by dividing the weighted sum vector by the criterion weights determined previously.
- Than compute λ by simply average value of consistency vector.
- CI is calculated by $(\lambda-n)/(n-1)$. The term referred as consistency index.
- CR (Consistency Ratio) = CI/ RI; if CR< 0.10, indicates reasonable level of consistency.

4.8 Regeneration Index generation

The Regeneration index is generated by multiplying the consistent weight to the rankings determined for each indices over the wards. Than sum all the multiplication values and based on the performance the wards are identified for the regeneration first or the wards lacking in the analysed criterion of the regeneration.

The formula used to calculate regeneration index is described below

$$RIi = \sum_{i=1\ j=1}^{i=7, j=13} W_j * P_i$$

Here

$RI_i = Regeneration\ Index\ of\ ith\ ward$

$W_j = Weight\ of\ the\ Parameter\ j$

$P_i = Value\ of\ the\ parameter(Ranking)\ at\ ith\ ward$

5 RESULTS AND DISCUSSION

The regeneration project having quantitative and qualitative measures. The quantitative parameters are categorised on the basis of guidelines or best practices used worldwide. In context of India the parameters used are either from Indian guidelines or based on the world bodies' i.e. United Nations and World Health Organisation. Some guide lines like parking buffer and service walkability used after a lot of research of different urban planning bodies' guidelines. When no guidelines are found categories are based on equal interval based on maximum and minimum values of parameters obtained in the study area.

Qualitative parameters are covered through the visual interpretation. Architectural characteristic of the areas, river front development and traffic problems at junctions are discussed separately but not covers through indices. The values of the parameters obtained and categorise are ranked. The lower in the ranking is not satisfactory situation on the other hand the higher in the ranking is either depicts good scenario or relatively better performance with respect to other parameters over the wards under study. The parameters of the study their formulation obtained categories and the relative ranking given in the following table.

Table 5-1. Indicator Ranking Parameters

Score	Values
1.00	>= max. – 25% (max. – min.)
0.75	> max. – 25% (max. – min.) And >=min. + 50% (max. – min.)
0.50	> max. – 50% (max. – min.) And >=min. + 25% (max. – min.)
0.25	< min. + 25% (max. – min.)

5.1 Parameters and Relative Ranking

The parameters are listed in tabular format with their equations, categories and relative ranking. The categories are based on guidelines. In case if no guidelines available that represents the values at ward level the equal interval analysis based on above mentioned techniques are under taken. The relative rankings are given to parameters in order to calculate their performance. The relative ranking ensure the relative performance of wards towards urban regeneration.

The per capita public open/green space recommended to be more than 9 sq. m per person. And this considered as good situation and the ranking is 1. All the lower values are equally spaced to show the relative performance of other wards. The per-capita total green recommended to be more 15 sq. m per person, which is considered good scenario and provided the value 1; all the lower rankings are relative to this and equally spaced.

Table 5-2 Perameters, Categories And Ranking

S.N.	Parameters	Equations	Categories	Ranking	Remark
1	Per Capita Total Green	$\frac{A_{gti}}{P_i}$	00- 05 sq. m 05- 10 sq. m 10- 15 sq. m 15 sq. m & Above	0.25 0.50 0.75 1.00	Derived from Indian and other Asian city guidelines.
2	Per Capita Public Green	$\frac{A_{gpi}}{P_i}$	00 - 03 sqm 03 - 06 sqm 06 - 09 sqm 09sqm & Above	0.25 0.50 0.75 1.00	As per WHO recommendations
3	Percentage Green	$\frac{A_{gti}}{A_{wi}}$	00 – 05 05 – 10 10 – 15 15 & Above	0.25 0.50 0.75 1.00	Land use classifications of UDPFI
4	Land Use Index		10 – 20 20 – 30 30 – 40 40 – 50	1.00 0.75 0.50 0.25	Less commercial more preferred
5	Land Use Mix Index	- ∑i (1n Pi * (ln Pi/ln n))	0.0 - 0.25 0.25 - 0.50 0.50 - 0.75 0.75 & Above	0.25 0.50 0.75 1.00	Source: Arizona State University website
6	Space Use Mix Index	- ∑i (1n Pi * (ln Pi/ln n))	0.0 - 0.25 0.25 - 0.50 0.50 - 0.75	0.25 0.50 0.75	Derived similar to land use mix index

			0.75 & Above	1.00	
7	Road Density (Area)	$\frac{L_{Ri}}{A_{wi}}$	20 – 35 35 – 50 50 – 65	0.50 0.75 1.00	
8	Road Density (Population)	$\frac{L_{Ri}}{P_{wi}}$	1 – 2 2 – 3 3 – 4	0.50 0.75 1.00	
9	Per capita Road Area	$\frac{A_{Ri}}{P_{wi}}$	00 – 10 10 – 20 20 – 30 30 – 40	0.25 0.50 0.75 1.00	
10	Population Density	$\frac{P_{wi}}{A_{wi}}$	000 - 150 150 - 300 300 - 450 450 - 600 600 & above	0.50 0.75 1.00 0.75 0.50	
11	Built-up Density	$\frac{B_i}{A_{wi}}$	0.3 – 0.4 0.4 – 0.5 0.5 – 0.6 0.6 – 0.7	1.00 0.75 0.50 0.25	
12	Service Ratio Index		0.00- 0.25 0.25 – 0.50 0.50 – 0.75 0.75 & Above	0.25 0.50 0.75 1.00	
13	Parking Accessibility Ratio		0.00- 0.25 0.25 – 0.50	0.25 0.50	

			0.50 – 0.75 0.75 & Above	0.75 1.00	

5.2 Analysis of Indices

The analysis of indicators shows the relative performance of the wards with regard to that parameter. The analysis of indices keep inside deep to know the actual performance of the wards too and indicates how these wards performing against absolute benchmarks.

5.2.1 Land use Index:

Table 5-3. Land Use Ranking

Ward No.	**15**	**15Ex**	**18**	**19**	**20**	**21**	**23**	**24**
Land use								
Commercial	14.70	20.34	37.62	16.71	13.57	21.99	41.77	40.02
Residential	13.14	21.49	29.00	32.96	38.74	43.70	16.39	13.66
Cultural	1.07	1.62	0.59	0.02	0.07	0.02	0.00	8.26
Institutional	3.96	4.24	0.00	2.18	0.00	0.00	1.19	0.03
Educational	0.68	1.19	0.00	3.08	1.55	0.86	1.48	0.91
Services	0.07	0.12	0.47	0.26	0.00	0.00	1.95	0.56
Public Open	37.38	17.97	3.09	5.52	3.30	1.97	4.13	8.73
NP Open	5.48	3.72	3.09	14.00	24.39	8.64	4.13	5.35
Area of Road (SQM)	23.53	29.31	26.13	25.27	18.37	22.81	28.96	22.49
Sum	100	100	100	100	100	100	100	100
Ranking	1.00	0.75	0.50	0.75	1.00	0.75	0.25	0.25

Land use index is based on the concept that lesser the commercial activities, area perform better for their residents. As the analysis is based on ward population only and not considering the day time population the less commercial activities is preferable for residents. The equal interval approach based on maximum minimum rule is applied for the analysis. The better mixing of land use classes are the key of efficient planning. More commercialisation require more infrastructure. As for as the area of study is concern this area is setup as mixed use settlement with residential as main land use. The infrastructure i.e. roads and the services are only efficient when the level of commercialisation is restricted to a level. The ranking of land uses are based on less commercial activities as higher priority wards. As less commercial means to be less traffic jams, less noisy and more comfortable environment for local residents.

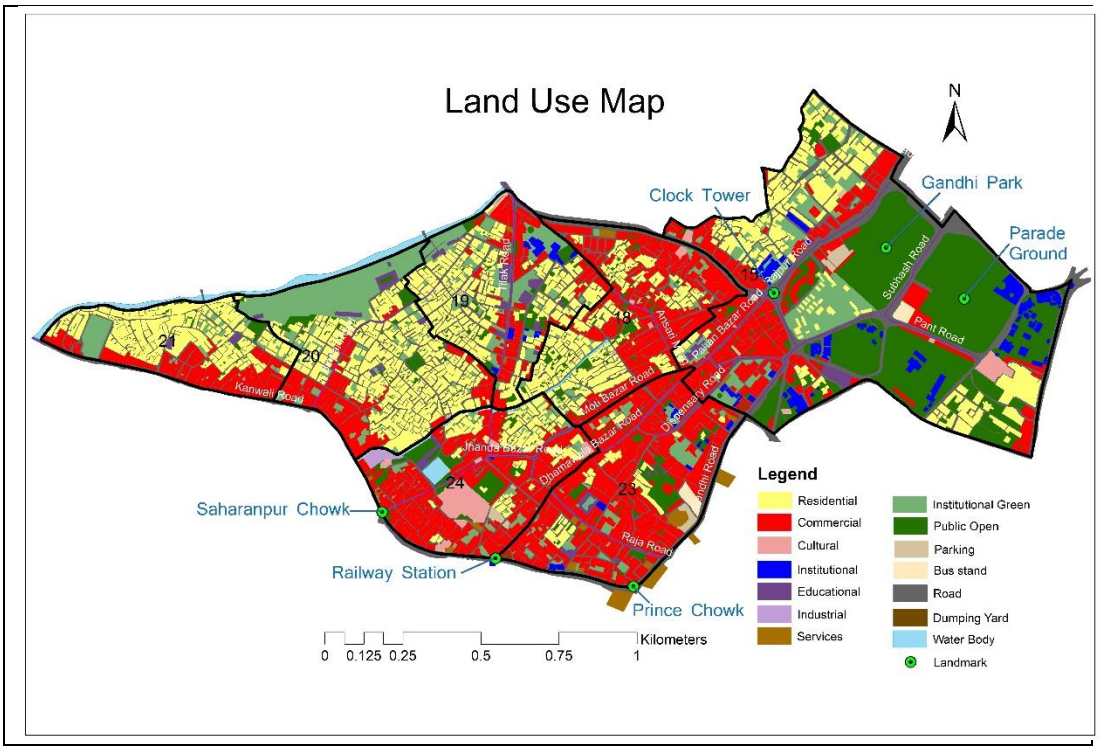


Figure 5.1 Land Use Map of the Study Area

5.2.2 Land Use mix Ratio:

Table 5-4 Land Use Mix Ratio

W. N.	Com.	Res.	Cul.	Inst.	Edu.	Serv.	Green	Mix Index
15	121385	108471	8830	32678	5629	545	353827.20	0.62
15EX	121385	108471	8830	32678	5629	545	102355.40	0.73
18	94402	70058	1482	0	0	1174	17036.98	0.51
19	41218	81301	50	5381	7585	649	48134.92	0.67
20	39879	119818	207	0	4568	0	81393.94	0.56
21	37310	74141	38	0	1459	0	18002.00	0.52
23	148214	13532	0	3302	4103	5422	22990.88	0.46
24	92767	31667	19145	67	2105	1289	32637.32	0.66

Higher the mix ratio the better mixing of land uses. The performance of a ward is describes in the form of weight gained by a particular ward.

Table 5-5 Ranking of Land Use Mix

Ward	15	15EX	18	19	20	21	23	24
Mix Ratio	0.62	0.73	0.51	0.67	0.56	0.52	0.46	0.66
Ranking	0.75	1.00	0.50	0.75	0.50	0.50	0.25	0.75

The mixing of the land uses should be promoted in the context of fuel efficiency, energy saving and simultaneously avoiding the traffic jams. The availability of the goods and services in the neighbourhood is necessary and the efficient planning tool. The segregation of land uses as promoted in late 20th century is ended up to traffic jams, less social security, safety and security of the residents. The mixing of uses is very ancient tool of planning forgotten in last century and now reviving again. The higher the ratio of mixing the better mix of land uses in the area and the areas are more efficient than any other. The ward 18 missing the educational and institutional facilities performing in mix table but the location of the ward is such that the educational and the institutional services accessed by the residents of nearby

wards. The ward 21 lacking in terms of services for example parking spaces and clinics. The ward 21 is the concern of development of public services. Ward 20 is not having institutional setups so the performance is lower but the absence of institutions is not a big concern as for as the primary services are provided. Although the ratio of mix is a categorising mechanism, the other categories are provided to classify the ratios on the basis of broad categories for primary regeneration activities.

5.2.3 Space Use Mix Index

Table 5-6 Space Use Index

Ward No.	Com.	Res.	Edu.	Public Green	Institutional Green	A	Ln5	Space use index
15	168440	224369	14062	308590.73	45236.47	-1.44	1.609	0.90
15Ex	119448	184085	14062	84803.93	17551.47	-1.21	1.609	0.75
18	162772	180179	0	9326.87	7710.11	-0.84	1.609	0.53
19	65528	189101	13932	13603.00	34531.92	-1.08	1.609	0.67
20	64813	259137	139915	9703.76	71690.18	-1.28	1.609	0.80
21	39698	208240	2508	3343.74	14658.26	-0.73	1.609	0.46
23	325157	81183	10946	11495.44	11495.44	-0.87	1.609	0.54
24	165489	106633	2478	20243.73	12393.59	-1.04	1.609	0.65

Table 5-7 space use Mix Ratio Ranking

Ward	15	15EX	18	18	20	21	23	24
Mix Ratio	0.90	0.75	0.53	0.67	0.80	0.46	0.54	0.65
Ranking	1.00	0.75	0.25	0.50	0.75	0.25	0.25	0.50

The space use mixing of different uses in the wards shows actual situation of the uses at different floor locations in 3D environment. The space use is the key to know the actual mode distribution of the space and helps in prediction of the requirement of the infrastructure and

road, parking services and the educational facilities. Space use also helps in calculation of taxes and the rate of properties. It provides better understanding of the uses.

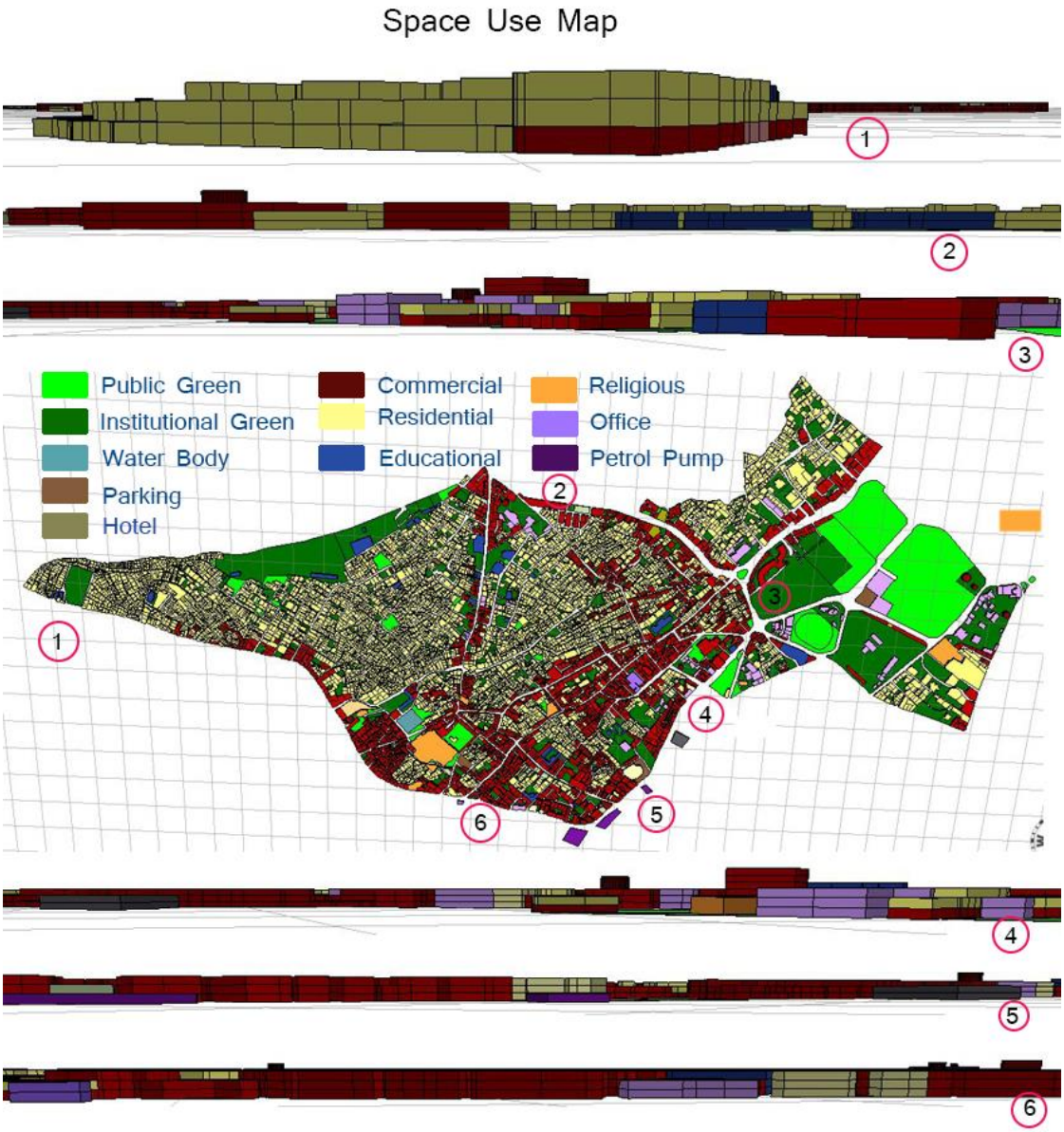


Figure 5.2. Space Use Map

5.2.4 Per-capita Total Green

The per capita total open/ green spaces availability in the area is very low except the ward no. 15 clock Tower, and the ward no 20 Khurbura all the other wards lacking too much. Clock Tower ward having large consolidated spaces the pared ground and the Gandhi Park. These

spaces are of regional nature used by the whole city and the government using these spaces for other purposes such as mela, rallies and for political and regional functions. The Gandhi Park is a regional park mostly used by the visitors during day time and morning walkers in the morning. The ward 15Ex representing the area of ward 15 excluding the regional open spaces, it shows quiet good amount of other total open space but not as much as it seems initially. Khurbara having a large open at the bank of river Bindal and that space is mostly comes under the supervision of two schools at that area and some part as government land but not developed. The others are categorise for the purpose of comparative study although that are not sufficient for public heath purposes. These per capita values reducing further to some extent as a large number of floating population visiting these areas regularly during the day. The most affected ward is the ward no. 21 Shivaji Marg. In ward 21 no open spaces seen either of public nature or private nature.

Table 5-8 Per-capita Total Green/Open

Ward NUM.	WARD NAME	Total Green Area	WARD POP.	Per-capita T. Green	Ranking
15	Clock Tower	353827.20	5341	66.25	1.00
15EX		102355.40	5341	19.16	1.00
18	Kalika Mandir Marg	17036.98	5326	3.20	0.40
19	Tilak Road	48134.92	8687	5.54	0.40
20	Khurbura	81393.94	7374	11.04	0.80
21	Shivaji Marg	18002.00	10237	1.76	0.20
23	Dhamawala	22990.88	5295	4.34	0.40
24	Jhanda Mohalla	32637.32	6727	4.85	0.40

These per capita total open spaces maintain the local climate and temperature of the area. The urban heat island effect is quite visible in the area. If these areas further reducing than the heat island effect is going to be adverse.

5.2.5 Per-capita Public Green

The public green areas are the areas of open to all nature. These spaces used as play areas by children, walking areas for elderly population and also used for local functions by the residents of the area. These areas directly related to public health. The public open spaces are further reduced compared to the total open spaces per capita. Most of the wards having per-

capita open spaces between 1 and 2 square metre. It is necessary to preserve and try to enhance the open spaces by clearing unauthorised structures present at some locations. As the per-capita public open spaces reducing the quality of life of the residents also reduced significantly.

Table 5-9 Per-capita Public Green/Open

Ward Num.	Ward Name	Public Open	Ward POP.	Per-capita P Green	Ranking
15	Clock Tower	308590.73	5341	57.78	1.00
15EX		84803.93	5341	15.88	1.00
18	Kalika Mandir Marg	9326.87	5326	1.75	0.20
19	Tilak Road	13603.00	8687	1.57	0.20
20	Khurbura	9703.76	7374	1.32	0.20
21	Shivaji Marg	3343.74	10237	0.33	0.10
23	Dhamawala	11495.44	5295	2.17	0.30
24	JhandaMohalla	20243.73	6727	3.01	0.40

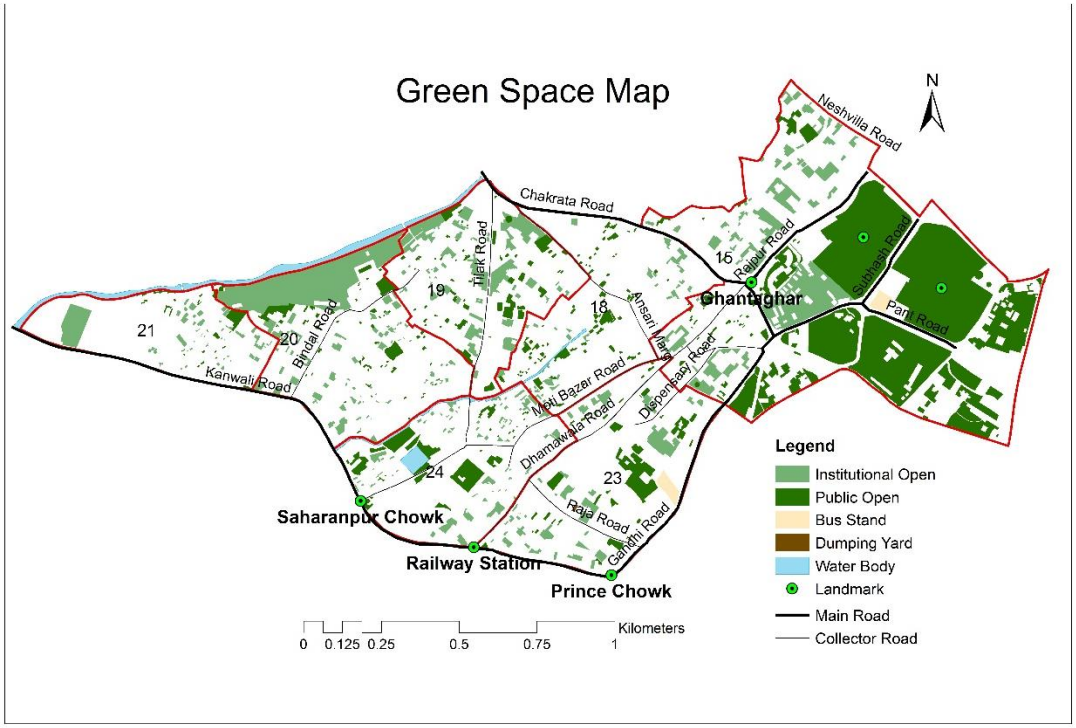


Figure 5.3. Green Space Map

5.2.6 Percent Total Green

The percent total green is the percentage of geographical area of the open spaces in the ward to the total ward area. This is the primary concern of the urban planners as the change in the geographical area of the ward having effect on the per-capita openness of the area. Clock tower having large open spaces in the form of pared ground and Gandhi Park, Tilak Road having some institution open spaces as theirs are offices and schools exists. Khurbura having large open space at river bank used by schools and undeveloped land of government. Jhanda mohalla having some open spaces in the form of Garden under the trust of Gurudwara. Most of these spaces are either regional or just used by institutions that are not open to public so the public open spaces are very low. Dhamawala the most commercialised ward having very little open areas and the areas available are used as unauthorised parking spaces making it zero effective open space in the ward. Shivaji Marg having some areas that are not developed and utilised by the persons for unauthorised actives.

Table 5-10 Percent Total Green

Ward Num.	Ward Name	Ward Area	Total Green Area	Percent Total Green	Ranking
15	Clock Tower	822284.22	353827.2	43.03	1.00
15EX		479465.32	102355.4	21.35	0.60
18	KalikaMandir Marg	241240.15	17036.98	7.06	0.20
19	Tilak Road	239242.92	48134.92	20.12	0.60
20	Khurbura	294377.09	81393.94	27.65	0.60
21	Shivaji Marg	171022.41	18002	10.53	0.40
23	Dhamawala	298879.87	22990.88	7.69	0.20
24	JhandaMohalla	243127.16	32637.32	13.42	0.40

In terms of geographical area of open spaces either not available in significant amount or utilised for parking and other commercial activities or undeveloped and utilised for unsocial activities. So the need of time is to develop the undeveloped or under developed open areas in some wards, on their hand open areas in some wards to be freed from parking and other commercial activities and provide to use by the local dwellers.

5.2.7 Road Density (Area Wise)

Too much or too less road is not better example for a sustainable and quality living scenario. In the case of ward 15 less road signifies the large open spaces or the property sizes that are bigger compared to other wards. It is seen during the site visits that the area having bigger houses and houses with open spaces with in their plot limits. Simultaneously the large regional open spaces and the regional park exists in the area. On the other hand to much road length in the ward 21 shows the dense built setups with less open spaces and the smaller size of dwellings. So apparently the length of the road per geographical area represents the socio economic condition of the residents.

Table 5-11 Road Density (Area Wise)

Ward No.	Ward Name	Ward Area(sq. km)	Road Length	Road Density(G)	Ranking
15	Clock Tower	0.82228422	20.37283	24.78	0.50
15EX		0.47946532	15.8843	33.13	0.50
18	Kalika Mandir Marg	0.24124015	14.04367	58.21	0.50
19	Tilak Road	0.23924292	13.86091	57.94	0.50
20	Khurbura	0.29437709	14.12763	47.99	1.00
21	Shivaji Marg	0.17102241	10.88147	63.63	0.50
23	Dhamawala	0.29887987	14.64754	49.01	1.00
24	JhandaMohalla	0.24312716	11.94892	49.14679216	1.00

As it is clear with its relation to socio economic condition too much or too less road length compared to other wards is not a good scenario and getting less ranking than the medium range wards. The more road length in a particular geographic area sometimes ended in narrower roads that are not very traffic and commuter friendly. On the other hand the ward with less road having chances of wide roads and due to bigger property sizes and higher living styles these wads are not fuel efficient. The road length per geographical area apparently also signifies the population density of the wards less road length signifies less population density and the more road length signifies more population density.

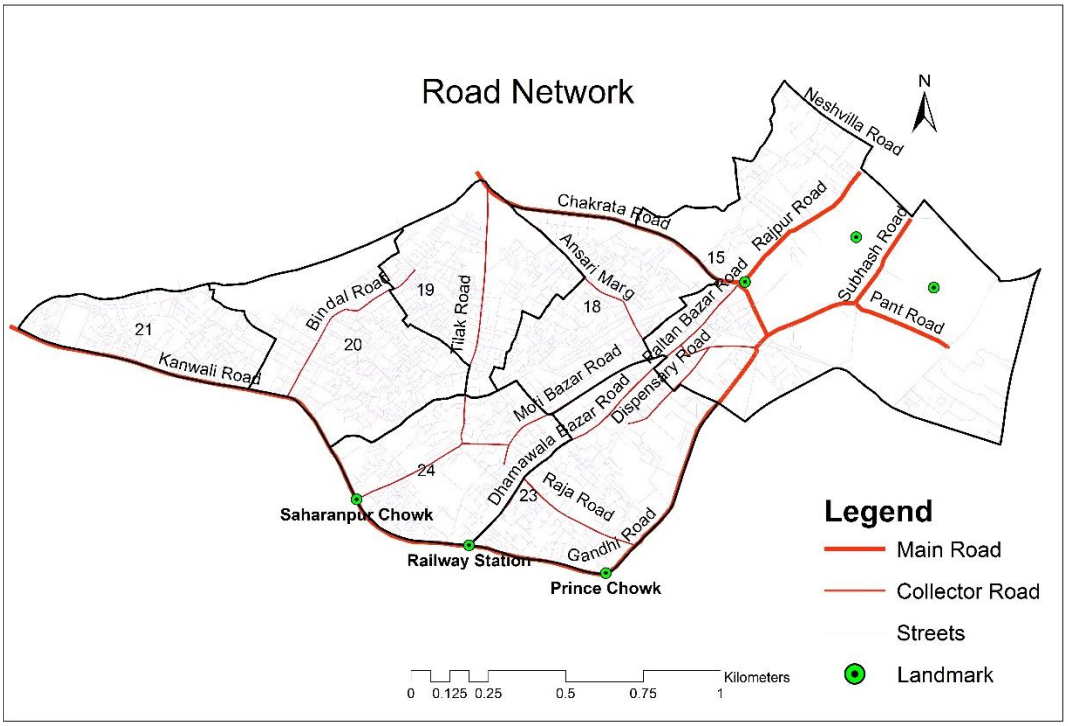


Figure 5.4. Road Network Map

5.2.8 Road Density (Population Wise)

The road length density with respect to population of the ward having direct relation to the quality of life. The higher road density as per population ensures smooth traffic, higher traffic speed and less possibility of jams. The ward 15, Clock Tower performs very high in the analysis so if assuming no or very less floating population using these roads than sufficient roads in the ward and traffic jams or less vehicle speeds are not problems anymore. As for as this area is regional hub very large number of floating population using these roads and then the effective road density per population is decreasing very significantly. The data of the floating population is not available so the study restricted to the analysis based on the actual ward population. The other wards having higher density are very good for movements when the floating population is not present during night hours or in the early morning. During day the floating population the effective density is reduced significantly and it turn in to slow moving traffic and jams. The ward 21 having least road density as per population makes it less comfortable to use the roads.

The comparative study of the road densities as per geographical area and as per population density provides the information about social and economic condition of the area. The living conditions, traffic and transport utilities the services and the immediate environment, the rate

of properties, the availability of education and health facilities understandable by comparative study of these two indices.

Table 5-12 Road Density (Population wise)

Ward No.	Ward Name	Ward Pop.	Road Length (m)	Road Density(P)	Ranking
15	Clock Tower	5341	20372.83	3.81	1.00
15EX		5341	15884.3	2.97	0.75
18	KalikaMandir Marg	5326	14043.67	2.64	0.75
19	Tilak Road	8687	13860.91	1.60	0.50
20	Khurbura	7374	14127.63	1.92	0.50
21	Shivaji Marg	10237	10881.47	1.06	0.50
23	Dhamawala	5295	14647.54	2.77	0.75
24	JhandaMohalla	6727	11948.92	1.78	0.50

5.2.9 Per-capita Road Area

Table 5-13 Per-capita Road Area

Ward No.	Ward Name	Area of Road(SQ M)	Ward Pop.	Per-capita Road Area	Ranking
15	Clock Tower	194227.08	5341	36.37	1.00
15EX		138324.308	5341	25.90	0.75
18	Kalika Mandir Marg	65138.99	5326	12.23	0.50
19	Tilak Road	62330.049	8687	7.18	0.25
20	Khurbura	53986.876	7374	7.32	0.25

21	Shivaji Marg	38702.09	10237	3.78	0.25
23	Dhamawala	80522.31	5295	15.21	0.50
24	Jhanda Mohalla	52145.507	6727	7.75	0.25

The area of road per person is the actual space on the road the commuters getting. This is directly related to the width of the roads. The lesser the road area per person signifies the modes of transport in the area is smaller vehicles or pedestrians otherwise it is direct invitation to the traffic jams.

Table 5-14 Relative Analysis of Per-capita Road Area and Road Density

Ward No.	Ward Name	Per-capita Road Area	Road Density (P)	PCRA/RD
15	Clock Tower	36.37	3.81	9.54
15EX		25.90	2.97	8.72
18	KalikaMandir Marg	12.23	2.64	4.63
19	Tilak Road	7.18	1.6	4.48
20	Khurbura	7.32	1.92	3.81
21	Shivaji Marg	3.78	1.06	3.56
23	Dhamawala	15.21	2.77	5.49
24	JhandaMohalla	7.75	1.78	4.35

The relative study of road density as per population and the road area per-capita directly giving the scenario of the width of roads. It depicts the highest road width in the ward 15 Clock Tower. The other wards such as kalika Mandir Marg, Tilak Road Dhamawala and jhanda Mohalla having good with of roads but these roads are the level 2 roads compared to Clock Tower ward. The other wards such as Shivaji Marg and Khurbura having comparatively narrower roads.

5.2.10 Population Density

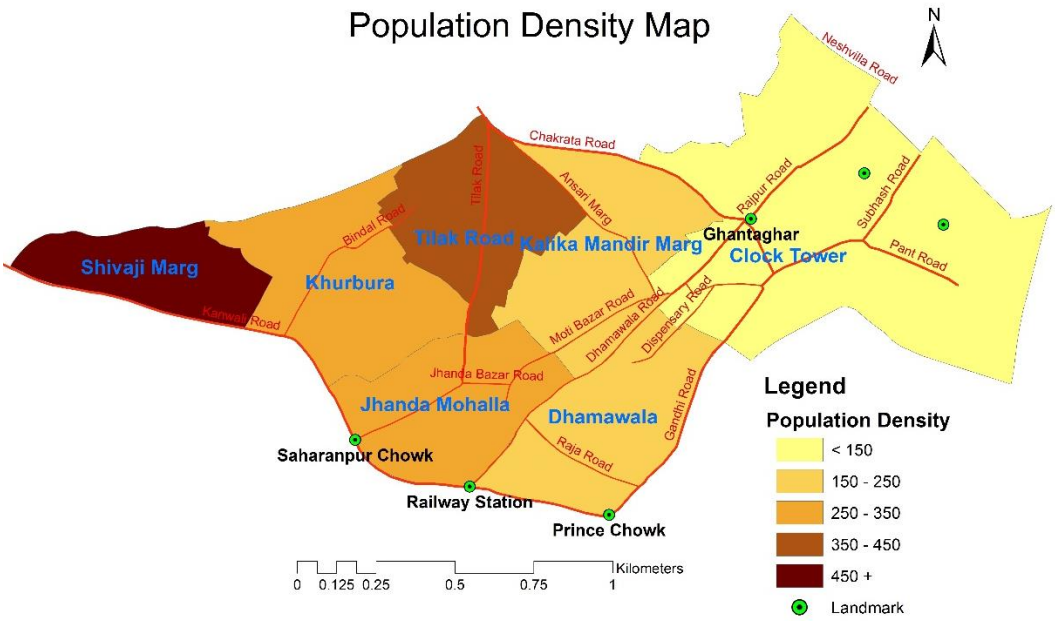


Figure 5.5. Population Density Map

Population density is an important parameter for urban studies. The amount of regeneration measures are mostly depends on the density of population.

The medium density settlements are more sustainable as the load on the resources is not too much and at the same time not so disperse and energy hungry. Based on this the wards with medium densities Tilak Road given higher priority and the wars with more or less dense than a medium dense settlements are given less priority.

Table 5-15. Population Density of the Area

Ward No.	Ward Name	Ward Pop.	Ward Urban Area	Urban Density	Ranking
15	Clock Tower	5341	50.24	106.31	0.50
18	KalikaMandir Marg	5326	23.92	222.66	0.75

19	Tilak Road	8687	24.12	360.16	1.00
20	Khurbura	7374	23.26	317.02	1.00
21	Shivaji Marg	10237	16.22	631.13	0.50
23	Dhamawala	5295	29.89	177.15	0.75
24	JhandaMohalla	6727	23.88	281.70	0.75

5.2.11 Built-up Density

Built-up density shows the foot print of the built masses. Higher built-up density signifies less availability of the land for further development. It also signifies the amount of impervious surface and accordingly need of water harvesting. It is directly related to the urban heat island effect. The built-up density of Dhamawala and Tilak Road is very high compared to other wards in the region and the Clock tower ward is very low in terms of the built-up density as is comprises large amount of regional open spaces.

Table 5-16 Built-up Density

Ward No.	Ward Name	Built-up	Ward Area	Built-up Density	Ranking
15	Clock Tower	279576.63	822284.22	0.34	1.00
15EX	Kalika Mandir Marg	230143.35	479465.32	0.48	0.75
18	Tilak Road	166455.70	241240.15	0.69	0.25
19	Khurbura	136368.46	239242.92	0.57	0.50
20	Shivaji Marg	158963.63	294377.09	0.54	0.50
21	Dhamawala	112874.79	171022.41	0.66	0.25
23	Jhanda Mohalla	173350.32	298879.87	0.58	0.50
24		145876.29	243127.16	0.60	0.50

5.2.12 Parking Accessibility:

Parking seems major problem in the region. For the concept of Pedestrianisation authorities needs adequate parking in amount, number as well as their spatial location. The spatial location analysis shows that most parts of the study areas not covered under the 400 metre walkable distances. The location of some major parking lot is such that the user has to cross the heavy traffic nodes to access the market area so the areas requires under passes or foot over bridges. One location is the parking of private nature as it belong to the hotel Drona so at present the area comes under the this parking buffer (ward number 23 Dhamawala) is really lacking the parking requirement. At the same time most of the parking lots are smaller than the required capacity. The basement parking of the Rajiv Gandhi Complex is not used at full extent because of inadequate lighting and security arrangements. The old bus stand plot having capacity to use as multilevel parking above the ground. The basement parking are not so much usable as the city markets shut down earlier and the user community of the parkingnot feeling secure to use the basement parking.

Table 5-17. Parking Accessibility Map

SN	Ward Number	Ward Name	400m Accessibility Ratio of Parking	ranking
1	15	Clock Tower	0.89	1.00
2	18	KalikaMandir Marg	0.71	0.75
3	19	Tilak Road	0.98	1.00
4	20	Khurbura	0.53	0.75
5	21	Shivaji Marg	0.00	0.00
6	23	Dhamawala	100	1.00
7	24	JhandaMohalla	0.97	1.00

Some wards performing very good in terms of positional or spatial allocation of parking simultaneously some wards are performing very poor too. The Dhamawala although showing 100 coverage but the specified parking is not accessible to all and even not sufficient in terms of number of parking lots. The location of parking are also not adequate as after parking people have to cross the busy road junctions, that slowing the traffic and may cause the accidents. That areas are identified during field survey. These areas need pedestrian over bridges or under pass for pedestrian or need under pass for vehicles and pedestrian keep walking on the surface.

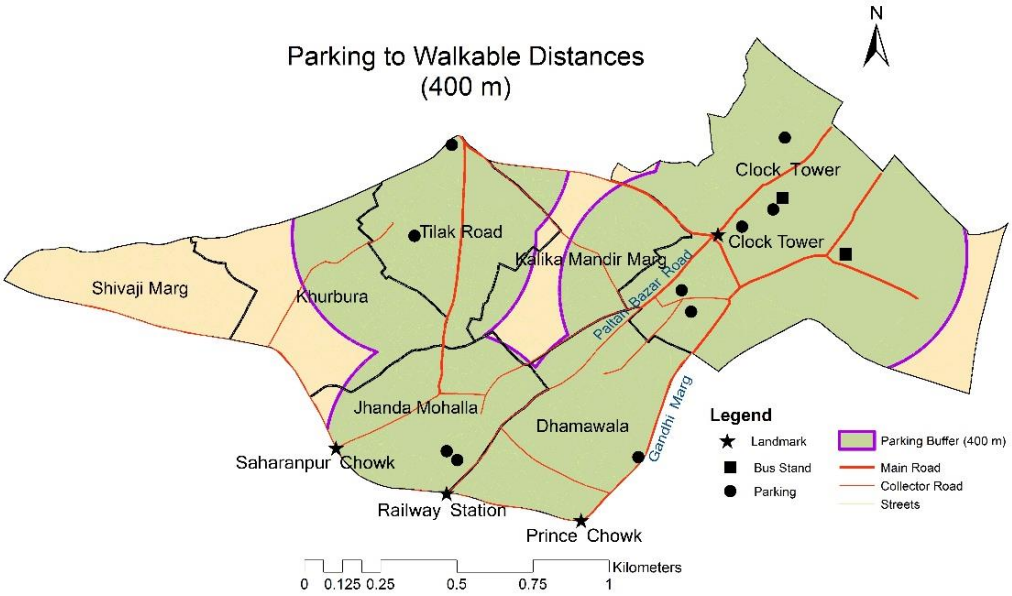


Figure 5.6. Parking to Accessibility Areas Map

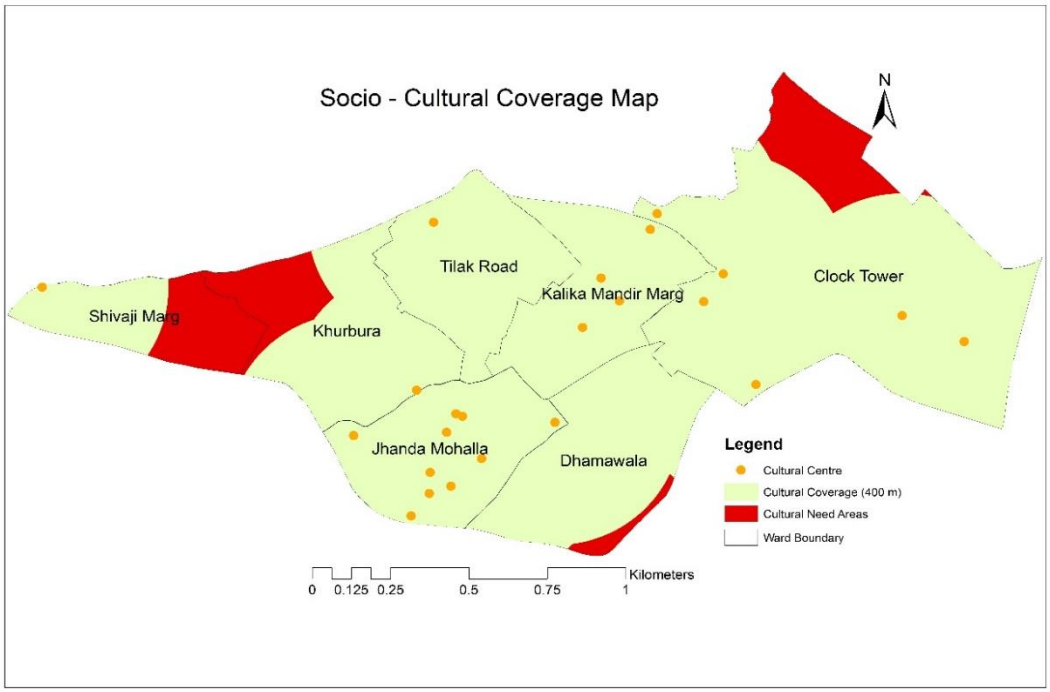


Figure 5.7. Socio-Cultural Coverage

5.2.13 Service Ratio:

Table 5-18 Socio- Cultural Ranking

SN	Ward Number	Ward Name	Area covered under 400m buffer of Cultural Areas	Ranking
1	15	Clock Tower	87.38%	0.75
2	18	KalikaMandir Marg	100%	1
3	19	Tilak Road	100%	1
4	20	Khurbura	76.44%	0.5
5	21	Shivaji Marg	53.04%	0.25
6	23	Dhamawala	99.67%	1
7	24	Jhanda Mohalla	100%	1

The services identified are the socio-cultural activity centres 400 metre buffer taken of the socio-cultural activity centres. Ranking is based on the percentage coverage of the area of the ward.

5.3 Multi Criteria Evaluation:

The multi criteria decision mechanism is applied for the final indexing of the criteria's. In the process of evaluation all the indices used for the study placed in a matrix format and the relative weights are identified based on the saaty's scale of relative importance. Reciprocals of that weights assigned are placed on the other axis. The sum of reciprocals axis calculated first than by dividing all the vales with the sums of column normalised weights are identified. The sum of the values of rows and dividing them by the number of indices the average values are come that average values are the weights. (Table shown in Annex.)

Than to check the consistency of the weights the values of weights are multiplies in the original pairwise comparison matrix. The first weight multiplies to the first column, the second to the second column and so on. Than taken sum of all the values in row and dividing the sum by the respective weights consistency vector is obtained. Than the average value of consistency vector calculated that isλ. Than consistency Index (CI) is calculated

Table 5-19 Multi-Criteria Evaluation Weights

Indices	Weight
Per Capita T Green	0.154
Per Capita P Green	0.206
Percentage T Green	0.063
Land Use Mix Ratio	0.137
Road Density (Geo.)	0.033
Road Density (Pop.)	0.042
Per capita Road Area	0.017
Urban Density	0.077
Land Use Ratio	0.019
Built-up Density	0.031
Service Ratio Index	0.050
Parking Acc. Ratio	0.058
Space Use Mix Ratio	0.112

CI = (λ-n)/ (n-1), where n is the number of indices. Than consistency ratio is calculated

CR = CI/RI.

The value of RI is taken from the table given by Satty. For n=13 the RI is 1.56.

The values obtained are λ = 13.80543

CI = (13.80543 - 13)/ (12) = 0.067119

RI = 0.067119/ 1.56 = 0.043025 < 0.1, so the values are consistent.

5.4 Regeneration Index

The weights obtained are consistent and used for the final weight calculation. The final weights are calculated but multiplying the values to the respective weight of the class and summing all the multiples. The final weight calculated over the wards are showing the need of regeneration in some wards.

$$RIi = \sum_{i=1\ j=1}^{i=7, j=13} W_j * P_i$$

Here

$RI_i = Regeneration\ Index\ of\ ith\ ward$

$W_j = Weight\ of\ the\ Parameter\ j$

$P_i = Value\ of\ the\ parameter\ at\ ith\ ward$

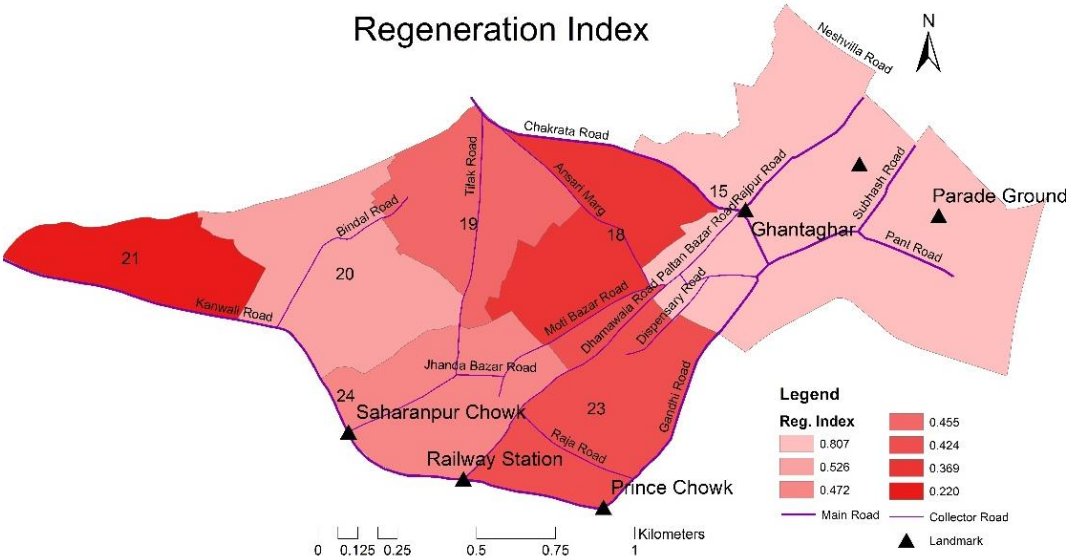


Figure 5.8. Regeneration Index

Table 5-20. Regeneration Index

Ward No.	Ward Name	Regeneration Index
15	Clock Tower	0.807
15EX		0.721
18	Kalika MandirMarg	0.368
19	Tilak Road	0.454
20	Khurbura	0.526
21	Shivaji Marg	0.219
23	Dhamawala	0.423
24	JhandaMohalla	0.471

The wards having low values of final indices need more regeneration activities with regard to the indicators of the study. The maximum value of regeneration index is for the Clock tower ward and it perform very well. The study limited to the actual population of the wards. Due to un-availability of the floating population data the actual infrastructure need of highly

commercialised wards may be considered to some less extent in the indices based calculations.

Table 5-21.Stastical analysis of Regeneration Index

Static	**value**
Count	7.000
Sum	3.268
Mean	0.466
Median	0.454
Minimum	0.219
Maximum	0.807
Range	0.588

The ward 21 Shivaji Marg performing very poor and the ward 15 Clock tower performing very well. It is clear that the day time floating population is not considered for the Regeneration Index calculation. If it is considered the performance of the Clock tower ward changes significantly. The Range between maximum and minimum values are very high it indicates high difference in the level of infrastructure and services among these wards.

4 wards out of the seven are performing below the mean and need the immediate regeneration. The ward Shivaji Marg (0.219) lacking in most of the aspects, having poor infrastructure and services. The quality of life and the level of hygiene is not satisfactory. The ward having to highest density not only compared to the other wards under study but whole Dehradun municipal corporation area. This ward lacking in per capita road area and performing better in per-capita road it signifies the roads are very narrow. This ward also having very low open spaces and the public services i.e. hospitals and schools.

Kalika Mandir Marg (0.368) ward is also need the regeneration very much. This ward performing low on services and the parking. The kalika mandir ward missing the educational facilities within the ward. So it scores very less at some points. Although the adjacent wards having the facilities and due to adjacency the ward able to access the facilities.

Dhamawala (0.423) having large amount of commercial activities have low score compared to other wards as the assigned weight to much commercial is low. The ward because of commercial activities facing problem of traffic jams and low speed of traffic problems.

The Clock Tower wards performance is seen well because of low population density large open areas and comparatively wide roads, but this ward facing large amount of floating population. The road width that are good for residents become very ineffective due to overload of visitors. The ward must be analysed for the traffic volume analysis. The traffic volume analysis data is not available for all the chowks in the wards so the comparative study is not possible because of it traffic volume indicators are not considered for the study.

Table 5-22. Comparission of Green Indicators

Ward NUM.	WARD NAME	Per-capita P Green	Ranking	Per-capita T. Green	Ranking	Percent Total Green	Ranking
15	Clock Tower	57.78	1.00	66.25	1.00	43.03	1.00
15EX		15.88	1.00	19.16	1.00	21.35	0.60
18	Kalika Mandir Marg	1.75	0.20	3.20	0.40	7.06	0.20
19	Tilak Road	1.57	0.20	5.54	0.40	20.12	0.60
20	Khurbura	1.32	0.20	11.04	0.80	27.65	0.60
21	Shivaji Marg	0.33	0.10	1.76	0.20	10.53	0.40
23	Dhamawala	2.17	0.30	4.34	0.40	7.69	0.20
24	Jhanda Mohalla	3.01	0.40	4.85	0.40	13.42	0.40

Khurbura is performing well in per-capita total green although it performing very poor in per-capita public green areas. It signifies khurbura having large green areas but the green areas accessible to public is very low. This ward need the maintenance of its public green areas and the river front development to enhance accessible green areas.

Ward 15 Clock Tower having large city level green areas and because of that it performing very well in terms of green areas but when analysed after excluding the city level green areas the actual green areas area drastically diminished. Although even after exclusion it perform very well in comparison to other wards.

Jhanda Mohalla is performing balanced in terms of per-capita total green as well as public green even in terms of percentage green areas. This ward having low green areas but the population distribution and percentage of total and public green areas is balanced. This balance come through the large green area of the Gurudwara, which is accessible to all.

5.5 Qualitative Indicators:

The analysis of some indicators are not possible on the comparative basis but are very important to discuss. Some of the qualitative indictors need attention in the area of study are age and condition of buildings, universal accessibility parameters, and buildings need retrofitting, architectural character and historical importance of buildings, river front development, solid waste management, need of urban furniture, fixture and public services i.e. public toilets, etc. Although these qualitative indicators are not used final index generation and based on that identification of priority areas for urban regeneration need appropriate interventions. Some of them are discussed below

5.5.1 Need of retrofitting:

During the widening process MDDA demolished existing building in parts hence remaining portion of the building structure was weekend and there is a need of retrofitting and reconstruction. The residents have no option to leave these buildings and they are continued to live there. These buildings if not repaired may cause to life. When authorities demolishing the buildings for public person they should not leave structures in this manner.

Figure 5.9 Buildings needs Retrofiting

Figure 5.10 Unsafe buildings after demolition

5.5.2 Architectural Character (Need of Conservation):

The architectural preservation of buildings and building facades must be carried out to sustain the characteristics of the area. Modification of the uses of these buildings carefully done with the supervision of professionals, instead of demolishing and rebuilding. The facades of these buildings should be maintained. These buildings add a value to the aesthetics of the area. This also useful for future generations to understand the historic character and layers of the city core. Careful intervention make these buildings profitable and only then these buildings are conserved. Some planning regulations also needed to conserve these buildings.

Figure 5.11 Architectural harectoristics

Figure 5.12 Retrofited Buildings

5.5.3 River Front Development

The river Bindal needs revival. The quality of water is so poor that it cannot be used for any purpose. The encroachment or river bed lost its capacity to maintain itself. It may cause flooding in the city at some time in future. As for as the availability of the green areas is very low in the area of study river front development helps to provide the immense open space to walk and recreate. The river front development first require the cleaning of the river, the drainages should not directly merge with the river without any treatment. It enhance the per-capita effective green spaces and further add to the health benefits. River front development stops the tendency of encroachment of river.

Figure 5.13 River Front Need to be Developed

6 CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

GIS acts as good platform for the indicator based analysis. The quantitative parameters are easily analysed through the indicator based regeneration analysis. The indicator based analysis is less subjective. The selection of indicators are important in order to analyse the regeneration process comprehensive in all aspects and provides the adequate results. The indicator based approach is very useful for regeneration studies of different cities. The indicators vary for city to city based on their spatial characters and needs. The indicator based approaches are data intensive and need large amount of data in order to analyse the city parameters. Due to inability of data some important aspects i.e. traffic and transportation parameters are not analysed in the study. Due to unavailability of floating population data the wards that are very commercial in nature or the hub of traffic are not represented truly. These wards i.e. Clock Tower may need regeneration although showing very good in the study performed.

Remote sensing data used for the urban green space extraction, Road network extraction that are directly used for indicator generation. Remote sensing information is very useful for indicator based urban regeneration analysis as it act as base layer provide spatial information and helps in indicator extraction that are spatial. Remote sensing information save time during preparation of land use land cover information and also eliminate the subjectivity of data. The information extracted through field survey easily added to these layers extracted from remote sensing data.

CityEngine easily utilise the GIS data sets as the base layer for rule based 3D modeling. 3D models with colour coded information of different floors showing various space uses are drawn with the help of ESRI CityEngine. Space use maps are very useful for the study of the vertical use patterns of the city. The uses at different level easily identified based on the attribute as well as the colour scheme of 3D model. The Space use maps although used only for the space use mix index calculation having potential uses that may extend to commercial tax calculation, FAR monitoring, vertical space use change monitoring, compensation calculation during hazards such as fire and flooding or earth quake, administrative applications, and visualization.

The regeneration index describes the immediate need of regeneration in some wards that are performing very low in terms of regeneration index.

Due to unavailability of floating population data the analysis of per capita requirement of infrastructure and services may differ and so the wards performance may differ. Due to lack of quantification of qualitative data at large scale the qualitative parameters are not considered in the process of index calculation. The parameters based on economic data are also not considered due to unavailability and limited time. Most of the urban design parameters i.e. façade control, urban furniture and public utilities are also not taken in to account because of

time constraints. The problems related to drainage and water supply are not considered due to unavailability of remotely sensed stereo data sets. Also number of regeneration parameters are required to analyse the area comprehensively but the present study limited to very few parameters so a large number of aspects that need regeneration or decide priority of regeneration are not considered due to data and time constraints.

Finally the recommendations are made based on the study of parameters under consideration, and derived regeneration index. The recommendations are also covering the qualitative considerations that are not used in index calculation but observed during field survey and discussed earlier.

Recommendations:

The following recommendations are made to regenerate the areas which are urgently need regeneration and the analysis of quantitative as well as qualitative parameters:

- To enhance the per-capita requirement of the green areas, the area near the river Bindal should be developed as public open area. The river front development should be done on priority basis to revive and enhance the per capita green spaces and it helps to check the further encroachment over the river bank.
- Roof top greening should be encouraged to maintain the local climate as very low green areas are available.
- A multi Activity centre, activity centre for children with parking facilities should develop at old bus stand site, near prince chowk, as there is need of activity centre for children, multi activity centre and parking facilities.
- The unauthorised constructions should be demolished. To reduce further encroachment over green spaces.
- The per capita road is very low that makes commuters uncomfortable to walk. It became adverse when adding floating population so the Paltan bazar and Dhamawala bazar road should be pedestrianized during shopping hours, only ambulance, fire service and police vehicles are allowed in these streets.
- The major roads need well maintain footpath. The footpath should be established and maintained.
- To communicate with parking needs some commercials setups should be demolished and the new multi storied commercial establishment with parking facilities need to be established.
- Parking should be connected to nearest market areas without conflicting traffic. To maintain hindrance free connection between parking at new complex near Clock Tower to the paltan bazar a pedestrian foot over bridge should be constructed. The subway should be avoided as the roads are empty early during night and the subways become crime zone in the area.
- Others need well maintained foot path.
- To maintain the roads pedestrian friendly the street furniture i.e. dust bins, benches etc. Must be installed and the trees planted on both side of the road where

possible. Some roads oriented in a manner that are exposed to direct solar gain for very less time during the day.

- Informal sector is a part of India's parcel. To legalize them informal market areas should be identified with in available framework.
- The space use map of the area should be prepared, it helps in monitoring and regularising the uses, FAR guidelines of 3 dimensional spaces.
- The firefighting systems should be installed over the areas that are not easily accessible by the fire fighting vehicles.

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APPENDIX

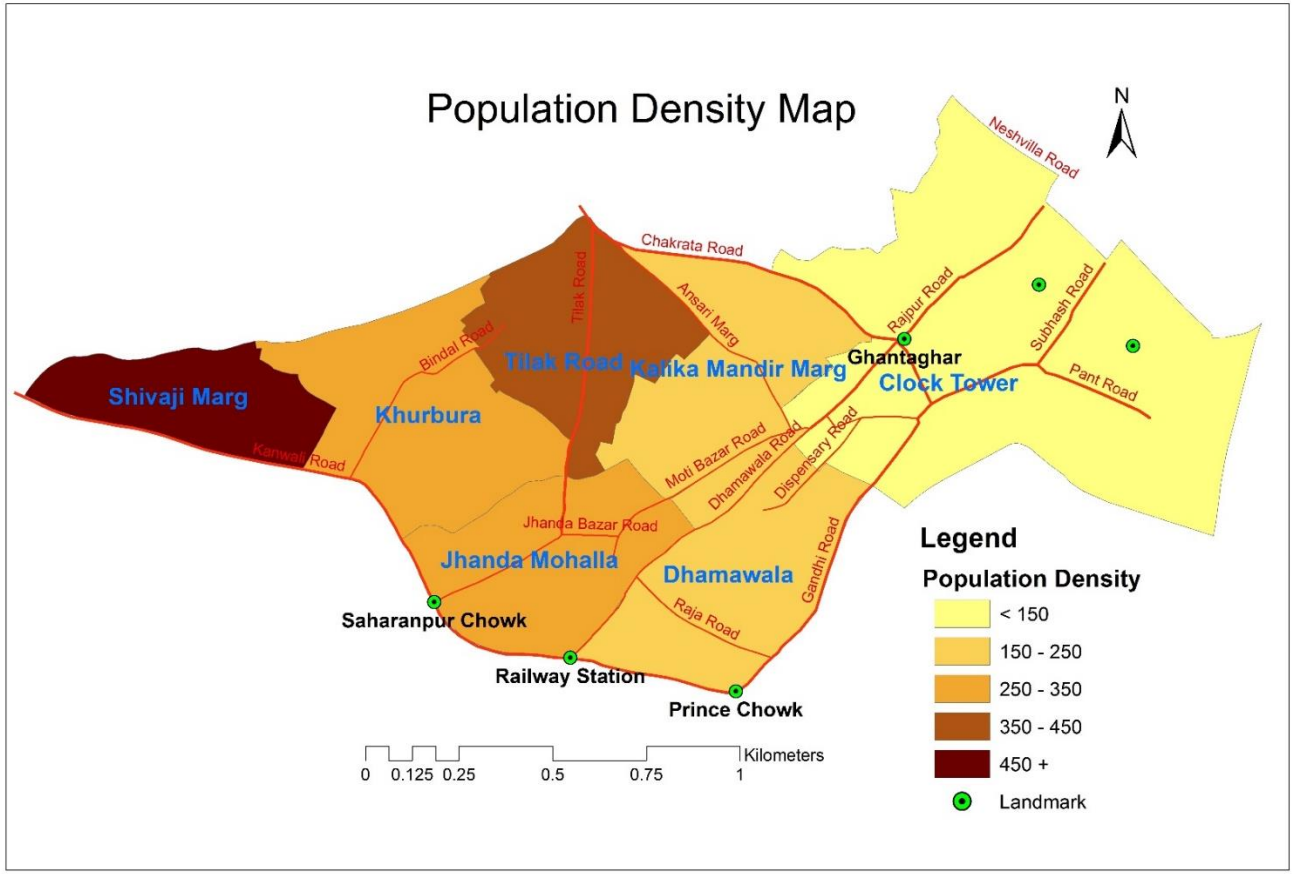


Figure A1.1Population Density Map of City Core, Dehradun

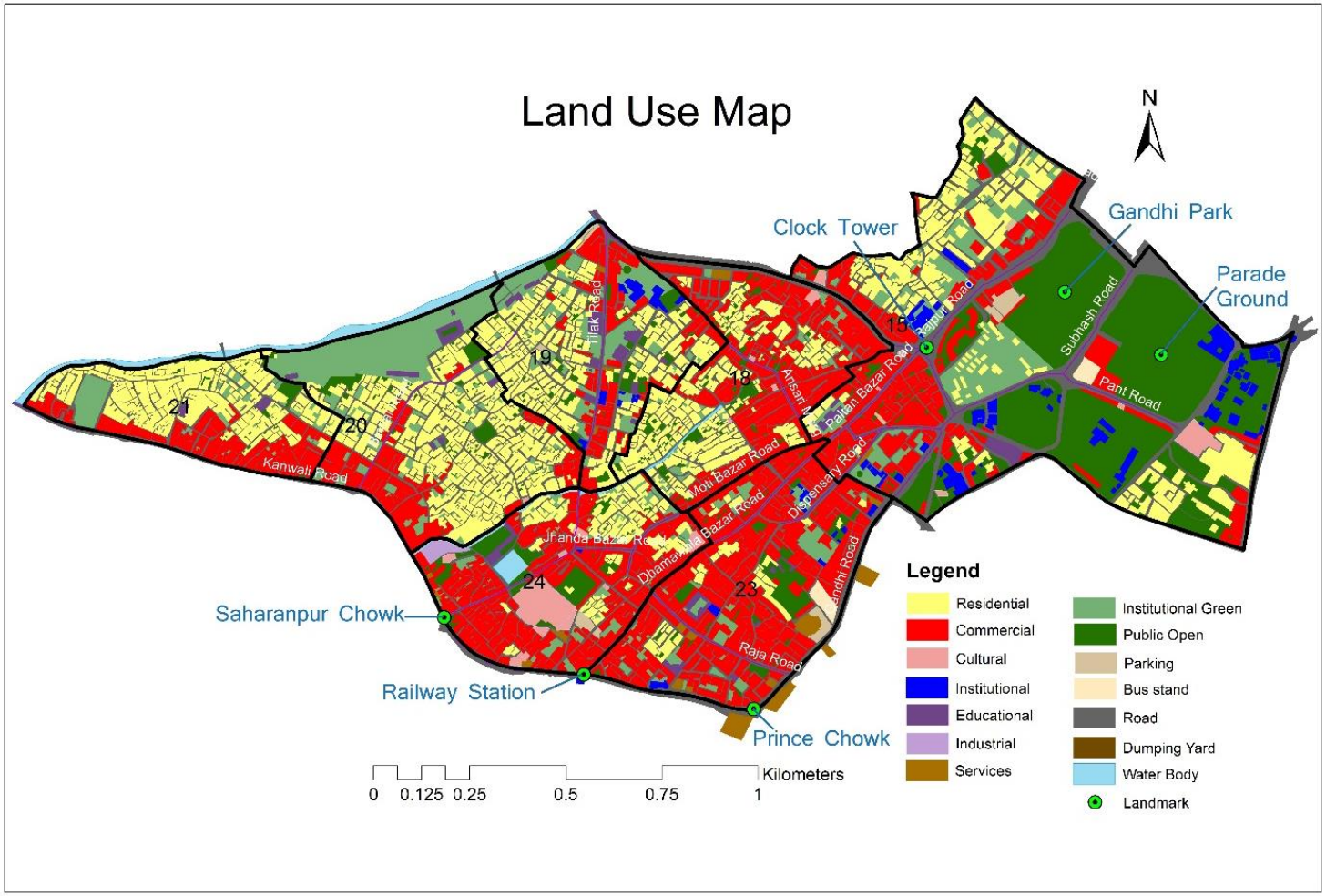
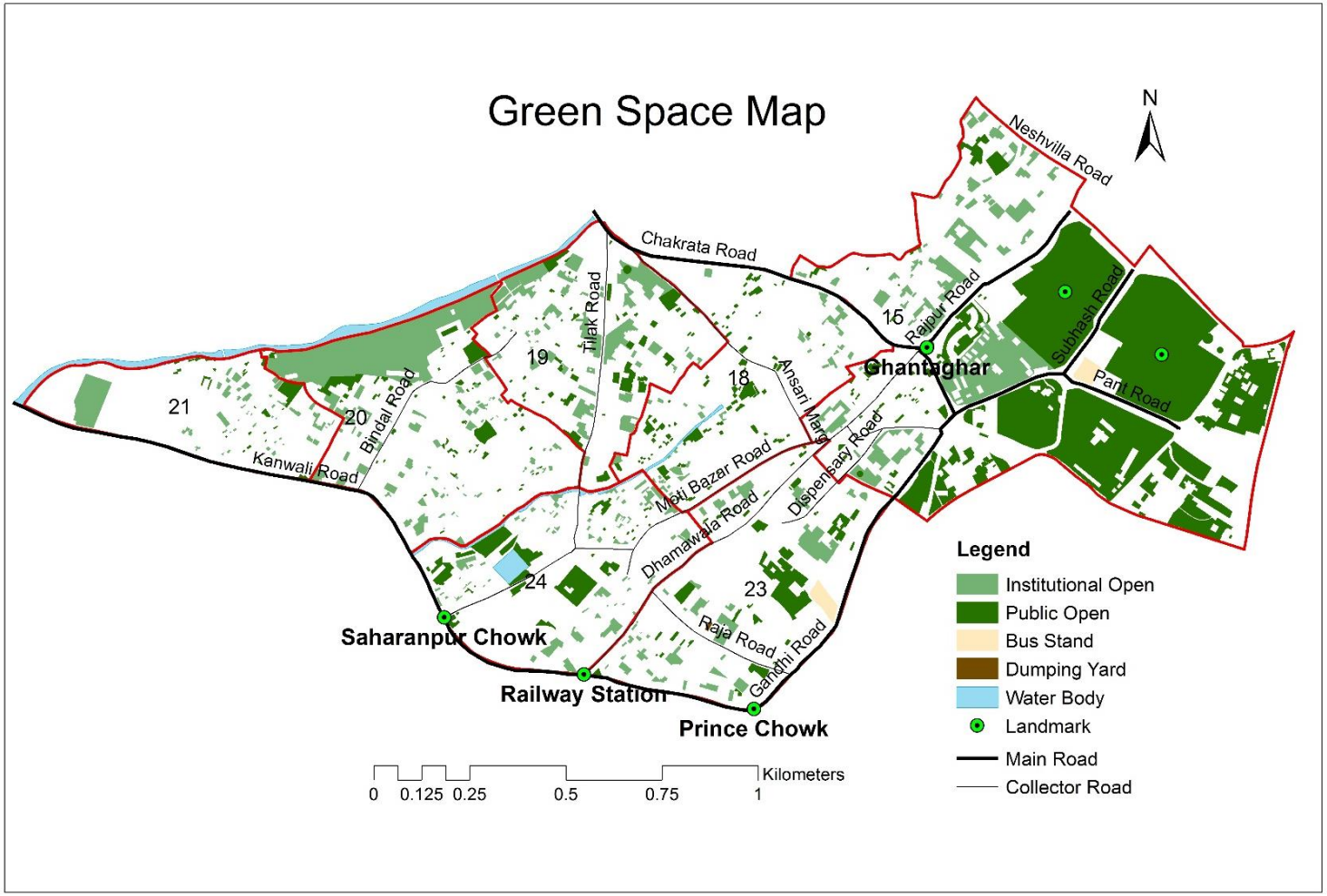


Figure A1.2 Land Use Map of Study Area



FigureA1.3. Green Space Map of City Core, Dehradun

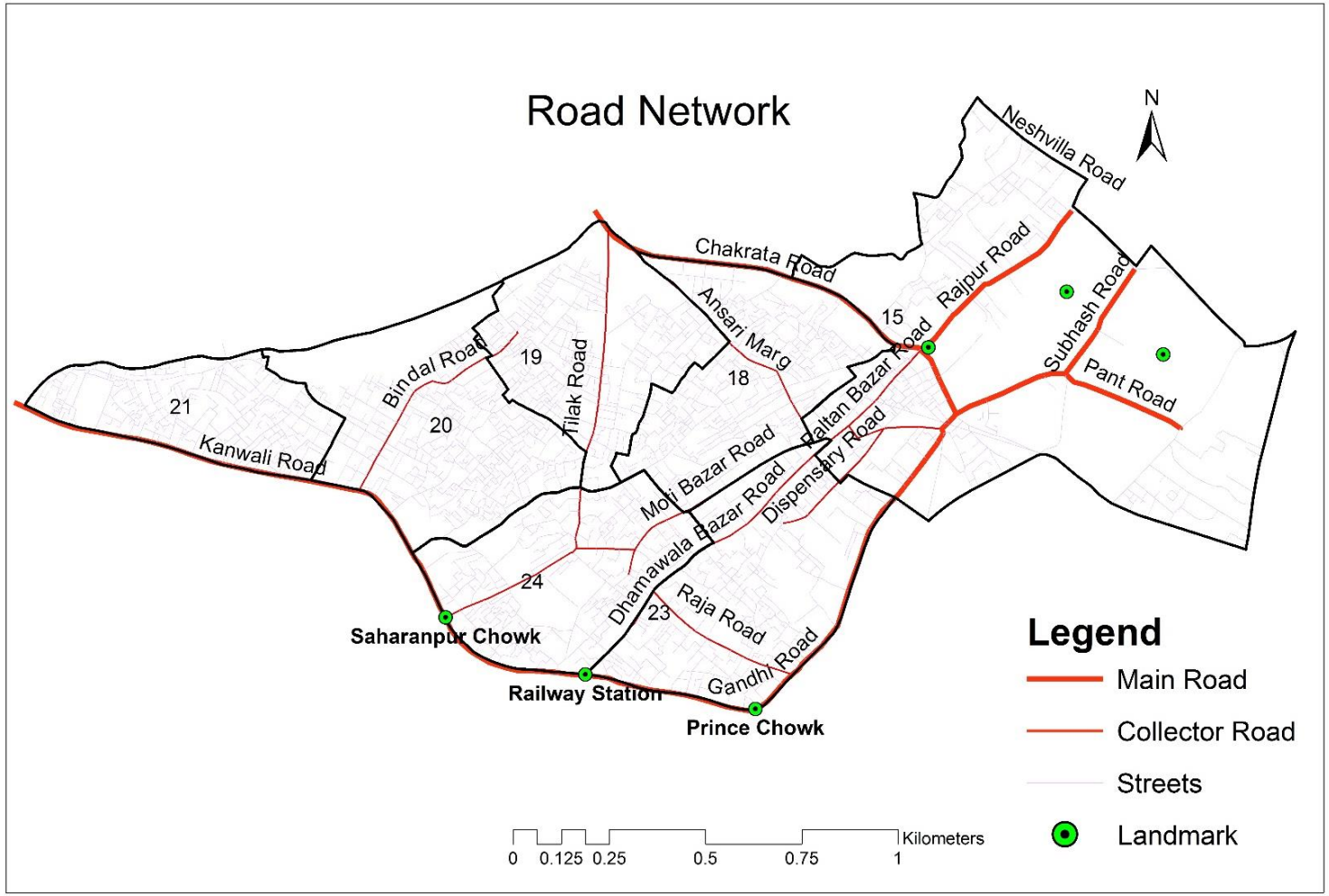


Figure A1.4. Road Network Map of City Core, Dehradun

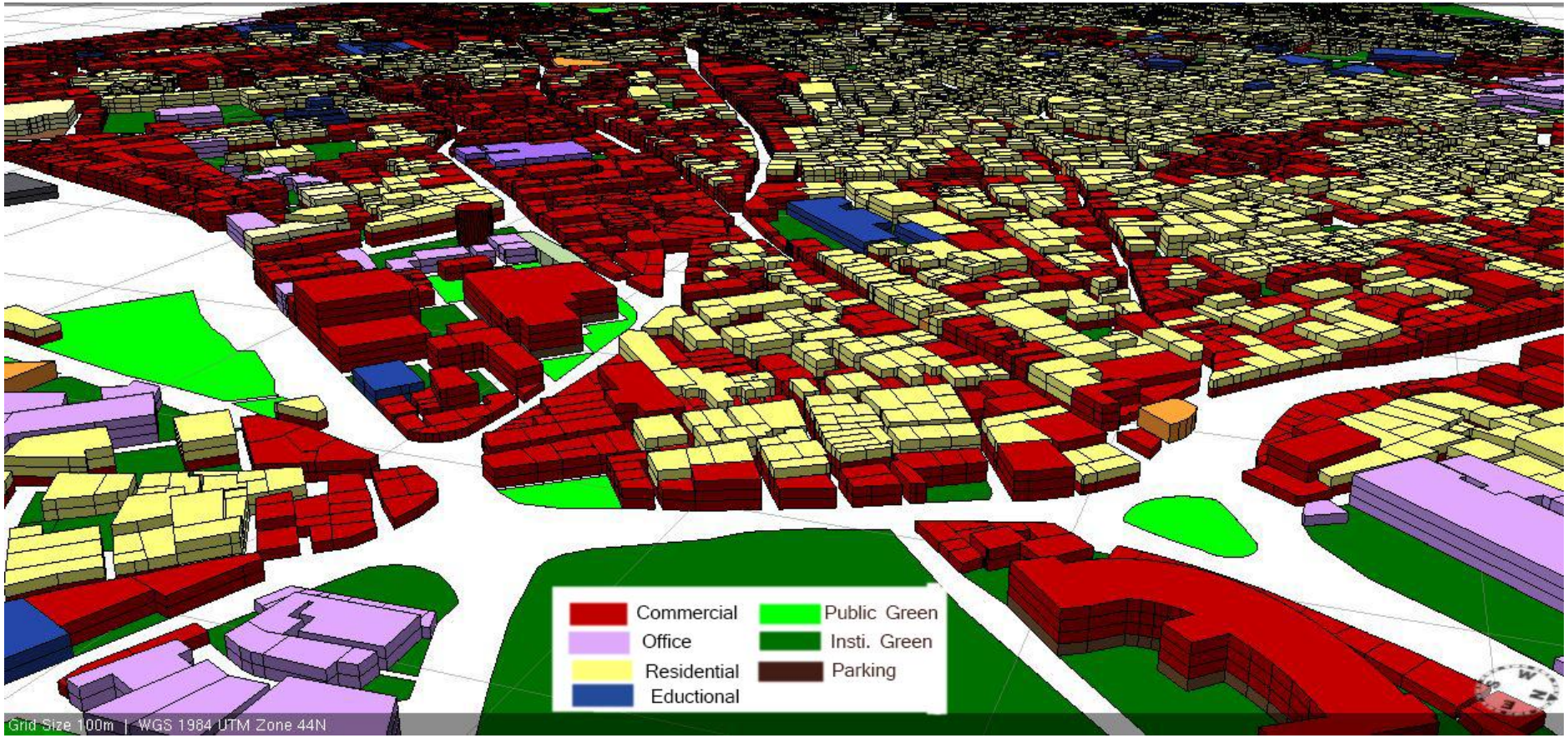


Figure A1.5. Space Use of Paltan Bazar Area, Dehradun

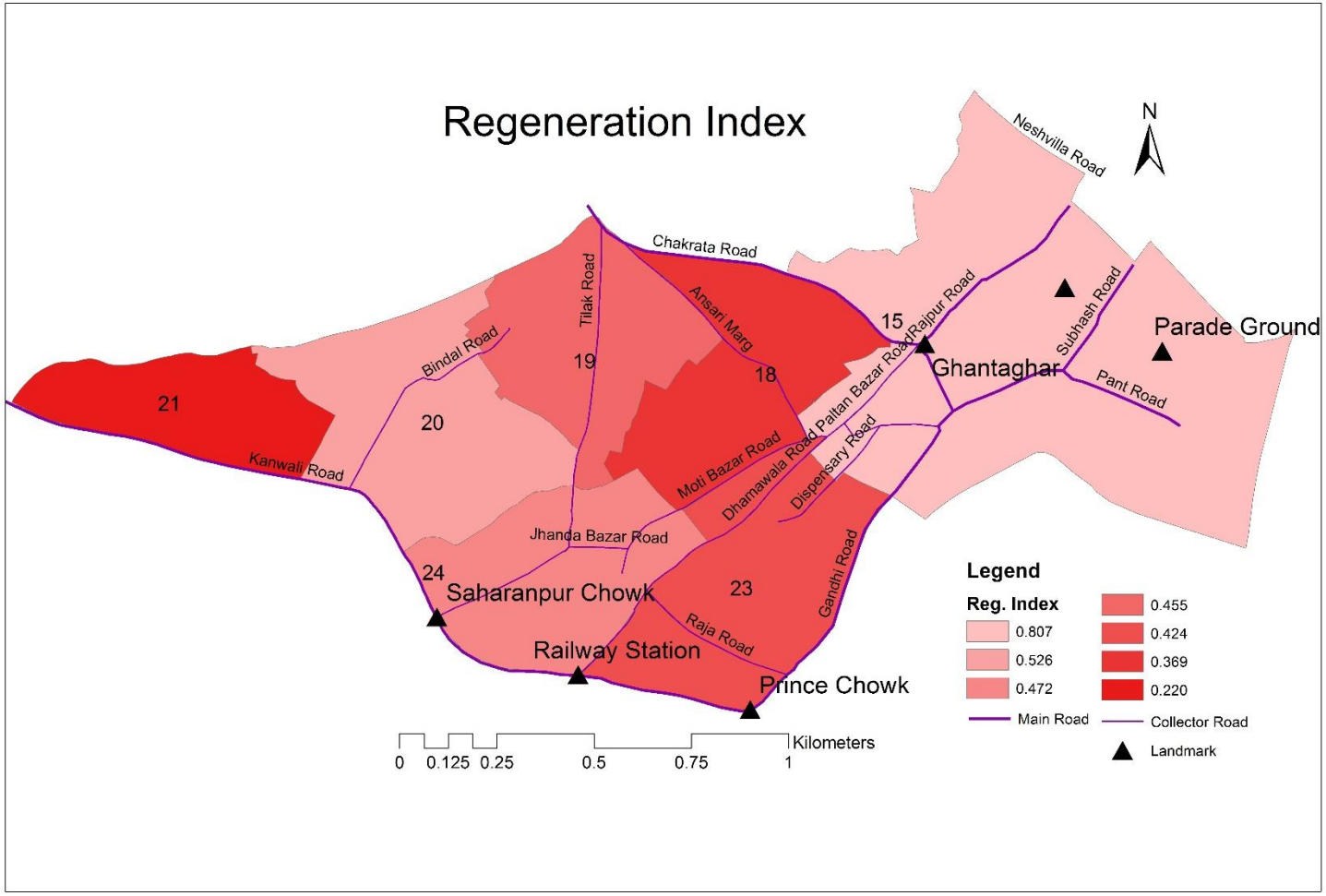


Figure A1.6. Regeneration Index of City Core, Dehradun