SYSTEM EVOLUTION USING HIGH RESOLUTION SATELLITE DATA FOR URBAN REGIMES

A THESIS

Submitted in partial fulfilment of the requirements for the award of the degree
of
DOCTOR OF PHILOSOPHY
in
ARCHITECTURE AND PLANNING

By

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DECEMBER, 2005

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled "SYSTEM EVOLUTION USING HIGH RESOLUTION SATELLITE DATA FOR URBAN REGIMES" in partial fulfillment of the requirement for the award of the Degree of Doctor of Philosophy and submitted in the Department of Architecture and Planning of the Institute is an authentic record of my own work carried out during a period from January 2003 to December 2005 under the supervision of Associate Professor R. K. Jain.

The thesis has been revised as per the suggestions of the examiner.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institutes/Universities.

Sadhana

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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Signature of External Examiner

ABSTRACT

Urban planning and management, both requires intensive information handling for decision-making. The poor information, limited integration and sharing poses difficulty in the plan implementation and its monitoring. The general mismanagement of urban areas and lack of accurate and timely available information often results in ineffective planning. Urban planning requires inputs from different experts of various disciplines. Proper and timely interchange of information at different levels can be helpful in planning and management. Thus, an integrated information system is the basic requirement of any city for effective planning and management. With this in mind, the aim of this research is to evolve an information system to support the various activities related to planning, its implementation, monitoring and management in an integrated manner, termed as urban regimes.

Effective and efficient planning of urban development requires current and accurate information. New generation of very high spatial resolution satellite data offers an important, alternative source of data in this regard. With the diversity of new digital information products particularly, very high spatial resolution imagery (1 m and fine), an evaluation of the capacity of these new data source is necessary in the framework of urban studies. In fact, the capacity of this new source of information to answer the end-user needs related with physical, social, fiscal, environmental and legal parameters have been investigated in this research. For this purpose, six representative wards, namely, ward no. 39 - Race Course (N), ward no. 12- Dharampur, ward no. 23 - Devsuman Nagar, ward no. 4 - D.L. Road, ward no. 36 – Dhamawala and ward no. 34 – Dandipura, of varying characteristics of Dehradun Municipal Corporation are selected for detailed study. The criteria for the selection of the wards are based on the land use pattern, development pattern, population density etc. Large-scale base map at the scale of 1:2000 has been prepared using IKONOS satellite data for these six wards.

Base map prepared from high-resolution satellite data is useful to integrate the attributes related with various parameters, which provide scientific visualization about existing scenario. Database prepared using the remote sensing and GIS are used to analyses the

existing scenario related to various aspects of urban areas. Physical scenario has been investigated through land use pattern and accessibility in study area. Quantitative determination of land use transformation in different wards allows to understand the changing pattern and functions within urban fabric. Social scenario is studied to trace the development pattern of different income groups. Within a small area, housing units of all categories shows the persuasive aspect of everyday life, which very much affects the conventional urban analysis. Fiscal aspect has been explored to understand the trend of property tax contributed by an average dwelling unit of different income groups. Environmental aspect has been studied to quantify the effect of increasing population on urban environmental quality, which draws together the relationship related to various land covers. Legal aspect is discussed to find the causes for the development of informal settlements and its consequences on the environment.

Investigations show that the use of remote sensing achieves greatest success when data are combined with other secondary data related to various aspects. The digital depictions of geographical reality in high-resolution satellite data are increasingly capable of capturing the physical as well as socio-economic structure of cities. This research demonstrates credible relationships between various parameters. It shows the capabilities of high spatial resolution satellite data to handle the problems related with changing physical and social scenario, urban environment and ecology as well as fiscal and legal aspects.

The integration and sharing of land-related information such as physical, socio-economic etc. are incorporated in the proposed system. System development emphasizes the data gathering process and structural changes to improve urban information management. The traditional hierarchically–oriented vertical system of city is supported by a horizontally oriented networks from ward to city level. It recognizes the diverse nature and the horizontal network model of the interaction field. It provides a set of circumstances under which urban local bodies can share data and collaborate on analysis.

ACKNOWLEDGEMENT

With sincere reverence, I give my whole-hearted thanks to the *God* for the help at every step of struggles of life. The present piece of work owes its successful completion with the blessing and support of many persons to whom I wish to express my gratitude and thanks.

I am pleased to extend my sincere gratitude to Shri R. K. Jain, Associate Professor, Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India for his affectionate inspiration, meticulous support and constant encouragement during the course of this research besides giving me full freedom to carry out the research work independently. I am also grateful to Dr. A. P. Subudhi, Director, Jharkhand Space Application Centre, Ranchi for his full confidence towards me.

At the outset, I express my deep sense of gratitude to Chairman, ISRO and Director, NRSA, for granting me permission for pursuing the Ph.D. I am highly indebted to Dr. V. K. Dadhwal, Dean, Indian Institute of Remote Sensing, Dehradun for providing me all the facilities, the help and encouragement that cannot be expressed through words. I am thankful to Prof. B. S. Sokhi, Head, Human Settlement Analysis Division, Dean, Indian Institute of Remote Sensing, Dehradun for the cooperation extended by him during the research.

I express my sincere thanks to Dr. V. K. Jha, Director, Regional Remote Sensing Service Center, Dehradun for his critical comments, which helped me in improving the manuscript. I am thankful to Dr. A. K. Tiwari for his suggestions to my specific queries. Thanks are also due to Mrs. Kshama Gupta for the moral support provided by her during difficult time.

I sincerely thank to Mr. Amit Bhargava, NIC, New Delhi for the discussions and necessary information about the NIC projects. My sincere thanks are due to Dr. Mahavir, SPA, New Delhi for his kindness and fruitful discussions during my work. I am also thankful to Librarian, SPA, New Delhi for permission to use the library facility for the research. I am also thankful to Prof. P. K. Garg for the useful discussion and suggestion in the last phase of the research.

I sincerely thank Mr. R. D. Garg and Mr. Sandeep Maithani for their help in many trivial but important matters. Thanks are also due to Ms. Sangeeta Chachra, Mrs. Shalini Bora and Mr. Kamlesh Jain for their help during the report compilation.

I am thankful to Lt. Col. Rajeev Katyal for checking the two important part of the report. I wish to give my special thanks to Amit Kumar for the help extended by him in the last phase of the research as well as Himanshu, Ujjwal and Sachin Sharma for their help during the field survey. Acknowledgements are also due to Mr. Sanjay K. Gupta of IIT, Roorkee for his timely and necessary help during the completion of this work.

I sincerely thank to Mr. N. K. Joshi, Administrator Officer and Mr. Umesh Sharma, Deputy Mayor of Dehradun Municipal Corporation for the information and discussions about the present situation. I also express my sincere thanks to Mr. B. B. Ratan, Chief Town Planner, Uttranchal, for his comments, which helped me to improve the work.

Special thanks to my friend Aditi (Bhasker) Kachole for her constant support, encouragement and always being with me even form the distance.

Last but not the least, I ought to express my sentimental gratitude to **my parents**, for their kind blessings and support. I put on record the love, affection and moral support given by *Nishi, Anvi, Pranshu, Prachi, Vijit, Kanchi, Vibhor* and *Shobhna-Nilind, Anjna-Prabhat, Vandna-Rajendra & Abha-Pradumn,* which lead me to successfully complete this study.

SADHANA JAIN

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ACRONYMS

CAA	:	Constitution Amendment Act
CPWD	:	Central Public Works Department
ERDAS	:	Earth Resource Data Analysis Systems
FCC	:	False Colour Composite
GICDP	:	Ganga Institutional and Community Development Project
GIS	:	Geographical Information System
GPR	:	Ground Profiling Radar
HIG	:	High Income Groups
HIS	:	Intensity, Hue and Saturation
IDSMT	:	Integrated Development of Small and Medium Towns
IT	:	Information Technology
ITPI	:	Institute of Town Planners, India
LIG	:	Low Income Groups
MIG	:	Middle Income Groups
MS	:	Multi Spectral
MUD	:	Ministry of Urban Development
NIC	:	National Informatics Center
NIR	:	Near Infra-Red
NNRMS	:	National Natural Resources Management System
NSDI	:	National Spatial Data Infrastructure
NUDB&I	:	National Urban Databank and Indicator
NUIS	:	National Urban Information System
NUO	:	National Urban Observatory
PAN	:	Panchromatic
PC	:	Personal Computer
PWD	:	Public Works Department
RCC	:	Reinforced Cement Concrete
RGB	:	Red, Green and Blue
RMP	:	Regular Modified Polyester
RS	:	Remote Sensing

SDI	:	Spatial Data Infrastructure
TCPO	:	Town and Country Planning Organisation
UAM	:	Unit Area Method
UDPFI	:	Urban Development Plans Formulation & Implementation
ULB	:	Urban Local Bodies
UPPBP	:	Urban Plan Preparation Business Process
URIS	:	Urban and Regional Information System
URT	:	Urban Regime Theory
USIS	:	Urban Spatial Information System
UTM	:	Universal Transverse Mercator
www	:	World Wide Web

CHAPTER I

THE RESEARCH CONTEXT

1.1 Introduction

In this era of information technology, it is most desirable to make its best use for decision-making and taking action (Kulshrestha, 2002). Any information is the backbone for the decision-making and provides the basis for the identification of issues, alternative approaches, strategies and finally the steps of action. A well-structured information system provides efficiency in co-ordination among various agencies such as urban planners, managers and administrators. Setting up of the information system is, therefore, necessary in practically all fields and the field of urban regimes is no exception. To the best of my knowledge, a comprehensive information system pertaining to planning, plan implementation, monitoring, management and administration of urban areas is not available in India and therefore, there is a need to establish such a system in this field.

Information has been and always will be the corner stone of urban and regional planning (Helden, 1994). Effective and efficient management of urban development requires current and accurate information (Opadeyi and Ali, 1999). It is essential, therefore, to establish an overall strategy for the design and development of the information system and to identify the major components of the urban system that we are concerned with (Cater,1974). Local planning authorities need the backing of a comprehensive information system for development and management of basic infrastructure facilities. For urban planning, topographical maps from Survey of India and census of population are used as prime source of information. Obviously this falls far short of many of the requirements, particularly because a full census is conducted on a decennial basis, and topographical maps for most of the cities do not provide for a continually updated database.

Urban planning and management are generally seen as information intensive activities and the adoption of IT by urban planners is therefore quite a natural development (Sliuzas, 2004). The database requirements for the potential end users' i.e. development authority and municipality have shown that the main application of these data are related with the implementation and management levels for which 1:2000 scale or larger base maps are needed. Absence of large-scale base map for the preparation of zonal plans is one of the major reasons for the poor implementation of the master plan/ development plans. With the diversity of new digital information products particularly, very high spatial resolution imagery (1 m and fine), an evaluation of the capacity of these new data source is necessary in the framework of urban studies. In fact, the capacity of this new source of information to answer the end-user needs related with physical, social, fiscal, environmental and legal parameters have been investigated in this research.

The emphasis of the research has been the successful incorporation of high resolution satellite data and GIS functionality into integrated system and also its use for the quantitative assessment of basic elements to support decision making with high degree of spatial data content. This is a fundamental to facilitating better understanding of decision problems across a range of spatial scales from local to regional and national. With this in mind, the aim of this research is to evolve a system to support various activities related to urban planning, implementation, operations and management in an integrated manner, grouped together under the domain of urban regimes.

1.2 Relevance of the research

It is widely recognized that urbanization is necessary for social and economic development in all countries. Urbanization builds diversified and dynamic economics, which raise productivity, create jobs and wealth, provide essential services, absorb population growth, and become the key engines of economic and social advancement. The process of urbanization is complex because of the interdependence of various factors. Within the urban fabric, many of the pressures upon urban development are generated by the sheer scale and rapidity of economic and social restructuring of cities and their consequent effects upon spatial structure (Longley *et al.*, 2001b). The continuous nature of the planning process means that there must be continual feed back of information on changing scenario resulting due to the planning policies.

The perquisite for any planning and action programme is the information of the reality for the planners to understand the urban complex system. The planned development of urban areas to achieve a reasonable level of personal and societal well-being is an important aspect of national progress. The planned development can be achieved through sustainable management using optimum information system, which will include the various stages viz. data acquisition, data storage and retrieval, data processing and analysis, decision making, monitoring and review of plan implementation. Thus, an integrated information system is needed to achieve the objectives of the planned sustainable developments.

In India, urban local bodies are responsible for a number of policy measures to control and divert development for a suitable and better living environment. But the information crisis and lack of systematic appraisal of urban problems is hampering their capacity to develop effective urban governance. In order to devise effective policies, the decision makers need to rely on a set of measures that point to specific urban phenomena. Existing tools for urban policy are largely inadequate in providing an overall picture of the various aspects at ward level. Thus, an integrated information system is needed in order to enhance effectiveness and efficiency of urban local bodies from ward to city level.

To monitor and control urban system, it is necessary to visualize, how that system might evolve and what are the outcomes of different kinds of stimuli and interventions. During the last 3 decades, remote sensing has been established as a useful means for urban planning, suitability analysis, resource management etc. But it's role in real-time monitoring for urban management is still in infancy. While advances in satellite sensor technology, particularly those relating to sensor spatial resolution, are helping to make remote sensing more appropriate to the study of urban areas (Longley *et al.*, 2001a). Today's remote sensing technology has almost unlimited spatial and temporal flexibility, and it is parcel independent. Derived information is easily aggregated to parcels level.

Remote sensing data is capable of detecting and measuring a variety of elements relating to the morphology of cities, such as amount, shape, density, textural form and spread of urban areas (Webster, 1995; Mesev *et al.*, 1995; Yeh and Li, 2001, Lata *et al.*, 2001). The application of remote sensing techniques and geographic information system in the urban planning is of great scientific importance and is now sufficiently established. Integration of remotely sensed data with other secondary data in GIS environment provides a more systematic analysis of the relationships between urban form and process (Pathan *et al.*

2004). Thus, remote sensing technique has gained increased acceptance among physical planners in urban and regional areas due to inherent advantages (Rao, 1996).

Luthra (2002) emphasized that there is a dire need to update the planning tools in the light of technological advancements in different fields. It is proposed that comprehensive research should be initiated to update the planning concepts, principles, considerations, norms and standards and to workout guidelines for the integration of various datasets. The starting point of urban regime theory is also the complexity of civil society. In relation to the management in local governance, Stone (2002) emphasized the concept of urban regimes as coalitions based on informal networks and formal relationships. Institutions and actors are part of a complex network that is characterized by fragmentation, lack of consensus and mutual dependence.

1.3 Objectives

The objectives of research includes-

- Evaluating the potential of high-resolution satellite data and GIS to investigate the existing scenario related to physical, social, environmental, fiscal and legal aspects at micro level.
- To improve the information structure for effective implementation and monitoring of plans at micro level.
- Evolving the system to cater the needs for planning and sustainable management.

1.4 Scope

Urban regime is a relatively new and vast domain. In this research, “urban regimes” is used as umbrella term for various activities i.e. planning, implementation, monitoring, management and administration. For this purpose, five basic parameters including physical, social, fiscal, environmental and legal have been selected for detailed study. Physical parameter is an important component and a basic requirement for planning of urban areas. Thus, land use and accessibility are selected to study the physical aspect. Land use is a product of activities likes residential, commercial, public and semi public etc. and it depicts the spatial distribution of city functions. Social environment also plays a major role in the formulation of the form and functioning of urban areas. In other words, social dimension in the cities can be described in terms of spatial configuration of lifestyles such as high income groups (HIG), middle income groups (MIG) and low income groups (LIG). Social aspect in this research have been studied through the spatial distribution of different income groups i.e. HIG, MIG, LIG and squatters. While, fiscal aspect is related to the property tax calculation of residential unit of different income groups. The parameters used to calculate property tax is taken form the proposed Unit Area Method (UAM) of property taxation by Delhi Municipal Corporation. It is used to quantify the contribution of property tax by an average dwelling unit of different income groups.

Urbanization brings many changes in urban land cover composition. For this purpose, study area is classified into three broad land cover categories- hard surfaces, soft surfaces and green cover to quantify the effect of increasing population on urban environmental quality, that can draw together the relationship related to various land covers. It can provide scientific vision about existing scenario and relationship among various factors for careful planning. Another reason for the degradation of urban environment is haphazard growth of informal settlements. Such unauthorized and haphazard development negates the purpose of planning as once these developments have taken place there is no choice but to incorporate them. Thus, legal aspect studied in this research includes the development pattern of informal settlements.

Physical, social, fiscal and environmental parameters have been assessed quantitatively, while legal parameter is assessed qualitatively in the different wards selected for detailed study. Database derived from high-resolution satellite data is proposed to be incorporated in an integrated system to fulfill the need of urban local bodies (ULBs). Organizational restructuring required for the same is also proposed in this research.

1.5 Methodology

Methodology adopted to carry out this research work is divided broadly into 3 parts- investigation of existing scenario, evaluating the potential of high resolution satellite data and system development (figure 1.1).

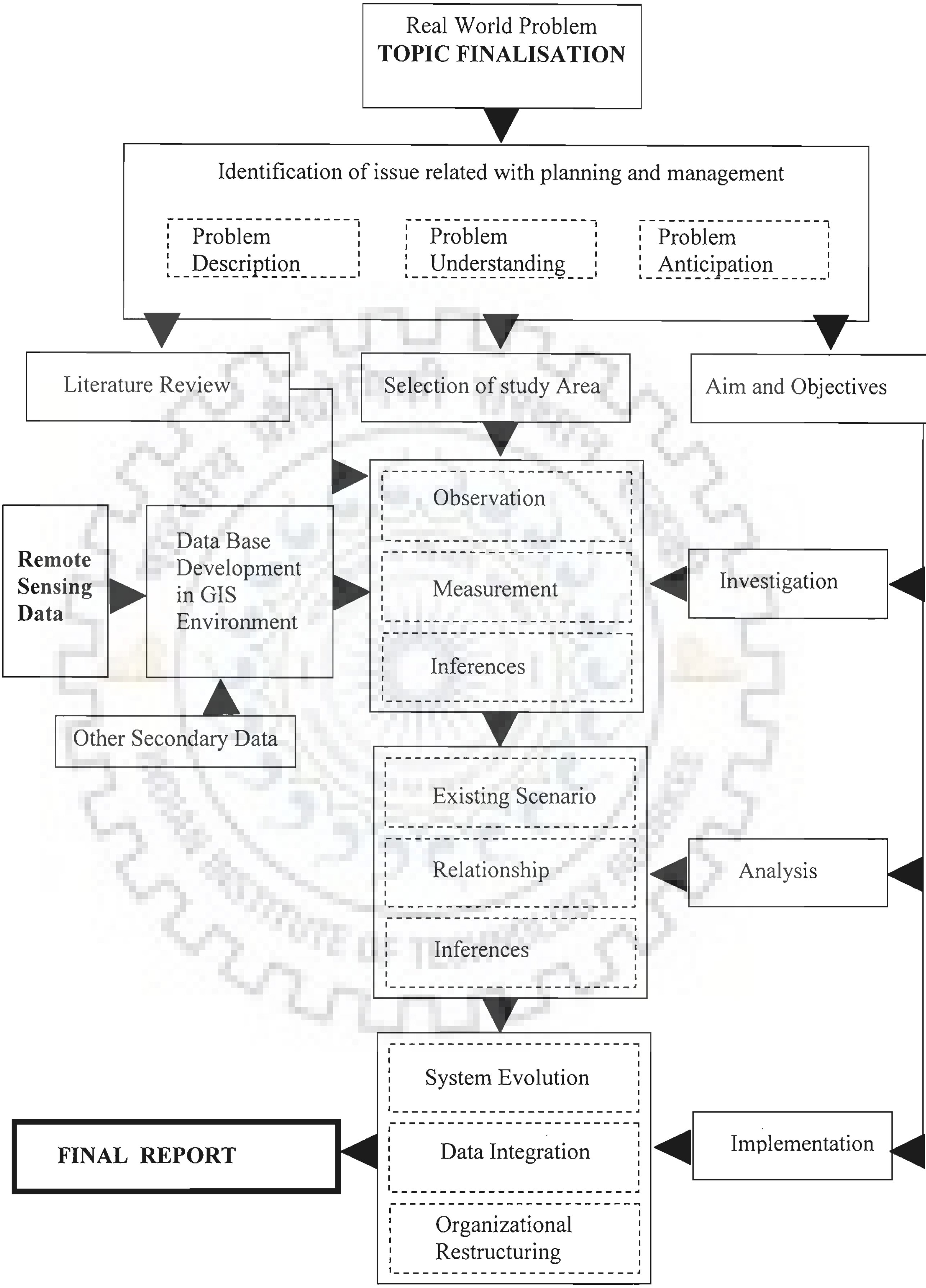


Figure 1.1: Methodology flow chart

(i) First part of the research includes study of existing scenario including planning process, causes for poor implementation and problems related with monitoring of plans and present spatial data policy in India. It also includes the case studies of projects related to the application of remote sensing and geographical information system (GIS) in urban areas and national policy on spatial information such as National Urban Information System (NUIS). This has been carried out through literature review and field visits to various organizations.

(ii) Second part of the research includes the evaluation of the potential of high resolution satellite data (IKONOS) and GIS to cater the need of urban planners, administrators and manager. Various image processing operations have been carried out to extract information from imagery of different spatial and spectral resolution. Fusion of panchromatic and multi-spectral imagery enhances the interpretation capabilities. Thus, fused image has been used for the detailed study related with various parameters of urban sphere.

Investigation about the existing scenario has been carried out considering five parameters, viz., physical, social, environmental, fiscal and legal. Large scale base map at parcel level has been prepared for all six wards selected for detailed study supplemented with field survey. Structure features i.e. buildings, roads are main representation information extracted from satellite imagery directly.

Detailed land use map showing the use of every land parcel and its accessibility have been prepared as a part of physical measure for all six wards. Interpretation keys like, pattern (layout), shape, size (small, medium, big), tone and association are used to find the location and spatial distribution of the different income group i.e. HIG, MIG, LIG and squatter settlements to visualize the social aspect in different wards. The rapid growth of population has created unprecedented problems of adjustment of behavior to new conditions. The development pattern of changing income levels create grouping and regrouping of class on the basis of housing type. Housing type shows the characteristics and affordability of population, which enables prediction for physical infrastructure and community facility needs.

Fiscal aspect investigated in this research includes the property tax calculation using Unit Area Method (UAM). Unit Area Method is emerging as an alternative to the rental method as the base to compute Property Tax. Tax contribution by an average dwelling unit of different category i.e. HIG, MIG, LIG and squatters is calculated to visualize the contribution of property tax by different income groups.

Supervised classification has been carried out to study the environmental aspect in study area. For this purpose, study area is classified into three broad land cover categories- hard surfaces, soft surfaces and green cover and an attempt is made to establish the relationship among different land cover, as well as, population density. It provides scientific support and visualization for sustainable development of urban areas. Investigations related with legal aspects have been carried out to trace the development pattern of informal settlement, impact of topography and its effect on the environment. An attempt is also made to quantify the extent of temporary structures in a part of study area through digital classification.

Statistics derived from various datasets have been used to investigate the relationship between different aspects to visualize, anticipate, recognize and interpret the existing scenario and improve the information structure at micro level.

(iii) Third part of research includes the system evolution and incorporates the inferences derived from first two parts for planning and sustainable management. Database derived from remote sensing has been integrated within the conceptual model of the system. Various aspects related with system and its operationalisation are proposed which include development of intranet at city level, organizational restructuring etc. for urban regime.

1.6 Limitations

The limitations of the research include-

- Detailed study related to various parameters has been carried out within defined scope and in the selected representative wards of varying characteristics.

- This research proposes a conceptual model for the evolution of the system to cater the needs of urban local bodies. Software or web development does not come within the preview of this research.

1.7 Organization of the Research Report

This report comprises nine chapters focusing on the various aspects related to the research. Chapter first highlights the relevance of the research and an overview to research objectives, scope, methodology and limitation of the study. This chapter forms the basis on which the subsequent analysis is based.

The second chapter covers the review of the relevant literature through research papers, books as well as academic projects and other documentations, at national and international level related to the subject. This chapter comprises the literature related to the system development, remote sensing and GIS for urban applications, urban regimes and related laws enforced in the urban areas.

Chapter three mainly deals with the work done by various organizations involved with the creation of spatial database through case study of two live projects of different scale. This chapter also discusses the policy framework for the spatial data of urban areas (NUIS) in India proposed in the light of technological innovations.

Characteristics of study area are given in chapter four. It comprises criteria for the selection of wards for detailed study also. Detailed study has been carried out on six selected wards of varying characteristics of Dehradun Municipal Corporation.

In chapter five, various aspects related to the database creation have been discussed in detail including the data used, methodology involved viz. image fusion, pre field interpretations, field verification, post filed updation and development of thematic maps. High-resolution satellite data has been used for the preparation of thematic maps related to physical (land use and road network), social (dwelling units of different income groups) and environmental (classification of various surfaces) aspects. While potential of high-resolution satellite data to extract various issues related to fiscal (property tax calculation through the proposed UAM) and legal (identifying informal settlements and development pattern of these settlements) aspects has been explored. This chapter highlights the potential of high-resolution satellite data and GIS for the preparation of large-scale base map, while analysis of database is carried out in chapter six.

Chapter six is related with the analysis of information derived from the datasets developed using high-resolution satellite data and GIS in chapter five. This analysis leads to the development of correlation matrix. The analysis helps to explore the hidden relationships between different parameters at micro level.

Chapter seven focuses on devising an information structure to integrate various parameters for effective implementations and monitoring of plans. It is leading to the conceptual model of the system and related aspects. The approach is based to explore a general integration framework that is relevant to different organizations related with the planning and development of urban areas.

Chapter eight is related with the system assessments to fulfill the needs of various activities such as planning, implementation, monitoring, management and administration grouped under the umbrella of urban regime. It also comprises an overview to the various issues related to the implementation of the system including technical strategy, implementation cost and phases of system development.

Chapter nine highlights the main findings and conclusions, recommendations and direction for future research.

CHAPTER II

LITERATURE REVIEW

2.1 An Overview

Literature review is carried out for finding out the gaps in the existing studies, and thus guides in formulating the research plan addressing the issues not covered earlier in a systematic manner. It highlights the different aspect of this research through review of research papers, books as well as academic projects. It helps to understand the types of work done by various authors, techniques used along with their advantages and limitations. The literature review carried out in this chapter is comprises of 3 parts. First part of the chapter is related with the system development highlighting the need for the system evolution. It comprises of literature related with definitions, information system and spatial data infrastructure to support the information system. Second part of the chapter is related with the remote sensing and GIS for urban application. While, third part is concerned with the urban regimes and related laws.

According to Puissant and Weber (2002), urban analysis is a complex domain due to multiple interactions between social, politic and environmental spheres. The field of urban development is thus composed of different types of applications: first daily management of the territory (network, facilities and green space), in second pace, urban planning (operational planning, impact study, regulations documents) and finally urban prospective (distribution analysis of objects, phenomenon). Since the functions of departments are different, so too are their data requirements, and hence to conclude the separate department require their own systems. Thus design of a subsystem for each department or group of department is dependent on closely similar data requirements. A major benefit of the approach would be in a reduction in the number of data items collected more than once. Within this management process two distinct functional domains can be identified: viz. an administrative and a functional domain (Helden, 1992, 1993; Plandata 1989, 1992; Helden, 1994). The information requirement for these functions can be grouped into three basic categories (Martin, 1990; Helden, 1994):

- **Operational or transactional information**: this level of information is concerned with the routine processing and execution of the daily tasks, that is information regarding the transactions that take place between the entities in the system. It requires data input, but not much processing or manipulation and can often be automated;

- **Control information**: this level of information has to do with control over efficiency and effectiveness of the operational tasks. It measures the output and compares it with a standard or goal;
- **Planning information**: this information has to do with medium and long term planning and includes diagnostic information that measures the impact of transactions on the organization and the cause of any problems; anticipatory information, which concerns the environment of the organization; trend and relationship information for measuring change, prediction and simulation.

As defined by Chevalier (1990) and Puissant *et al.* (2002), these categories of applications correspond to three levels of responsibilities (operational, tactical and strategic) and three specific end-users (technicians, planners, decision-makers). Represented in a pyramid (figure 2.1), each level of responsibility corresponds to specific data requirements and output documents. A vertical data management level (storage, updating, exchanging) can also be defined because data flow across these levels from raw data to integrated information. All these applications require the access to reliable update data and a good knowledge of the land cover evolution.

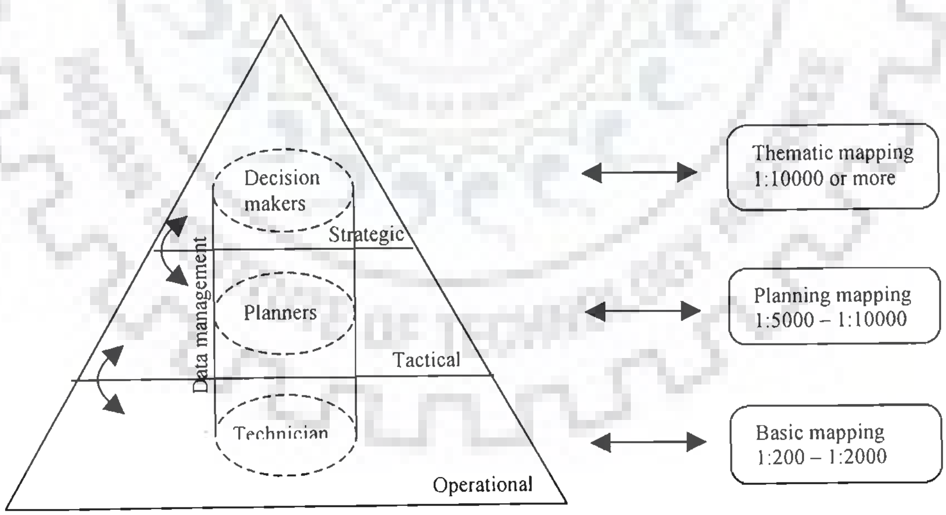


Figure 2.1: The decision pyramid of end-users and their requirements (Puissant et al. 2001, 2002)

Although the value of linking such data has long been recognized, it was not until recently that computer technologies came into being that are capable of manipulating large quantities of geographic data in digital form. With the arrival of geographic information systems handling technology during the 1980s, the potential for linking geographic data increased dramatically and the modern geographic information economy came into being. Consequently it must be recognized that there is a need for some measure of standardization if the potential linking data sets is to be fully exploited (Masser, 1998).

2.2 System development: A research perspective

"We have a lot of data but we are information poor."

…………………..(Nghi and Kammeier, 2001).

In the information era, there is still the contradictory situation of information-poor activities and the under utilization of advanced information tools such as GIS, even though the latter is increasingly affordable (Krishnan, 1995; Nghi and Kammeier, 2001). More effective use of spatial information can assist the process of urban and regional development, planning and management. The internet now permits public access to a wide variety of static and dynamic information and integration of different types of spatial data at different scale in a GIS environment using spatial modeling analytic tools and the visualization of output of such analysis and modeling (Pettit *et al.*, 2003). Developments in geographical information system (GIS) and internet (WWW) technology allow us to view the results of urban and regional analysis in a spatially integrated environment (Stillwell *et al.,* 1999, Shyy *et al.,* 2000, Pettit *et al.*, 2003).

Advancement in the field of information technology needs to be suitably accommodated in urban planning and governance as well as day-to-day practice among the town planners to produce physical and spatial plans. The availability of personal computers with the graphic capability, and the rapid development of IT including GIS, makes it easier now to apply such 'flexibility principles' for timely corrective actions, with transparency and informed participation of multiple-stakeholders. Such an approach will preempt urban problems at the nascent stage before get out of control. However, this will require a shift in policy, particularly in developing countries subjected to rapid economic and demographic change, from the conventional practice of treating City Master Plans as rigid legal documents, and instead, viewing them as a 'live'

Development Plan that is responsive to people's need, and subject to 'navigational change' (including changes of land use and planning regulations if needed, thus avoiding freezing the evolving option for 20 long years, the usual Master Plan period) (Chakrabarty, 2001). Government of India has also enacted the Information Technology Act 2000, providing legal status to the advancement in the field of Cyber Technology.

2.2.1 Defining system

As per Oxford dictionary, system is a "group of things or parts working together as a whole" *or* "orderly way of doing things; tidy arrangements." A system can be defined as "a regularly interacting or independent group of items (components) forming a unified whole" (Webster's dictionary). The components of a system should be identifiable, independently designable and analyzable independently of other components. It must have specific purpose and supported by interaction between its components. The combination of components of a system is called structure (Gautam, 2003). General systems theory is concerned with developing a systematic, theoretical framework for describing relationships of the empirical world. An ultimate but distant goal of system framework is to tie all disciplines together in a meaningful relationship.

According to Johnson *et al.* (1975), "A system is an organized or complex whole; an assemblage or combination of things or parts forming a complex or unitary whole." The systems concept can be a useful way of thinking about the job of managing. It provides a framework for visualizing internal and external environmental factors as an integrated whole. It allows recognition of the proper place and function of subsystems. The systems within which businessmen must operate are necessarily complex. However, management via systems concepts foster a way of thinking which, on the one hand, helps to dissolve some of the complexity and, on the other hand, helps the manager to recognize the nature of the complex problems and there by operate within the perceived environment. It is important to recognize the integrated nature of specific systems, including the fact that each system has both inputs and outputs and can be viewed as a self-contained unit. Hoos (1975) defined a system as "a set of parts coordinated to accomplish a set of goals".

Hughes and Mann (1975) explain the system as a complex of interacting elements. Wholeness, as a system attribute, means that the system behaves as a whole, changes in every element depending on all others, as opposed to independence. Recent developments involve application and diffusion of general systems theory into public policy and social science. This spread has relevance to planning in that, first, it can eventually provide greater understanding of specific material peculiar to urban and regional planning. In other words, the complex, dynamic, and highly interrelated cultural, social, political, and spatial phenomena that define the environment of planning may be modeled or formulated into quantified, understandable systems. Second, it can aid understanding of the process of public policy formulation and possible provide the basis or model of an optimal policy formulation procedure.

A working definition of an information system distinguishes it from a data bank, which is simply a set of files of disaggregated data that can be processed to provide a variety of summary tabulation. An information system represent to a mega system, which is dependent upon various subsystem. It includes data files in different department, data collected for particular purposes in special surveys, and data obtained from secondary sources for example census of population.

Dale and McLaughlin (1989) gave guidelines, which are, however, important for helping multiple organizations achieve mutual system related goals. A database within the system is a collection of data that can be shared by different users. It is a group of records and files that are organized so that there is little or no redundancy. The objectives in creating a data base include-

(i) Permits various methods of access- the structuring of the data to permit various methods of access.

(ii) Stores data independent of application- the storing of the data in formats that are independent of current and potential applications

(iii) Controls access to data- the control of access to the data, including who is allowed to use or alter any data entry.

(iv) Facilitates data modification- the facilitation of record updating, changing, or modification, including the insertion of new records and deletion of old.

(v) minimizes data redundancy- the minimizing of data redundancy.

The salient features of the system as given by Dale and McLaughlin (1989) -

- Currency: The data will be accessible in an up-to-date form that meets the needs of the different functions.
- Precision: Data related to different activities can overlay precisely to visualize the existing scenario. For example, underground facilities can be recorded to a precision with which they can be dug up expeditiously.
- Verifiability: Different users will be able to get the same answer to the same question.
- Clarity: The information will be free from ambiguity.
- Quantifiability: The numerical information at appropriate level will be available.
- Accessibility: It makes possible to extract information quickly and easily.
- Free from Bias: There would be no alteration or modification to the raw data in order to influence those who receive them.
- Comprehensiveness: The data will be complete in spatial cover and content.
- Appropriateness: The information derivable from the data can be related to visualize various scenarios of urban areas.

2.2.2 Information system

Singh *et al.* (2004b) emphasized the need of a comprehensive urban information system for India. Proper urban planning, decision-making and implementation raises the demand for generation of comprehensive urban information system. This information system should include some of the key areas like urban land use, sprawl, zoning, demography, environment, transportation, housing, water supply, sewerage, solid waste, power supply etc. A comprehensive UIS can assist in such work and can contribute to increasing the efficiency and effectiveness of urban management practices, which involves very wide range of activities.

Vyas *et al.* (2004a) assessed the role of remote sensing and GIS as a policy instrument for urban local governments. This paper discussed the objectives of UIS and role of remote sensing in GIS in urban planning. Advantages of adoption of new technology in urban local bodies are highlighted through the case study of Ahmedabad, India. The paper states that Ahmedabad Urban Development Authority has for the first time initiated the use of high resolution satellite imageries. It made possible to correct and realign the road network by superimposing the map over the satellite imagery. In absence of the use of advances technology, at the time of implementation at intermediate stage of town planning schemes the process would have been delayed because of the wrong allocation of the land for road network. The use of real time data saves not only the time and enhances the accuracy but it also avoids the repetition of the work and increases the public confidence among the authority.

Masser (2000) discussed the challenges related to the management of urban areas, role of Remote Sensing and GIS to meet these challenges arises due to the rapid urban growth and sets out a vision for sustainable urban development and its implementation at the local level.

Cete and Yomralioglu (2004) points out the need of large scale cadastre maps as key component in urban based information systems in Turkey. This paper discussed the various aspects related to cadastral maps, the process of cadastral studies, cadastre based information system in urban areas and in national perspective. Singh (2004a) proposed a Web Service Approach for collaborative urban information systems. This research studied the information flow within and across planning organizations and developed web based services for connecting information system across organizations. It encourages the interconnection of planning and mainstream information technology.

Wyatt (2003) developed methodology for increased public participation in the urban planning. This study demonstrated that how computer program unobtrusively quantifies relationships between people's personal characteristics and their planning priorities. It helps in the prediction of the various alternatives of the plans considering the wider community interest. Vyas (2003) listed the possible use of spatial data in municipal governance to emphasize the essence of information system. Some of the mentioned uses exist land use, taxation, information about building permit, infrastructure network, land suitability analysis etc.

Different authors have emphasized the need regarding the systems development through state-of-the-art technologies for enhancing participation in the planning process, support systems for strategic planning, environmental planning, land use and infrastructure planning in the book "Planning Support Systems in Practice" edited by S. Geertman and J. Stillwell. Kodmany (2003) proposed web-based tools and interfaces for participatory planning and design. This study described several different interface designed with the purpose of finding which combinations of online tools and maps are most productive in soliciting feedback in a community planning process. Ventura *et al.* (2003) discussed the opportunity to access a variety of web-based resources that support technology-facilitated land use decision-making for the city of Verona in Dane county. The toolkit offers software modules that support geographic data exploration and analyses, land use allocation and impact assessment. The web site presents data to provide citizens with an accurate and easy-to-understand view of their community, and tools to develop land use scenarios and understand their impacts for land use planning.

Williamson (1992) discussed the reasons for having Urban Land Information System, its benefits and role in the managements of cities. Opadeyi and Ali (1999) adopted a modular approach for developing an urban land information system for the city of Port of Spain and its environs. Samadzadegan *et al.* (2002) introduced the concept of fuzzy logic in order to increase the potential of a UIS and make proper Spatial Decision Support System to deal with descriptive parameters and uncertainty levels of the decisions for the city of Rasht, Iran. Koh (2001) discussed the role of urban land information system for sustainable urban management in Korea. Helden (1994) emphasized the need of an integrated information system for urban land use management for a number of local authority and urban planning departments in the Republic of South Africa. This research termed information system as an aid for urban planning. Yigitcanlar (2002) examines the role of online urban information systems or in another words Internet based geographical information systems as spatial decision support systems to support local planning process for Shibuya city, Japan.

Carver and Peckham (1999) addressed the role of World Wide Web (www), on line GIS and on line decision support system for the planning. Gouveia and Camara (1999) highlighted the role of multimedia in the planning. One of the major contributions of multimedia technologies to planning has been the creation of multimedia spatial information systems. Leigh *et al.* (1999) focused on the integrated information directory services for facilitating the transfer and exploitation of science and technology on the World Wide Web.

2.2.3 Spatial data infrastructure

The concept of spatial data infrastructure (SDI) is coming as a core infrastructure supporting different types of information system. The concept of SDI as given by Williamson *et al.* (2003) is based on principle that SDI allow the sharing of data, which is extremely useful, as it enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with generation and maintenance of data and their integration with other datasets. By reducing duplication and facilitating integration and development of new and innovative business applications, SDIs can produce significant human and resource savings and returns. With this arrangement, an effective SDI allows all cooperating bodies to access accurate and consistent spatial databases used to inform local and inter-jurisdictional decisions and to support implementation of resulting initiatives. Therefore, an SDI has to ensure the jurisdictional consistency of content to meet user needs.

Rajabifard *et al.* (2003) defined the hierarchy of spatial data infrastructure (figure 2.2). The SDI hierarchy creates an environment in which decision makers working at any level can draw on data from other levels, depending on the themes, scales, currency and coverage of the data needed. The double-ended arrow represents the continuum of the relationship between different levels of detail for the data to be used at the different levels of planning corresponding to the hierarchy of SDIs.

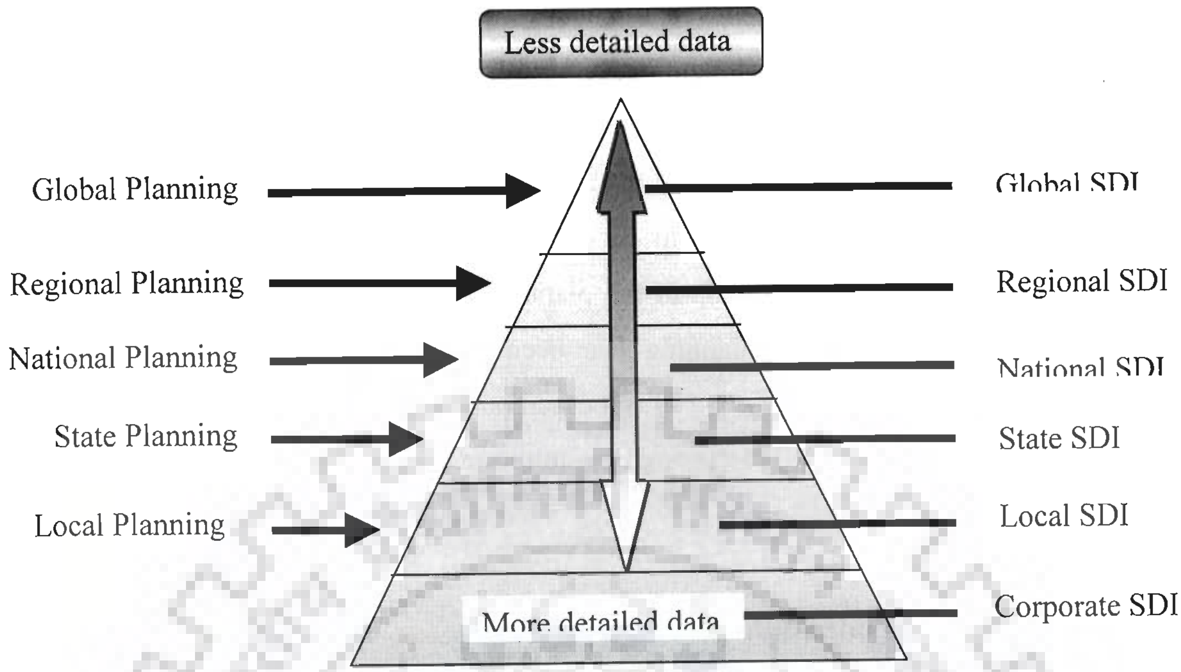


Figure 2.2: Relationship between data detail. Different levels of SDIs and Level of Planning (Rajabifard et al. 2003).

Mckee (2000) tried to explore the relevance of geo-spatial data infrastructure and its impact on social and cultural environments. Loenen and Kok (2004) discussed the legal and economic issues related with the spatial data infrastructure in Europe. It includes rules and laws regarding access to government data, copyright, database protection and similar intellectual property protections, liability and other legal means for ensuring the suitability of data and protection of personal information privacy.

Croswell (2000) highlighted the role of standards in support of geo-spatial data infrastructure. Salge (2004) recommended some action for geographic information network in Europe while Laarakker and Gustafsson (2004) identified bottlenecks and gave policy solutions for the European land information service.

Bishop *et al.* (2000) examines the status of spatial data infrastructure in developing countries and highlighted the issues facing in establishing spatial data infrastructures to support efficient urban land management. This paper describes the Bangkok Land

Information System to manage the urban environment. This study mentioned that design and implementation of a workable spatial data infrastructure in developing countries is often a dream for the future, and without a SDI, GIS are not possible.

Konecny (2000) point out that largest cost in a geo-spatial data infrastructure is related with the building and maintaining the databases. Thus, remote sensing for the preparation of thematic maps and cadastral photogrammetry for large scale base maps have very important role in building the database to support geo-spatial data infrastructure. Doucette and Paresi (2000) emphasized the need of quality management in geo-spatial data infrastructure including definitions of the responsibilities, authorities and accountabilities for the interfaces, main processes and procedures necessary to achieve quality objectives of the organization.

2.3 Remote sensing and GIS for urban applications

Remote sensing is a tool to provide information on existing land use and land cover and their updating and monitoring while GIS provides spatial data handling. Satellite remote sensing can be used to provide accurate, unbiased and timely information about the urban areas.

Raghavswamy (2003) mentioned a variety of urban applications where satellite based remotely sensed data are being applied. The important areas of applications are base mapping, urban sprawl/ urban spatial growth trends, mapping and monitoring urban land uses, urban change detection and updation, urban utility and infrastructure planning, urban land use zoning, urban environment and impact/hazard assessment, urban hydrology, urban management models, census or urban population estimation, urban green belt or open spaces mapping. Donnay (1999) also highlighted the advantages of use of remote sensing information in planning.

Generally, the features in the urban area (e.g., buildings, gardens and roads) are relatively small. The finer spatial resolution imagery resulted in fewer mixed pixels and, consequently, therefore more accurate interpretation than the coarser spatial resolution imagery. Developments in remote sensor technology, during the last few years, provide an innovative set of space borne systems with improved spectral and spatial mapping capabilities. In general, the spectral response from a land surface is strongly related to the sensor spatial resolution (Price 1997, Herold *et al.*, 2002). Herold *et al.* (2002) points out that there are only a few systematic investigations that specifically focus on the spectral properties of urban surfaces in general and their representation in high spatial resolution space borne remote sensing data.

The use of remote sensing along with GIS benefits in the better data integration, accessibility and enhanced utility, reduced cost with added efficiency, better integration of operations and collaboration with outside entities, good quality customer services (Vyas *et al.*, 2004b). Masser (1998) emphasized that geographic information must be seen as a special case of information as a whole. It is defined as "information that identifies the geographic location and characteristics of natural features and boundaries on the earth". This definition makes the distinction between two types of geographic information: location and attribute. Location is clearly essential in order to make information geographic. However, location information without attribute information is of little inherent interest.

2.3.1 Satellites and sensors

Advancement in the technology of remote sensing has brought miracle in the availability of the higher and higher resolution satellite imageries (Vyas *et al.*, 2004a). They are IRS-P6 Resourcesat imagery with 5.8 meter resolution in multispectral mode, IRS-1D Pan image with 5.8 meter resolution, IRS-P5 Cartosat imagery of 2.5 meter resolution with stereo capabilities, IKONOS imageries of Space Imaging with 4 meter in multispectral mode and 1 meter in panchromatic mode, Quickbird imagery of Digital Globe with 61 cm resolution in panchromatic mode and so on. Tanaka and Sugimura (2001) discussed the characteristics of the IKONOS sensor from the viewpoint of how its panchromatic and colour composite images are perceived. These high resolutions of the sensors provide a new methodology in the application with newly raised technical restrictions.

Table 2.1: Recommended spatial resolution of satellite images for various levels and scales of planning (Mahavir, 2000)

Level	Scale(s)	Spatial Resolution of Satellite Image
Regional Planning	1:50,000	72.5 m or lower
	1:100,000	
	1:250,000	
	1:1000,000	
Perspective Planning	1:50,000	36.2 m
	1:100,000	72.5 m
	1:250,000	
Development Planning	1:10,000	5.8 m
	1:25,000	10 m
	1:50,000	36.2 m
Annual Planning	1:5,000	5.8 m
	1:10,000	10 m
	1:25,000	
Project/scjemes/site Planning	1:500	1 m
	1:1000	5.8 m
	1:2,500	
	1:5.000	

Puissant and Weber (2002) assessed the utility of very high spatial resolution sensors to provide reliable and useful information for the end users (city councils, urban community, county) in urban planning, monitoring and management. An analysis of the capacities of new sensors to extract urban objects was carried out for different resolutions and with several extraction methods. The conclusions of the study recommended that a resolution of less than 0.80 m is necessary to study the urban morphology and to distinguish the three main constitutive objects of the urban structure (housing, vegetation, roadway network). In a discontinuous urban environment, where the urban structure is composed of homogeneous large objects (high buildings of more than 10 m), a "functional" resolution of 2 m is adapted. If the urban objects are smaller (houses of less than 5 m side), a "functional" of 0.80 m resolution is necessary.

Mahavir (2000) recommended spatial resolution of satellite images for various levels and scales of planning (table 2.1). High resolution images may be useful working at scales varying from 1:500 to 1:2,500 (i.e. site planning, projects and schemes), relatively lower resolution images would be more useful for planning at scales varying from 1:25,000 to 1:50,000 or 1:100,000 etc.

2.3.2 Various aspects of urban application

Urban remote sensing opens up enticing new prospects for comparing cities in terms of functional interrelationships and indicators of well being and the integration of the study of spatial forms with an understanding of social, economic, cultural and political dimensions that led to their creation (Longley *et al.*, 2001b). Mahavir (2003) emphasized the role of indicators for monitoring various aspects of human settlements. These ranges from socio-economic, health, belonginess, satisfaction levels, land more physical indicators like ecological performance, physical growth and development, and infrastructure. The available indicators vary in their scales of application (i.e. settlement level, sub-regional and regional level, national and global level).

2.3.2.1 Physical

Chen *et al.* (2001) compared semi automated and interactive visual based change detection approach for detecting and enumerating new building structures utilizing very high resolution imaged data. Result of the study demonstrated that visual based interactive approach appear to be most accurate and efficient for generating the information on the number of new buildings associated with single family residential land use.

Raghavaswamy *et al.* (1992) mentioned few examples of land use/ land cover mapping and monitoring urban sprawl using IRS data. Rural land use map was prepared for north-east region of Rajasthan, India. IRS LISS-I and LISS-II data were used for mapping land use/ land cover of parts of Sawai Madhopur and Tonk districts in

Rajasthan on 1:250,000 scale using visual interpretation techniques. While, the use of IRS satellite data in urban applications has been made for mapping and monitoring urban sprawl, land use, transportation, zoning, change detection and demographic studies for Srinagar, Allahabad, Bombay, Hyderabad, Madras, Nagpur and Banglore have been attempted using IRS, LISS-I imagery on 1:250,000 scale and IRS, LISS-II imagery on 1:50,000 scale using visual interpretation.

Lata *et al.* (2001) used IRS 1C (LISS-III+PAN) merged data to measure the urban sprawl of Hyderabad, India. This study demonstrated the utility of integrating of remote sensing and GIS techniques for entropy approach to identify, measure and monitor spatio-temporal patterns of urban sprawl in Hyderabad city and its environs.

Weber (2001) carried out study on urban agglomeration delimitation using remote sensing data. In this study, remote sensing data is used for the quantitative and repeatable measurements of the built-up areas and population density to define the concept of urban agglomerations. These measurements help in the development of different urban indicators related with different spatial structures. It can therefore make an important contribution to the definition and delineation of urban entities.

Pathan *et al.* (2004) adopted remote sensing and GIS based approach for the preparation of master plan of Indore city, India. For this purposes, IRS LISS-III plus Pan merged product is used for the preparation of thematic maps. The information system created using RS and GIS based methodologies has facilitated working out sustainability of urban environment and generating alternate planning scenarios. The information system has flexibility to accommodate any new data and provides integration as well as updation. It allows aggregating the information at any level i.e. Development authority or Regional level.

Barnsley *et al.* (2001) attempted to infer urban land use by spatial and structural pattern recognition in high-resolution satellite data. It focused on the production of land use data for urban areas from satellite sensor images. Several different methods have been developed to infer land use from an analysis of the spatial, textural and contextual arrangements of land cover types present within an image. This study highlighted the very considerable potential of the new generation of commercial satellites, which have on board very fine spatial resolution optical sensors and offers unprecedented opportunity for mapping and monitoring urban areas from space.

Kuo *et al.* (2001) also used IKONOS satellite imageries for the identification of urban characteristics. Land cover classification adopted total seven classes out of which urban areas falls under the only two categories - large structure and small structure. Guindon (2001) applied perceptual grouping concepts to the recognition of residential buildings in high-resolution satellite images. Jensen *et al.* (2001) used a neural network image interpretation system to extract rural and urban land use and land cover information from IKONOS data.

Zhang (2001b) used Landsat TM and SPOT pan data for the detection of urban housing development by fusing multi-sensor satellite data and performing spatial feature post classification. Zhang *et al.* (2001a) used GIS based approach for spatial dynamic modeling for urban development. Gar *et al.* (2001) used remote sensing data with integration of GIS for the measurement and monitoring of urban sprawl in a rapidly growing region using entropy. Harts *et al.* (2003) presented a prototype for a GIS based system to monitor the aspects of urbanization. GIS Database is used to trace the urban pattern changes over the period of time, which yields a policy relevant picture of changes in urban land use and density patterns. The approach formulated classification rules on the basis of the eight variables in the database after rasterisation of vector database. Applying these rules, the cells are classified according to a functional morphological typology of small urban areas. Comparison of data of 1990 and 1996 shows the changes in urban density, function mix and dynamics of urban pattern. Petit and Lambin (2001) integrated land cover maps obtained form aerial photograph of 1954 and SPOT multi-spectral imagery to obtain the changes in the land cover.

Accessibility is an important characteristic of urban areas and a crucial link between transportation and land use (Liu and Zhu, 2004). As urban transportation planning is increasingly being considered as an integral element of overall urban land use planning, accessibility is becoming a key element in analyzing the efficiency of transportation system, in predicting travel demand in programming transportation investments, and in evaluating planning policies in the urban transportation planning process (Tolley and Turton, 1995; Handy and Niemeier, 1997; Gutierrez *et al.*, 1998; O'Sullivan *et al.*, 2000; Liu and Zhu, 2004).

Matt *et al.* (2005) studied land use and travel behaviour from the perspective of utility theory and activity-based theories. Lu and Tang (2004) analysed the fractal dimension of a transportation network and its relationship with urban growth of Dallas-Fort Worth area. Liu and Zhu (2004) demonstrated Accessibility Analyst- an integrated GIS tool for accessibility analysis in urban transportation planning.

2.3.2.2 Social

Baudot (2001) carried out geographical analysis of the population of fast growing cities in the third world. This study emphasized that effective management of the urban population problem demands good diagnostic tools. Accurate and reliable information is also required to quantify the current situation and to predict future trends: information on patterns of land use is one obvious example, while basic data on population is another. Population maps derived from the remotely sensed data permit a far more efficient method of analysis and homogenous housing areas are socio-economic indicator of its inhabitants.

Craglia *et al.* (2004) worked towards the development of quality of life indicators in the information rich European city, termed as "digital" city. In this study, socio-economic indicators were kept in the central to the measuring the quality of life. This study concluded that the rapid evolution and transformation of the modern society make it necessary to update the conceptual and the empirical approaches needed to study living conditions in the urban areas. Gluhih and Portnov (2004) attempted to visualize the spatial patterns of inter urban income disparities in Israel.

Dayyeh and Ziadat (2005) applied remote sensing and GIS for understanding physical and social change in urban settings of Amman, Jordan. In this study, cadastral maps, aerial photographs and land use maps are used in conjunction with the other attribute data related to the statistics data on the construction of buildings and land ownership registry. Integration of spatial and non-spatial data provides the changes in the ownership patterns over the different time periods with the pattern of construction activity in the smaller study. This research concluded that such study give us a better view and understanding of the physical transformations in different parts of the city and subsequently allow us to define varying sets of issues that would in turn invite further investigation, which could eventually give us a better overall understanding of the spatial and temporal dimensions of change at the more general level of the city.

Lo (2003) evaluated the use of satellite data for zone-based estimation of population and housing units from land use/ land cover maps generated at census tract and county levels. Land use/land cover database prepared from Landsat MSS and TM imagery of 1973 and 1997 for the metropolitan area of Atlanta were used. This research found reasonably accurate estimates of population and housing units of city obtained from land use/ land cover maps produced from automated image classification of satellite sensor images in a zone-based approach.

Harvey (2003) studied population estimation at the pixel level. This study find that pixel based models use simpler and more robust mathematical formulations, provide greater spatially flexibility in application and are more amendable to spatially targeted refinement than zone based models. While Sutton (2003) used night-time satellite imagery for the estimation of human population.

Thomson and Hardin (2000) incorporated remote sensing and GIS integration to identify potential low-income housing sites in the eastern portion of the Bangkok Metropolitan area using Landsat TM data. This work demonstrated that how satellite imagery can provide both site specific information on land cover for mapping urban residential land use, and also act as a medium to generate a variety of GIS coverage.

This study concluded that the use of satellite imagery and its integration into a GIS can provide a timely and appropriate tool for identifying potential housing sites at medium scale. The thematic maps obtained at relatively low cost and in a short time compare favorable with traditional methods of investigation.

Pathan *et al.* (1993) also integrated satellite imagery of different time periods with the population profile derived from census data and demographic projection techniques to examine growth trends in Bombay metropolitan area. Lo (1997) incorporated socio-economic variables and satellite imagery to study the quality of life in Athens-Clarke County, Georgia.

Urban problems have a significant social and environmental dimension, requiring application of the 'principle of social responsiveness'. This means 'the ability of a corporation to relate its operations and policies to the social environment in ways that are mutually beneficial to the company and to society'. This is receiving increased attention due to the interdependencies of the many groups in our society. Such interdependencies are more crucial in respect of urban organizations, as urban development is a joint public private enterprise, where decisions about the use of resources are made in the market place and by governments (at various levels), in an interactive way. Therefore, there is need for a policy to apply the principle of social responsiveness in the operation of urban organizations, to indicate that they are discharging their social responsibilities (Chakrabarty, 2001).

Martin (1999) discussed the use of digital methods for the creation of census geography and introduction of GIS to UK census planning during the early preparation stages of the 2001 census. Alvanides and Openshaw (1999) illustrated some typical applications of zone design in planning. Zone design is introduced in relation to the modifiable area unit problem and illustrations of typical applications of zone design in socio-economic planning: electoral redistricting, studying redistricting, studying deprivation and creating safe data reporting areas.

2.3.2.3 *Fiscal*

Gnaneshwar (2003) discussed the broad picture of the municipal finances in Andhra Pradesh, India, covering the revenue and expenditure trends, strategies of financial improvement and the reforms in property tax administration. Unfortunately, the urban local bodies all over the country suffer from inadequate financial resources to undertake even the basic civic functions, not to mention about the developmental functions.

According to Singh (2001b), many of the municipal services are not directly priced or if priced (such as water supply) the rates are fairly low. Similarly it is difficult to quantify the use of many services (such as street lighting and street cleaning) and hence pricing itself is not possible. Overall recovery of amount spent by a municipal body is abnormally low, being only 10 to 30% of non-plan expenditure (National Institute of Urban Affairs, 1987, 1988, 1989). Property tax can be considered as a principal fiscal instrument to finance municipal services. For example, in Delhi over half the total revenue of Municipal Corporation of Delhi (55%) is generated by property tax. Thus, property tax is most important component of municipal finance. Although the constitution (74^{th} Amendment) Act 1992, envisages Urban Local Bodies to function as effective institutions of Local Self Government, they are in no position to discharge their Constitutional obligations in view of their poor financial health. To overcome from such deficits, Basu (2001), recommended for computerised database of municipal property. The concerned departments of Urban Local Body should regularly update the database.

Financing of a urban local government units is unique because each of them may be the creation of a separate statute. However, the nature of these organizations in terms of their constitutions, functions and financing is uniform. So the common aspects of financing of ULBs are procurement of funds for providing services. Therefore, it is rightly told that local government finances is concerned with raising its resources necessary to meet the expenditure needed to provide local government services (Bhattacharyya and Purohit, 2001). In such a context, Bhattacharyya and Purohit (2001) tried to find out the sources of finances, heads of expenditures, their trends, identification of new sources of finance and the evaluation of the financial performance of the Calcutta Municipal Corporation, India. Dhameja (2003) discussed the various issues related with the physical and social infrastructure and it's financing.

Singh (2000) emphasized the need of reforming administration of property tax in Uttar Pradesh, India. This paper discussed the assessment functions, which involve numerous technical and clerical activities that are required to convert a mass of data into a tax base. The administration of property tax is undertaken generally through following steps-

- Identification of properties through periodical survey and continuous visits,
- Details of properties,
- Fixation of rates,
- Valuation of properties,
- Assessment of properties,
- Levy of tax,
- Collection of tax,
- Monitoring and follow up.

Singh (2001b) discussed the unit area method based approach for the property tax assessment adopted by the Patna Municipal Corporation. The results of this new approach shows that net assessment of property tax to the corporation has increased. Singh (2001c) shared the experiences of the successful statewide reforms initiative in Tamil Nadu for improved financial accounting system in urban local bodies. This paper concluded that transparent financial information and standardized accounting practices not only enable effective governance, but also form the foundation for carrying out municipal credit ratings, development of commercially viable urban infrastructure projects, and involvement of the private sector in the delivery of urban services.

Patel (2001) point out that municipal sector reforms in Ahmedabad were initiated through a financial turn around. This involved reforms in the information base, assessment and collection mechanism of octroi and property tax to minimize under assessment and enhance recovery. This resulted to almost 100 percent increase in the revenue proceeds from these two sources.

2.3.2.4 Environmental

Rapid urbanization and adversely increasing man land ratio increases the pressure on urban land and makes it a precious natural resource. Development and distribution of open spaces in urban areas are essential to maintain urban environment and ecosystem. Distribution of open spaces varies in urban areas according to their densities (Jain *et al.*, 2003b).

The relationship between man made and natural features of cities are required to be redefined because-

- The impact of industrial revolution and motor vehicle on urban form, social relationship, resource exploitation and pollution could not have been foreseen 100 or even 50 years ago, which generate new problems for cities as well as urban planners.
- Due to urban agglomeration, the view of the countryside from the town, the symbol of pre industrial dependence has been disappeared and sizes of cities are increasing at faster rate.
- The value of sun light, fresh air, free movement in promoting health and the psychological need for the sight of grass, bushes, flowers, trees and open sky have been increased the value of open spaces.

Land covers in urban areas tend to change more drastically over a short period of time than elsewhere because of incessant urbanization (Zha *et al.*, 2003). To estimate the impact of light-coloured surfaces (roofs and pavements) and urban vegetation (trees, grass, shrubs) on meteorology and air quality of a city, it is essential to accurately characterize various urban surfaces (Akabari *et al.*, 2003). Information obtained from remotely sensed data on urban land-cover characteristics and their change over time may be related to ecological, demographic, socio-economic and dynamic aspects of developed regions at various spatial and temporal scales (Phinn *et al.*, 2002). Ridd (1995), states that modeling of storm water runoff, evapotranspiration, thermal properties, air pollution, water uptake by vegetation and impact of human response are a few of the areas of urban research that would benefit from refined information on urban land cover composition and distribution.

Akbari *et al.* (2003) also mentioned that researchers involved in the analysis of urban climate have tried to estimate the composition of various urban surfaces. Satellite remote sensing has the potential to provide a useful monitoring tool by visualizing the various factors of city fabric and their changes in relation to policy scenario. Increased spatial resolution will help in an accurate estimation as well as reliable relationship among various land covers at micro level. Ong (2003) emphasized that current research on sustainability of cities has favored the implementation and conservation of greenery in the urban context. According to Zhang (2001c), inventory and mapping of urban treed areas is important for urban environment study and urban planning.

Krafft *et al.* (2003) tried to find out the impact of urban growth on environmental degradation and health risks. This study concluded that comprehensive research approaches covering social, economic, environmental and medical issues of environment related health aspects would help to improve our understanding of complex interdependencies in this field of research.

Hebble *et al.* (2001) re-examined the correlation between housing lot size and impervious surface area using Landsat 5 TM image data. The results showed a distinct correlation between lot size and impervious surface area. Areas with smaller lots generally have larger average impervious surface area. Claramunt *et al.* (1999) discussed the role of GIS technology in database modeling for environmental and land use changes.

Green open spaces are termed as the "lungs" of the city in ever growing urban areas, hence these should be developed properly to achieve a satisfactory social, economic and ecological environment and quality of urban aesthetic. In general, "open spaces" is a comprehensive term used for wide variety of open areas on which nothing has been built. It includes vegetation cover, playground, parks as well as barren lands. Private green space is commonly ignored in land use maps and yet may constitute a larger share of the urban system than public green spaces (Jain *et al.*, 2003b).

Freeman and Buck (2003) developed methodology for ecological mapping of urban areas in New Zealand. A comprehensive database containing information on all open space types is emphasized to inform decision-making regarding development proposal and to guide the future development of open space and natural habitats. Such information is necessary to develop urban amenity indicators to evaluate opens spaces, its type, quantity, quality and other factors such as accessibility.

2.3.2.5 *Legal*

As per the census of India, 2001, total 607 towns in India recorded slums. Total population of these towns is 1783.9 lakh, out of which 406 lakh people are living in slum areas. It is about 22.76% of total population of 607 towns having slums. The estimated requirement of dwelling units in slums is about 8.12 lakh.

Sliuzas (2001) referred the citywide estimation of development density in informal settlements from SPOT satellite images for Dar es Salaam. The study found that the adoption of digital mapping technology makes it possible to use roof area coverage as a measure of density in informal areas. These data sets can be combined with sample socio-economic surveys to estimate population and other socio-economic characteristics of informal residents. In this manner, relatively straightforward and replicable approaches to generating data on the dynamics of informal settlements can be developed.

Malcolm *et al.* (2001) identified the locations of poverty areas using integration of RADARSAT and Landsat imagery in Rosario, Argentina. The result of the study outlined that the characteristics of these areas and misclassification results in over estimation for locating likely areas of urban poverty. The poverty area class received a much larger portion of the total area than is the reality of urban poverty in Rosario.

Thus, use of high resolution satellite data is a necessity to mapping and monitoring of these areas.

Dare and Fraser (2001) mapped informal settlements using IKONOS satellite data and compared panchromatic and MS imagery. The variation in texture and radiometry of the 4 meter image are sufficient to classify different types of urbanization and hence separate formal from informal settlements. However, the 1 meter image allows more detailed analysis of the informal settlements since it clearly shows individual buildings as well as roads, paths and tracks. Furthermore, fusion of the panchromatic and multi-spectral data highlights differences in the underlying soil and vegetation in the informal settlement, a feature that is not obvious in the raw panchromatic data.

Daniel (2001) discussed the integrated programme for social inclusion in the city of Brazil. The programme was implemented in selected slums and focused on poor through a two pronged criterion i.e. economic indicators and non-economic indicators. The programme has been taken up in a highly participatory manner and specific support under the programme covers the basic municipal services, integration of housing and income generation, slum upgradation, basic education and other social facilities.

In many developed countries, a land use survey constitutes a legal prerequisite to any urban planning process. This is often undertaken by a compilation of maps and aerial photographs complemented by some field survey, but increasingly such land use survey is becoming a typical application of satellite remote sensing (Donnay, 2001a).

2.4 Urban Regime: Present status

Urban regime is comparatively new concept came into existence in late 1990. The term 'urban regime' was used first time by Clearance Stone (1989) to describe the government of the American city of Atlanta. Afterwards, Stoker used Stone's case as a starting point for working out a foundation for 'urban regime theory'. Numerous authors gave different definitions to define urban regime and related theory.

2.4.1 Definitions

The meaning of "regime" as per Oxford University Dictionary is 'way of administration'. Thus, literary meaning of 'urban regime' is 'way of urban administration'. According to Cornelissen *et al.* (2004), urban regime theory (URT) is based on the complexity of civil society. To be able to govern within that complexity, a coalition is required. An urban regime is such a coalition. Essential characteristics of an urban regime are co-operation between public and private actors and durability. Stoker (1995) states that urban regime theory offers a new concept to make valuable analysis of city governments. Stone (1989) defined an urban regime as "the informal arrangements by which public bodies and private interests function together in order to be able to make and carry out governing decisions." This definition builds on the fact that formal structures of local governmental authority are inadequate by themselves to mobilize and coordinate the resources required to "produce a capacity to govern and to bring about publicly significant results".

Mossberger and Stoker (2001) described urban regimes as coalitions based on informal networks as well as formal relationships, and they have the following core properties:

- partners drawn from government and nongovernmental sources, requiring but not limited to business participation;
- collaboration based on social production - the need to bring together fragmented resources for the power to accomplish tasks;
- identifiable policy agendas that can be related to the composition of the participants in the coalition;
- a longstanding pattern of cooperation rather than a temporary coalition.

Stone (2002) defined an urban regime as the set of informal but relatively stable arrangements by which a locality is governed. The study of urban regimes offers one perspective on civic cooperation. Regime arrangements are informal because there is no overarching power of command. Cooperation stems from a non-coercive inclination to work together. If the inclination is weak and unsteady, as it often is, the regime is weak.

Regime theory views regimes as the collaborative arrangements through which local governments and private actors assemble the capacity to govern. From its origin it has been a tool to explain public and private sector relationships. And the concept has been applied to other areas beyond this area (Jo, 2002).

Saartenoja (2003) points out that regime theory can be used to interpret administrative and structural multiplicity in urban context. In the light of urban regime theory, three essential questions come up: what is the co-operation capacity among different agencies, do they have common aims and what kind of regime types they are able to formulate. Regimes recognize the diverse nature and the horizontal network model of the interaction fields. In the same time the regime aims to control and outline the interaction by holding the co-ordination role within the city and supporting the formation of different centers for improved management.

2.4.2 Indian Context

In Indian context, for several reasons, urban regime is not clear, as one would expect. Way of urban administration/governance and planning in India is formulated within the framework provided by 74th Constitution Amendment Act (CAA) and Urban Development Plans Formulation & Implementation (UDPFI) guidelines. 74th CAA forms the basis for the urban local governments, while UDPFI guidelines provide the framework for the planning at different levels from regional to local level.

The 74th CAA empowers Urban Local Bodies for the development and management of city. Municipal Corporation is responsible for the urban basic services including waste management, water supply, public health, and local tax collection. The urban development authority is responsible for the planning of a broader area including the municipal corporation area and the area defined for future development. The district administration is responsible for smooth governance in the district including law and order of the city. The limited integration and sharing of information pose an extreme difficulty to integrated planning and development. As a result, poor plan implementation and slow coordination give rise to prolonged project assessment, delayed development and illegal construction everywhere in the city. The relationship between Municipal Corporation, development authority, district administration, the district development authority and metropolitan planning committee is usually under developed (Rout, 2002).

It is unfortunate that despite the apparent enthusiasm in support of decentralization, there is no concerted attempt in the country to standardize the municipal database, barring a few fragmented efforts in a few cities. Nonetheless, there is one clear-cut prescription that has come from a large number of agencies, involved in municipal finance. They want the local bodies to segregate the earnings and expenditures for different sectors and maintain separate accounts (Kundu, 2002).

2.4.2.1 74^{th} Constitutional Amendment Act (CAA)

The municipal government/local government has attained a special status as the government at the third level, after the two levels of Central and State governments after 74^{th} CAA, 1993. The twelfth Schedule of the Constitution 74^{th} CAA, 1993 on municipalities enumerates eighteen major functions belonging to the legitimate domain of the municipalities:

(i) Urban planning including town planning;
(ii) Regulation of land use and construction of buildings,
(iii) Planning for economic and social development,
(iv) Roads and Bridges,
(v) Water supply for domestic, industrial and commercial purposes,
(vi) Public health, sanitation, conservancy and solid waste management,
(vii) Fire services,
(viii) Urban forestry, protection of environment and promotion of ecological aspects,
(ix) Safeguarding the interest of weaker sections of society, including the handicapped and mentally retarded,
(x) Slum improvement and upgradation,
(xi) Urban poverty alleviation,

(xii) Provision of urban amentites and facilities such as parks and gardens,

(xiii) Promotion of cultural, educational and aesthetic aspects,

(xiv) Burial and burial grounds; cremations and cremation grounds,

(xv) Cattle pounds, prevention of cruelty to animals,

(xvi) Vital statistics including registration of births and deaths,

(xvii) Public amenities including street lighting, parking lots, bus stop and,

(xviii) Regulation of slaughterhouses and tanneries.

But present system of municipalities is unable to meet the challenges of rapid urbanization. Changes in urban areas arising from new land use policies or zoning regulations, new transport infrastructure and others are difficult to monitor. In fact, absence of information about rapid changing urban areas is a challenge for monitoring and management of basic services. Hence, improved tools for monitoring and management of urban areas are of immense requirement of local bodies.

Venkatakrishnana (2003) emphasized the need of e-governance in a municipal corporation in India with detailed study of Visakhapatnam Municipal Corporation. Gnaneshwar (2000) studied the post constitution 74th Amendment scenario in Andhra Pradesh and Tamil Nadu to examine the municipal functions. This study recommended that a longer perspective must be taken for modernizing and capacity building aspects of the ULBs on a priority basis to meet the emerging challenges of urban growth. Streamlining tax administration, reforming accounting and budget practices, developing database and computerization, active involvement of the people and fostering of partnerships basis are some of the areas which need specific attention in this regard.

Singh and Maitra (2001a) presented case study summarizing the ongoing decentralization process in the states of Kerala and West Bengal. This paper discussed the people's participation in urban governance at grass root level through formation of wards committees. The functions of ward committee include identification of problems and priorities of the ward, supervision of the municipal works, planning and undertaking development activities, convening annual general meetings, and submission of administrative and financial reports and resolutions adopted to the municipality.

Jain (2002) discussed some issues related to massive urbanization and urban governance in Indian situation. This paper concluded that quality of urban governance can be improved through decentralized decision-making models and feedback mechanism. According to Likhi (2000), although, the 74th Amendment to the Constitution of India empowers the local bodies with the responsibility of planning and governing the areas under their jurisdiction, the necessary institutional structures with clearly defined roles, reforms in legal and regulatory frameworks as well as systems and procedures required for effective implementation of the Amendment, have yet to be developed.

2.4.2.2 *UDPFI Guidelines*

Taking into account the problems of existing planning system of urban development in India, the UDPFI Guidelines (1996) recommended urban development planning system consisting of a set of four inter-related plans i.e. (a) Perspective Plan, (b) Development Plan, (c) Annual Plan and (d) Plans of Projects / Schemes (Anonymous, 1996a).

Perspective Plan: Perspective Plan is a document, containing spatio-economic development policies, strategies and general programmes of the local authority. This plan presents to the state government and people with the intentions of the local authority, regarding development of the urban center in the next 20-25 years. The scope of this plan covers social economic and spatial development goals, policies and priorities relating to all those urban activities that have spatial implications. It would also cover long-term policies regarding development of infrastructure and resource mobilization that are necessary to promote urban activities. The special care is required to be provided in this plan to minimize the conflicts between the environmental protection and urban development.

For the preparation of perspective plan, base map 1:10,000 or large along with decadal population growth and other inputs like slope, soil, geomorphology, hydrology are required.

Development Plan: Development plan prepared within the framework of the approved perspective plan is medium-term (5 years) comprehensive plan of spatio-economic development of the urban center. The objective of a development plan is to provide further necessary details and intended actions in the from of strategies and physical proposals for various policies given in the perspective plan depending upon the economic and social needs and aspiration of the people, available resources and priorities. The scope of this plan covers an assessment of current issues, prospects, priorities and proposals for development of the urban center including employment generation, economic base, transportation and land use, housing and other infrastructure, and matters like environment, conservation and ecology. It also contains implementation strategies, agency-wise (including private sector) schemes projects, development promotion rules, and resource mobilization plan with particular reference to finance, land and manpower and provides an efficient system of monitoring and review.

A development plan is a statutory plan, approved and adopted by the local authority for implementation with the help of schemes and projects and would be co-terminus with Five Year Plans of state governments / local bodies, which would provide opportunities to incorporate the needs and development aspirations of the people through the elected representatives. For this purpose, base map at 1:4000 or larger along with trend of population growth are required.

Annual Plan: The purpose of preparation of Annual Plan, is to identify the new schemes/ projects, which the authority will undertake for implementation during the year taking into account the physical and fiscal performance of the preceding year, keeping in view the priorities, the policies and the proposals contained in the approved development plan.

These Plans would also provide the resource requirements during the year and the sources of funding including those mobilized by the local authority, grants, aids and project/scheme funds of the state and central governments. It is thus an important document for resource mobilization as on its basis the plan funds will be allocated by the funding agencies. The base map up to the scale of 1: 2000 is sufficient for the preparation of annual plans.

Plans of Schemes/Projects: Conceived within the framework of the Development Plan, schemes / projects are the working layouts, providing all necessary details for execution including finance, development, administration and management. These schemes/ projects could be for any area, old or new; of any activity or land use, like residential, commercial, industrial, recreational, educational or health related; or infrastructure development separately or in an integrated manner; by any agency such as government, semi-government, private or even individuals; or for any agency prepared by town planners, architects, engineers as the case may be.

The schemes / projects provide all the required planning, architectural, engineering, financial and administrative details required for execution. These are to be prepared by the respective executing agencies, which could be public or private. The very large scale maps with a scale of 1:500 to 1:1000 are required for this purpose.

As per UDPFI Guidelines, *implementation of Development Plans* has to be through Annual Plans and projects. The various steps for effective implementation include:

- formulation of the Annual Plan and identification of projects for implementation within the framework of approved Development Plan,
- identification of a various agencies responsible for (i) development promotion and management and (ii) execution of action projects and schemes,
- actions for implementation would include public -sector interventions, private sector actions and joint venture or public-private partnership.

Public Sector Interventions: Public sector interventions pertain to legal and non-legal matters and capital improvement programmes, however, prioritization of projects, under capital improvement programmes would need more inputs.

Private Sector Actions: Private sector actions for implementation of development plan/projects includes formulation of project, fiscal resource mobilization, execution of the project, its management and post-project maintenance. Private sector can execute all types of projects provided they are economically viable and remunerative. Under the current liberalization policy and policy of private sector participation in implementation process, less resources are likely to be made available to the local authorities as plan funds, or grants, role of private sector will, therefore, 'be increasingly significant and should be effectively utilized.

Joint Venture: Joint venture or public-private partnership is yet another system for effective implementation of development plans. It is an effective system and can be used to ensure social commitments towards the community and people below the poverty line.

The products of planning process and potential stakeholders as suggested by Gautam (2003) are given in figure 2.3. The primary function of urban planning organization is to prepare blue prints to direct the future physical development of human settlements and their regions in a sustainable manner. The products are in form of written policy documents providing technical services to the society. Different walks of city community to plan and execute their own developmental projects and programs thus utilize these products.

2.4.3 Overview of Planning Process

While developing the database for information system, generally the argument concerns whether data is needed for management and forward planning, different to that required for administration. It is generally found that there is little difference between planning and administrative data. A database approach is useful in day-to-day administration, while available as a by product for routine monitoring and planning. The noncorrespondence between administrative and planning data is more due to the role of data collecting agencies and incompatibility among them. Rehman (2000) recommended the following data to deal with the planning tasks.

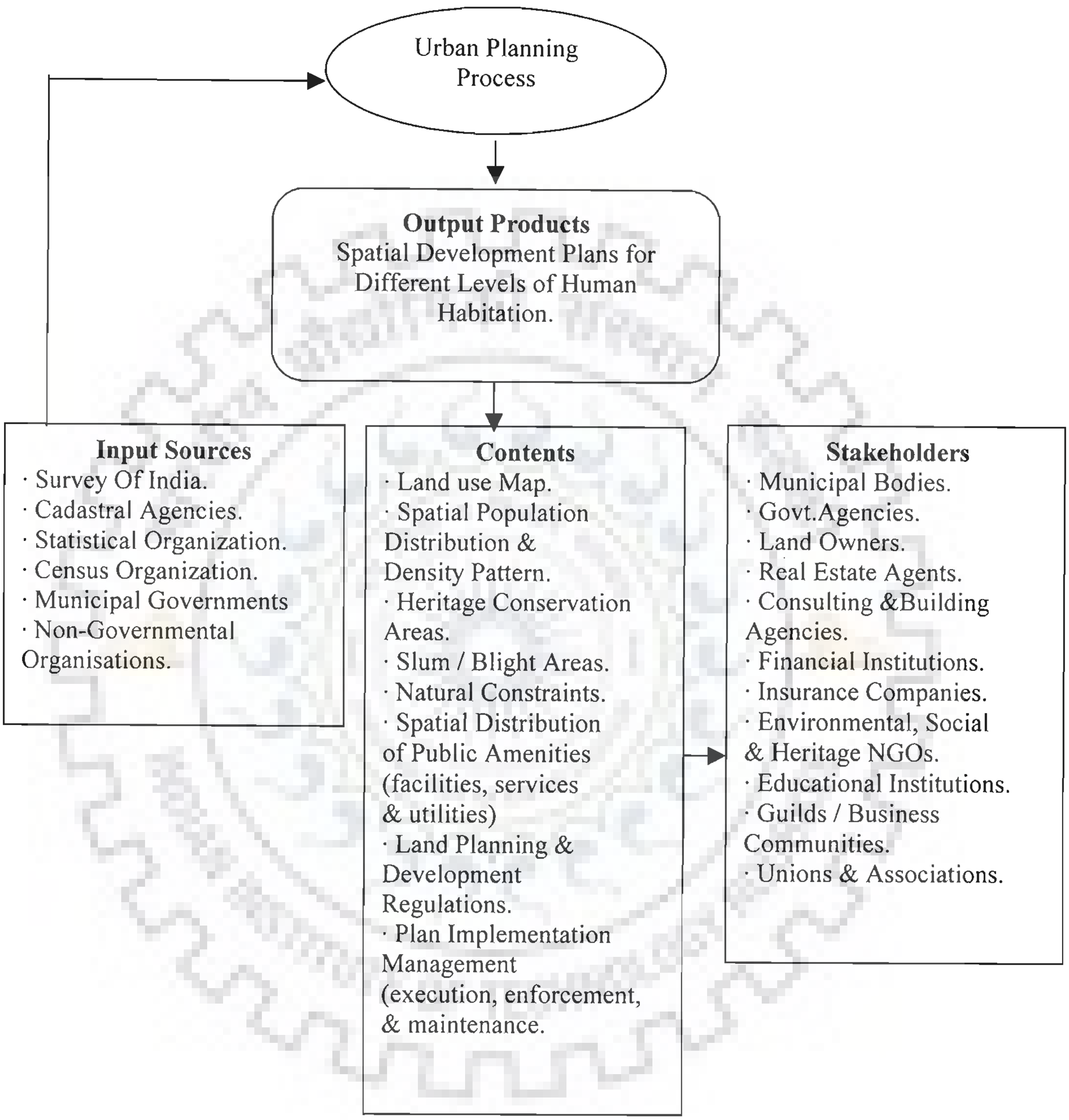


Figure 2.3: Urban Planning Products And Stakeholders (Source: Gautam, 2003)

Base Map: If there is one problem faced by the Planning Community, which needs immediate attention, it is Base map. Before taking up any project of spatial planning, the planners need a base map on which or with the help of which they could depict their own markings or design features.

Population Data: Population data is another basic requirements for the planning. The basic source of population data is Census of India. Census data is collected at the interval of ten years. But data for intermediate years are collected through primary survey.

Environmental Data: This data consists of several layers related with environment such as layers of soils, geology, vegetation, landform, hydrographic, slope and related geographic features. In a typical municipality, these layers are used to associate the suitability and capability of land for various types of uses.

Planning Related Data: Any planning activity requires some special data, which should keep in separate layers. Planning related data component contains layers of urban land use, development plan land use, zoning, special district/planning areas, special management areas etc.

Network Facilities Data: This data component consists of layers, which indicate information for locations of roadways, utilities and infrastructure, layouts (i.e. lines for water, sewer, cable television, gas, electricity, hydro, sidewalks, fire hydrants, utility poles, etc.). These maps are typically used for reference in grading and construction of facilities.

Land Records Data (Parcel Data): These maps provide the basic drawings of land ownership boundaries for all public and private lands. Parcel maps are typically maintained at a variety of scales and may range from precise to very general maps.

Structure Data: These are the architectural and engineering drawings of the buildings. These highly detailed engineering records are considered in evaluating cartographic activities within the municipality.

Utilities Data: These layers hold information on the location of utilities. It includes tube wells, water pumps, electric transformation etc.

Street Network File: This is typically a topological street network file providing intersection numbers, street names, link numbers of each street, address ranges of the streets and the polygon to left and right side of the street. This street base files provides a linkages between address data and street faces that surround a municipal block. By using the concept of address geo-coding, parcel data may be matched with the street network to create street tabular data.

Administrative Data: Area data bases comprised with the polygon outlines of blocks, enumeration areas and various administrative boundaries such as school districts, police districts, census summary district, zip codes and so on. These maps correspond directly to the area tabular data described above.

According to Cowie (1974), the process of planning involves a five-step paradigm of data use to-

- o indicate and define a problem
- o be used to analyze the problem
- o be used to generate alternative courses of action
- o be used to implement a paradigm to alleviate the problem as suggested by item (iii)
- o provide feed back for monitoring.

Planning is a continuous process and requires up-to-date information at each step of decision-making. Traditional information system tend to be static in that once collected and stored with no arrangements made to keep it regularly up to date. Updation at various levels independently is a costly and time-consuming process.

Traditional practice usually involves a stage of survey and data collection after problem definition but before the problem can be analyzed. The initiative towards information system development arises from planning departments to cater the needs of continuously reviewed development plans imply a dynamic database. It accepts the links between continuous review and a dynamic database for system developments on the grounds of requirement to fulfill statutory responsibilities. An information system can allow greater flexibility in the use of data collected for the purpose of plan making (Jain *et al.* 2003a).

Chakrabarty (2001) stated that the principle of flexibility and navigational change, providing for plan review from time to time, and redrawing them if required, is an accepted traditional practice to cope with uncertainties. It is also suggested that, because of too numerous pay-off matrices and uncertainties in the urbanization and development process, an incremental planning approach with flexibility should be adopted for guiding the development of cities, providing for constant feedback about the response of the urban system, and for changing again and again the rules (such as zoning, provision of infrastructure and so on). Urban planning (including land-use planning at 'urban spatial unit' level) should be seen as part of the 'planning function'. It is necessary to compare plans with results, and to take corrective actions in order to achieve results, thus making planning and control functions inseparable.

Various stakeholders have put forward a number of reasons for poor/ non-implementation of development plans and policies. Most important is the non-preparation of detailed plans at lower levels like zonal plans even in the case of Delhi Master Plan / Bhopal Development Plan. However, four major reasons, which are often underscored-

- o inadequate people's participation in the preparation as well as in implementation;

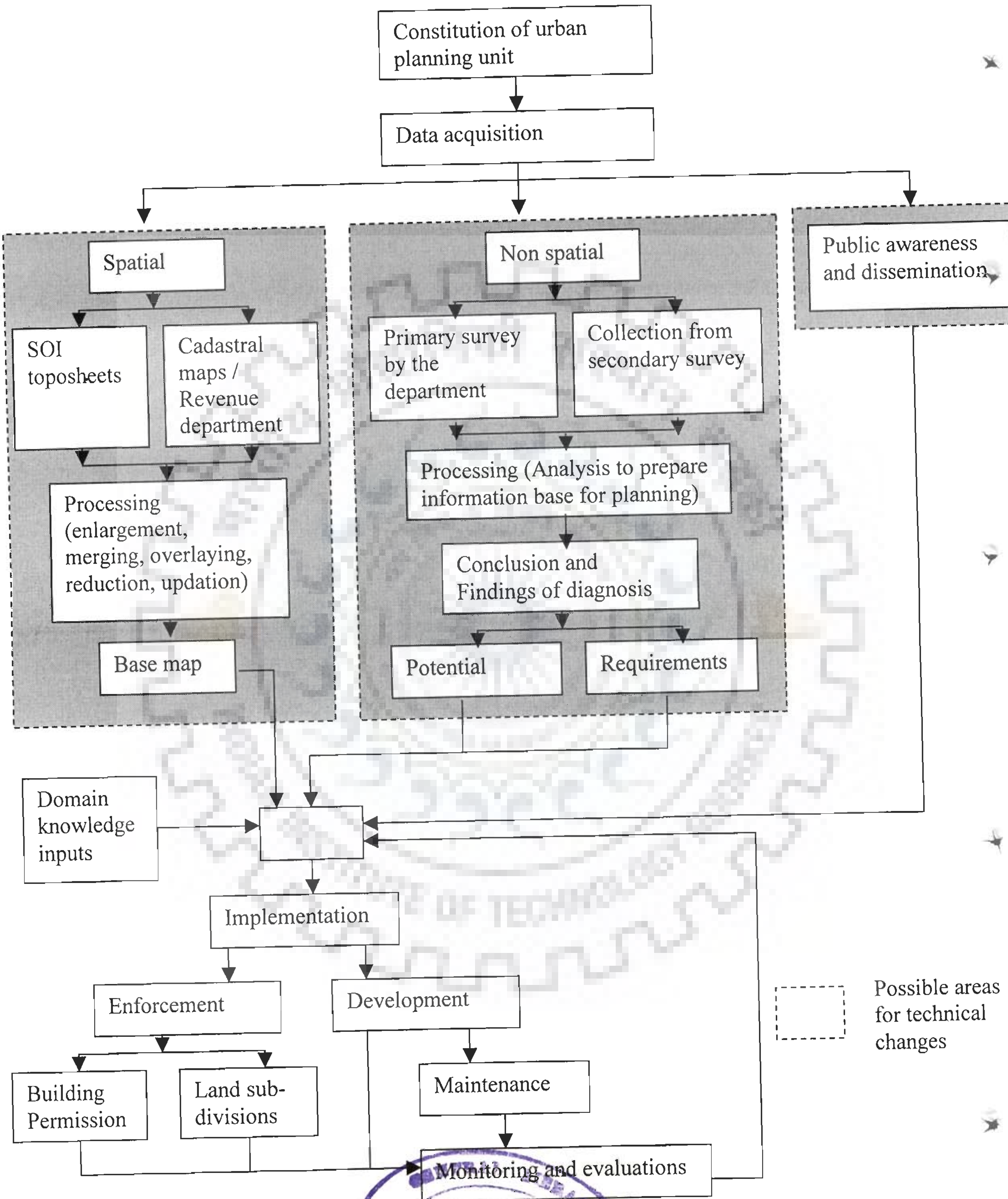


Figure 2.4: Existing Urban Planning Process Model (Source: Gautam, 2003).

- political interference;
- weak financial resource base of urban local bodies;
- lack of co-operation and coordination with other related organizations and line departments or agencies responsible for the development and governance of cities and towns.

Gautam (2003) carried out project on optimization of Urban Plan Preparation Business Process using Geoinformation Technology & Management Techniques. The project aim was to optimize the Urban Plan Preparation Business Process (UPPBP) by suggesting changes in institutional, technological and managerial aspects of its functionality, to make it more robust and fit to meet the emerging challenges on it at. The existing urban planning business process model (figure 2.4) highlights the possible areas for technological change.

2.4.4 Organizational Setup

Advances in technology seem to evolve faster than the institutional and organizational capacity to adjust to them and absorb them. Although technological solutions carry with them the potential to revolutionize the planning, management and administration of urban development, organizational capabilities and structures remain unprepared for the new forms and processes required for effective utilization of planning and decision support systems (Godschalk *et al.*, 1986; Bollens and Godschalk 1987; Nedovic-Budic 2000).

2.4.4.1 Existing Scenario

Eagleson *et al.* (2003) points out that the problem of spatial hierarchy and data integration are also related with the organizational setup. Historically, countries have divided social, economic and political responsibilities amongst a variety of agencies. In turn, these agencies have established independent administrative, planning and political boundaries that rarely coincide (Robinson and Zubrow, 1997, Huxhold, 1991 and Eagleson *et al.*, 2003). Various agencies related with development of urban areas in India are-

- Municipal corporation/ Municipalities
- Town & Country Planning Department

- o Urban Development Authority
- o Electricity Board
- o Water Supply Board
- o Telecommunication Department
- o Public Works Department (PWD/ CPWD)

Municipal Corporation is the supreme body at city level. The main objective of municipal government is to provide basic services to the citizens. A municipality serves the community through several departments, each of which performs one or several urban management functions.

Town and Country Planning Department are state level institutions established under law to fulfill the prime objective of optimum, sustainable and judicious utilization of land resources by devising strategic plans from regional to local level.

Urban Development Authority is responsible for the enforcement of development plan and monitor the development in the city. It is also responsible to full the demand of various sectors i.e. residential, commercial etc. from time to time at reasonable cost. Its jurisdiction varies and depends upon the population.

Electricity Board is an independent organization under the Ministry of Power supply. It is responsible for the infrastructure development for power supply, billing and tariff collection etc.

Water Supply Board consists of two organizations, Jal Nigam and Jal Sansthan, which are responsible for providing water supply with different type and level of services including tariff structures associated with the respective cost of the service, planning and design of the relevant scheme, supervision of implementations (generally by private contractors), contract management and technical assistance to local communities as required in identifying water supply and sanitation options etc.

Public Works Department *(PWD)* is responsible for the development of road network with the city. It is an independent department within the Municipal Corporation.

Central Public Works Department *(CPWD)* is responsible for the construction of buildings for state/ central government and development of highways. This is an independent institution under the Ministry of Urban Development.

The institutions involved for urban management lack co-ordination. Over the period, to address the urban problems the, state government has created many parastatial institutions such as water supply, public health, and public works department to assist the local bodies. But these institutions pursue their own objective, which the local government may not have in mind for development. The development of institutions and rules determining the behavior of urban managers are important. Urban management is relatively new discipline, born out of the need to deal with the problems of cities. Administering the happenings in the city is no longer enough to manage a city (Rout, 2002). In India, urban local bodies are facing following problems-

- Absence of spatial database,
- Uniformity of database,
- Accuracy of database,
- Difference in attribute,
- Integration of information

Eagleson *et al.* (2003) illustrates (figure 2.5) an abstract view of the current situation. Each agency establishes a differently sized or shaped spatial unit, based on their individual- and often unique- requirements, using the land parcel (in most cases) as the bottom layer. In turn, each agency aggregates these boundaries in a hierarchical fashion to cover the state. The problem of spatial hierarchy has occurred due to hand drafted paper maps in individual organizations.

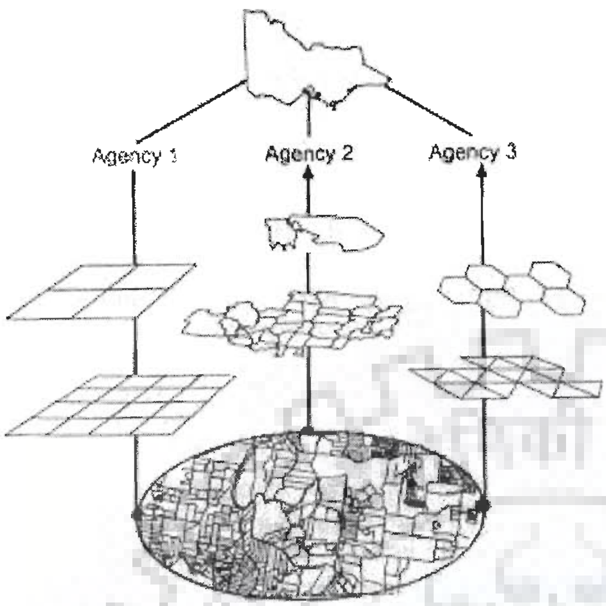


Figure 2.5: An abstract illustration of the various boundary layers that exist in Victoria (Source: Eagleson et al.,2003).

GIS implementation in organizational settings is a complex process that involves installing, maintaining, using a system in (institutional) environments that have diverse functions, tasks, resources, motifs, interests and goals (Nedovic-Budic and Pinto, 1998, Moudon and Hubner, 2000). Bueren *et al.* (2005) emphasized the need for improving governance arrangements in support of sustainable cities in The Netherlands. Chakrabarty (2001) discussed the concept, principles, techniques and education of urban management with special emphasis as distinct discipline to help application of an integrated urban management approach using modern management techniques, to solve urban problems efficiently and effectively. McGill (2001) suggested urban management checklist from the city manager's perspective of developing countries.

Eason (1988) in his book "Information technology and organizational change" discussed the various aspects related to the organizational restructuring such that design and implementation process, specifying the system, user evaluation, information technology strategies etc. Moudon and Hubner (2000) explored that organizations are related dynamically to the technologies that serve them- they influenced each other as they changes over time. This relationship is complex and evolves slowly. In the arena of local governments, organizational change often trails behind technological change and thus slows the creation of conditions in which geographic information systems can be used effectively for land supply and capacity monitoring.

2.4.4.2 *Need for Organizational Restructuring*

Nedovic-Budic (2000) found that one of the main reasons for planning agencies to seek adoption of GIS technology is its capability to integrate graphical and tabular data from various sources and across different areas. Many GIS functions match the day-to-day needs of planning practice. Unfortunately, in the face of those needs, there is little coordination among organizations and jurisdictions, and GIS and database developments remain fragmented even within single organizations.

Campbell and Masser (1995) in the book "GIS and Organizations" discussed the effectiveness of GIS in practice. This book has discussed the various aspects related to the diffusion of GIS within the local government. The diffusion of GIS in British Local Government is taken as case study to highlight the benefits and problems associated with GIS, reasons to adopt GIS in organizations, characteristics of the GIS technologies being implemented in the case study authorities, system development etc.

Three core tasks emerge to ensure that local governments fully exploit advances in technology for the purposes of system (Moudon and Hubner, 2000 & Nedovic-Budic, 2000)-

- identifying and motivating the agencies included in inter-organizational activities aimed at coordination and corporation in developing GIS and sharing spatial data,
- finding the most effective techniques and strategies for achieving successfully inter-organizational activities integration,
- understanding the changes required for incorporation of the new technology into organizational processes and for improving the flow of information between organizations.

Nedovic-Budic (2000) emphasized that at a minimum, planning agencies will have to establish links with land records management and tax assessment offices, zoning administration and building permitting units. These "links" involve a true integration of organizational processes, functions, personnel and resources. The changes associated with such links will likely generate impacts across organization-indeed, the uncertainty related to the anticipated impact may be sufficient to stall the integration efforts. Focusing on the minimal partnership necessary for establishing parcel based GIS, the interdependence between planning agencies and land records management and assessment offices is examined. So far, the relationships between these agencies have been mostly one-way: land records and tax assessment offices generate data that are essential for planning operations; thus, planning agencies are dependent on these offices. Some reciprocity is also evident: land records and tax related databases often include information derived from planning implementation documents, such as zoning ordinances and maps. It is also argued that the land records and tax assessment offices would benefit from more detailed and precise information on land supply and capacity, their dependence on planning data should be further clarified (Meredith, 1995, and Nedovic-Budic, 2000).

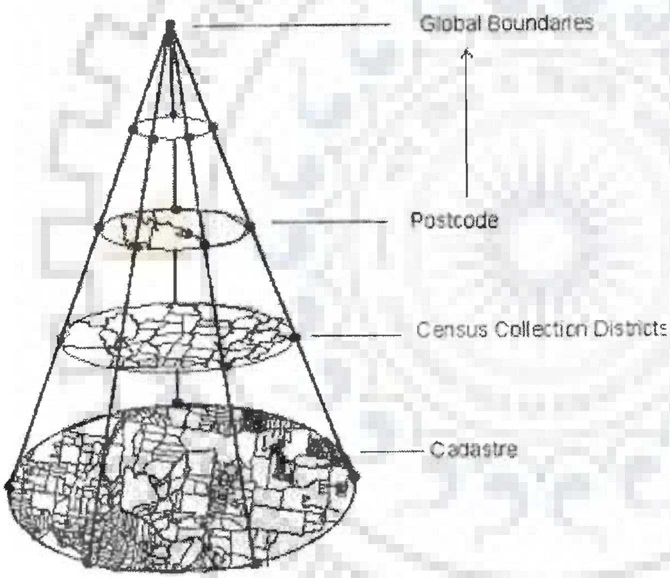


Figure 2.6: Future hierarchically organized administrative structures.
(Source: Eagleson et al., 2003).

Thus, Eagleson *et al.* (2003) proposed design of administrative boundaries in support of SDI (figure 2.6). The development of a coordinated spatial hierarchy is intended to provide a framework in which agencies are able to construct administrative boundaries based on a common spatial layer. These boundaries are then aggregated to form new administrative units that meet the needs of more than one agency. It provides freedom to analyst to examine alternative scenarios, whist preserving the confidentiality of individuals.

Masser (1998) point out that the development and implementation of a coordinated national geographic information strategy is likely to depend heavily on the extent to which there is a spirit of collaboration between the various government agencies involved with geographic information. The case study of geographic information infrastructure in Britain, The Netherland, Australia and United States demonstrated that a wide range of government agencies are involved in the collection and dissemination of geographic information. Thus, it has been necessary to leave out many of these from the detailed analysis for practical considerations and to concentrate the discussion around the activities of three main types of geographic information providers: agencies with responsibilities for land titles registration, surveying and mapping agencies and organizations concerned with socio-economic data provision.

2.5 Inferences

- The inferences drawn from this part of research shows that present organizational setup in India is established during last 50 years. Impact of population explosion and technology on urban form, social relationship, resource exploitation and management could not have been foreseen 50 years ago. The present sets of data from different sources used by the planners' are often incompatible.

- The failure of urban planning is result of general mismanagement and lack of accurate and timely information. Urban planning requires inputs from different experts of various disciplines. Proper and timely interchange of information at different levels is required for planning and management. Thus, spatial data infrastructure is the basic requirement of any city for effective planning, its implementation and management.

- Urban planning decisions are often characterized as a result of a complex deliberation process that involves consideration of many factors. Planning control occupies an important stage in the whole development process where the developers get into closest contact with the planners. Planning certainty is essential in ensuring credibility and legitimacy of the planning process. However, the decision making process of the planning authority remains dependent upon unorganized data. It is argued that planning policies must always be responsive to unforeseeable circumstances over time. Decision making in urban planning is often describe as a complicated process that involves consideration of a whole range of factors.

- To fulfill the needs of planning, various aspects of the data base organization are necessary to examine to fulfill the demands made upon it. The organization of the data system and its regular updation should be able to accommodate the changes in the urban system, over time. Since most of the data is collected and supplied by different agencies, standard procedures need to be devised for the collection, coding and storage.

- Town and Country Planning Organizations are responsible for planning tasks. After an urban plan takes effect, it is used by related development agencies, municipalities to assess and monitor development in the city. This structure strongly emphasizes the top-down approach in city planning.

- Successful planning requires that planners must have full assessment of urban conditions to work out alternative plans that optimize the use of land and resources, protection of the environment and preservation of heritage and landscape. Planners and managers urgently need an effective method to improve land related information integration and sharing in planning works for implementation of plans at different levels.

- The integration of remote sensing and geographic information systems in urban planning applications has become increasingly common in recent years. Remotely sensed images are an important data source for urban GIS applications and conversely GIS capabilities are being used to improve planning procedures. Generally the use of remote sensing achieves greatest success when data are combined with other secondary data. Thus, efficient information network is needed to utilize full potential of technology in urban planning.

- There has also been a growing awareness that limited management capabilities in urban local bodies, not lack of technology or capital, is generally the key constraint in achieving sustainable urban development. Therefore, an integrated system is required under the umbrella of "urban regime".

- Inconsistencies of data over space, time and definitions cannot be ignored out. The present sets of data from different sources used by the planner are often incompatible as far as aerial definitions are concerned. The spatial units used differ between data collecting authorities, both at central and local government levels, but they also differ within local authorities. They may also differ even within departments, such as comprehensive development areas and street units used within the planning department.

- The scale and type of data requirements varies across the local authorities. Thus, integration and use of spatial data among various organizations is a challenging task. Also, scale of data varies from implementation level to decision-making level. Thus a new system using complex relationship with a high-speed communication network is required to integrate information at various levels.

- The organization of database requires the computerized information systems. It is only by computer storage that the vast complexity of data can be made operational. The computer allows for flexibility of organization and permits multiple accesses by different departments for different purposes. It also facilitates spatial as well as statistical analyses.

- Spatial Data Infrastructure (SDI) at local level is required to form a framework to share and exchange data across agencies and between various disciplines to achieve physical, social and economic development. Local SDI can create an environment where a wide variety of users are able to access and retrieve complete and consistent data in an easy and secure way. It forms a fundamental framework to exchange data across many agencies and disciplines at various levels of planning. The objective is to develop an integrated operational system with integration of high resolution satellite imagery for information gathering at local scale, that could later be extended to the state, regional and national level.

- SDI system can reduce the costs of data acquisition and eliminating duplication of effort. It can provide better data for decision-making. Standardizations of data can provide ability to perform cross-jurisdictional and cross-sectoral decision-making.

- Lots of developments have taken place in every field but integration of these at implementation level is required presently. To fulfill the gap and implementation/ use of satellite imagery at local level management needs proper policy framework. Policies related with the use of these data and its exchange requires proper strategy and considerations.

- Urban regime provides a set of new forms of networks and relationships that have emerged in present scenario of urban planning, monitoring and management. The regime theory is especially useful in pointing informal but relatively stable arrangement among various organizations related with urban areas. Therefore the horizontally oriented urban network is needed within a existing hierarchically-oriented vertical system of cities.

CHAPTER III

CASE STUDIES

3.1 An Overview

This chapter comprises of case studies of the Indian projects carried out over the last decade to adopt modern technology for urban mapping. The main motive behind the case studies is to find the success and failure of these projects and lessons learned from it. Various aspects related to these projects i.e. organizations involved, database developed, methodology adopted etc. have been discussed in this chapter. Despite the tremendous potential of the technology, what is the reason that such types of projects are not duplicated in other cities of India? In this context, current policy related to the spatial data of urban area (NUIS project) is also discussed in latter section of the chapter.

A number of attempts have been made through pilot projects in India over the last decade to adopt modern technology for urban mapping. Information technology now has reached to such an extent, that the role of remote sensing technology and geographic information system in identification, preservation and conservation of natural and man- made resources in the planning process is noteworthy (Som, 2003). Remotely sensed data with the integration of geographical information system is a cost effective way to update its expanding spatial datasets, manage customized applications and better serve the public for growing urban areas. High quality information that is accurate, timely, relevant and unbiased from high-resolution satellite imagery can be used for effective networking and action for urban management. Attempts to use remote sensing in large-scale surveys in India have remained at pilot level only. Though technically successful, remote sensing has not yet been adopted for cadastral surveying of urban areas. Some of the important projects carried out by the government and private institutions are-

(i) Ahmedabad Municipal Corporation, e-governance project developed by private consultant,

(ii) Hyderabad Land Information System, developed by private consultant,

(iii) Utility Mapping Programme of National Informatics Center (NIC)

(iv) Computerised Rural Information Systems Project (CRISP), Ministry of Rural Development carried by National Informatics Center (NIC),

(v) Bhoomi E-Governance project of Karnataka State Government by National Informatics Center, Bangalore.

(vi) Ganga Institutional and Community Development Project (GICDP), Mirzapur by government institution.

This chapter reviews the Utility Mapping Programme of National Informatics Center (NIC), New Delhi and Ganga Institutional and Community Development Project (GICDP) in Mirzapur are selected as case study to explore the potential of state-of-the-art technology in practical applications for the improved planning and management. The current policy related to spatial data of urban areas under National Urban Information System (NUIS) project is documented in the later part of the chapter. It is followed by the inferences.

3.2 Utility Mapping Programme, National Informatics Center, Delhi

Utility Mapping Division of National Informatics Centre, New Delhi started eight years back with the collaboration of Delhi Jal Board, Delhi Vidyut Board, Delhi Police and Mahanagar Telephone Nigam. These organizations worked jointly in the area of building an integrated system, which can demonstrate past, present and future of the Delhi region. The main objective of this project was to establish an automated production line for map production and develop a GIS, which will fit all components such as data collection from diverse sources, data analysis, complex visualization tools and presentation methods in one integrated system.

The methodology adopted in this project can be divided into three parts- integration of GPS in GIS, integration of photogrammetry into GIS and utility mapping. To prepare the maps of Delhi, the ground control points were fixed in and around the region. Global Positioning System (GPS) was used to provide the necessary control. GPS also helped to reduce the necessary ground control in block adjustment to a minimum. On board GPS also makes it possible to determine accurately the coordinates of each exposure station during a photo flight. Aerial photographs on scale 1:6000 were used to produce maps on scale 1:1000. The following processes were fit in to form an automated map production line. Transferring of ground control points on the aerial photographs.

Selection and marking of the tie and pass points on each photograph for extension of ground control.

- Observation of all desired model on stereoplotter.
- Extension of ground control by photogrammetric methods i.e. to assign Easting, Northing and height to each tie and pass points selected before. These tie and pass points will help us to orient the each stereo model on stereoplotter.
- Implementation of symbol library on the analytical stereoplotter system.
- Implementation of feature code list on the analytical stereo plotter system.
- Absolute orientation of the model on stereo plotter.
- Digitisation of all man made features, contours, all visible utility network and related objects etc. on the stereoplotter.

Figure 3.1: Water network (Chandra et al., 2003)

In India, in most of the cases, utility maps are not available with the organization. If available, they are not to the scale. Due to lack of co-ordination between the utility organizations each one is using map on a different scale and often information about parameters of map data is not preserved. The data thus available on paper map in the existing manual method is quite inaccurate, difficult to manage and unfit for taking measurements. As if it was not enough, the depth parameter is never cared for, enhancing problems faced by the field staff.

It causes problem, whenever any repair work or laying down of new lines is initiated, the field staff often damages the other utility lines crossing or running in close proximity to their lines. The avoidable damage during repair, result in large monetary losses. There are also reported incidents of loss of lives during the digging, due to accidental contact with electric lines, sudden burst of sewage/water lines, etc. Delhi Jal Board, Delhi Vidyut Board, MTNL and Delhi Police have deputed persons in NIC. These persons were trained by NIC to collect and input the data in computer system. Maps compiled from aerial photographs are supplied to the field staff. Utility network data from existing records and collected from field using detectors were measured and marked on the maps and entered in to the system. Water network for entire Delhi has been GIS. Water network in thick dashed lines is shown in figure 3.1. Delhi Vidyut Board has converted its EHV i.e. Extra High Voltage network in North East and southeast Delhi to GIS.

The basemap data and the utility data is kept at a central server at NIC HQs. The data is disseminated from NIC through dedicated lines to the various utility agencies HQs. Thereby a single database for all the utilities is in place. Any updating whatsoever to the base map is available to the user synchronously.

This project found that putting the information into the GIS is the dominant investment component of GIS work. There is a rule, which differentiates the costs in GIS according to

$$\textit{Hardware : software : data} = 1 : 10 : 100$$

A joint effort of various utility agencies, local authorities and infrastructure-developing agencies is the key to the success of the project. The huge cost of the project if shared by each agency could reduce the financial burden on each of them. Additional setup to execute such projects can be avoided by restructuring the existing setup within the utility agencies. Working in isolation has its own drawbacks, which can be avoided by sharing the base map and the utility network data of different utility agencies. One can define and view a free corridor to design and develop its network on the system before it is actually executed on the ground. These are the few benefits of the system but more can be visualized when system is in its full use.

3.3 Ganga Institutional and Community Development Project (GICDP), Mirzapur

Ganga Institutional and Community Development Project (GICDP) was developed with the collaboration of Governments of The Netherland, India and Uttar Pradesh. The objective of the project was to develop and test a geographic and management information system for improving the municipal administration of a small city of Uttar Pradesh. This was the first municipal gwographic information system in India developed for the small sized town to test the full range of applications for identifying, diagnosing and resolving administrative problems that had been unresolved for the decades.

The methodology adopted for the development of the database was based on the representative neighbourhood approach. In this process, all the 610 Mohallas of the city were classified into one of 7 neighbourhood types based on rent values. Mohalla and street coding on the base map was the foundation for the property tax assessment. An intervention package was also developed for immediate service improvements, property reassessment and investment planning to handle routine problems. Record related to basic infrastructure were also linked to the base map. In this process, street drain, water supply and solid waste collection maps were developed and linked to the databases of conditions documented through primary surveys.

The emphasis of the project was to increase revenue, maintaining and improving public services and infrastructure information through GIS. Since, all the data sets were linked with core maps, it allows cross analysis to improve the services related with the basic infrastructure. Integration with the GIS allowed to evaluate the water supply network with reference to the property maps to estimate the population at each node. For this purpose, coordinates for each node were identified. More importantly, since the water supply maps only showed recent system repairs and improvement, key elements of the system such as secondary distribution lines in neighborhood streets were not up-to-date. With the GIS, primary survey information was mapped directly to the streets without creating a new water system map. This allowed a much finer grain of analysis than was possible with only the water system map.

This project shows the potential of the technology for the improved management of basic infrastructure and increased revenue of the municipality. It facilitated systematic property valuation over 35 years, which resulted in 7 times increase in property taxation. Apart from these quantified achievements, this project also helped in improving the working culture as well as to restore public confidence..

3.4 National Urban Informatin System (NUIS): Overview

Existing policy for spatial data in India is related to National Spatial Data Infrastructure (NSDI) and National Urban Information System (NUIS). NUIS project is in progress and provides the base for the information system in urban areas. Some important aspects addressed by NUIS are given here.

The Ministry of Urban Development (MUD), hosts the NNRMS Standing Committee on Urban Management (SC-U), chaired by the Secretary, Urban Development and the Proposal to develop a holistic National Urban Information System (NUIS) scheme was mooted by the SC-U to be taken up in a National Mission mode.

The NUIS comprises of two major components as given under

- **Urban Spatial Information System (USIS)** - Which includes development of GIS based multi-hierarchical database, with application tools, to support Master/zonal plan generation; Urban Local Bodies administration and utilities management.
- **National Urban Databank and Indicator (NUDB&I)** - Which includes designing and establishing a comprehensive data bank and integration of these

parameters to support planning and derive indicators for National Urban Observatory (NUO) for monitoring the health of urban settlements.

3.4.1 Objective of the NUIS

The objective of the NUIS is to establish a comprehensive information system in the urban local bodies for planning, management and de-centralized governance in the context of the provisions of the scientific planning and implementation of the 74^{th} CAA and to this end the specific objectives are as given under.

- ❖ Develop attribute as well as spatial information base for various levels of urban planning and decision support to meet the requirements of urban planning and management by-
  - ❑ Enabling preparation of Development / Structure plans/Zonal development plans.
  - ❑ Creating a database at Local Body level for monitoring and management of at least the relevant functions enlisted in the 12^{th} schedule of 74^{th} CAA.
  - ❑ Use modern data sources such as Satellite and Aerial Platforms to Generate a comprehensive 3-tiered GIS database, in the scale of 1:10,000 for Master Plan and 1:2,500 for detailed town planning schemes and 1:1000 for Utilities planning.
- ❖ Develop a model in Utility mapping on pilot basis using Ground Profiling Radar (GPR) technology.
- ❖ Integrate conventional data sources with modern data sources to develop GIS database.
- ❖ Develop standards for USIS as well as NUDBI with regard to database, methodology, equipment software, data exchange format etc.
- ❖ Develop automated integration/application techniques in GIS to provide inputs to Master/Zonal Planning and utilities management - to be utilized by the urban administrator/planners.
- ❖ To create a town level repository of urban database through National Urban Databank And Indicator (NUDBI) unit which would also assist development of urban indices for National Urban Observatory (NUO) pilot basis.

- ❖ Build capacity among town planning professionals in the use of modern automated methods.
- ❖ Decentralize data generation, storage and manipulation at various levels of planning.

Implementation of National Urban Information System (NUIS) with above objectives is expected result in following achievements:

- ➢ Planning and Management of urban settlements will be based on updated and scientific database as a decision support system, employing modern planning methods using GIS technology.
- ➢ Data generation, storage and manipulation using spatial and attribute information base supporting development of urban indices for NUO.
- ➢ Standardized GIS database, methodologies and procedures to enable easy integration and sharing of information and replicability of procedures.
- ➢ Build capacity amount town planning and allied departments and create a cadre of professionals for the use of modern automated methods, envisaged under NUIS.

3.4.2 NUIS Content Standard

Broadly categorized, the NUIS will have the following two elements of data in database:

- ❖ **Spatial data** - consisting of maps, which have been prepared either by ground surveys or by the interpretation of Remotely Sensed data. Some examples of the spatial data are the land use maps, soil map, geological map, village map etc.
- ❖ **Non-spatial data** - attributes as complementary to the spatial data and describe what is at a point, along a line or in a polygon. The attributes of a land use may include its type, area, rate of change etc., that of soil category could be the depth of soil, texture, type of erosion, permeability etc. and for a geological category the attributes could be the rock type, its age, major composition etc. An administrative unit like a state, city or village could have attributes of its social and economic characteristics, which could be the demographic data, occupation data for a village or traffic volume data for roads in a city etc.

It is also clear that the information content will very for the 3 levels of NUIS with reference to identified planning function and levels planning as given in Appendix-I.

3.4.3 Design Issues For Data Bank Standards

The Steering Group on URIS set up in 1971 proposed the minimum critical data to initiate URIS into operation with the data organization grouped under three broad categories viz. (1) physical, (2) Socio-economic, and (3) basic infrastructure, services and amenities.

These reports proposed the minimum critical data to initiate URIS into operation with the data organization grouped into three broad categories viz. (1) physical, (2) socio-economic, and (3) basic infrastructure, services and amenities. The group recommended action on (a) Urban Information System (b) Urban Indicators (c) City data banks.

While a large amount of data is generated at various levels for urban planning and management it remains uncoordinated and often redundant to support decision making, as it is not available as a comprehensive compilation. Thus urban policymaking based on the linkages between various sectors e.g. health, education, physical infrastructure etc. leading to development of indices is not possible. On the other hand, planning activities involving spatial databases and decisions are not correlated with the sectoral/departmental data generated. In view of the developments in information technology (Hard Ware, Soft Ware and a web enabled networking) it is now imperative that the available technologies need to be exploited in order to enhance the efficiency in both planning and management of urban settlements.

As mentioned earlier, the NUIS will have 2 important elements and their detailed objectives are as follows:

- **Urban Spatial Information System (USIS):** Generate a comprehensive 3-tiered GIS database for each town/city that will be able to support the main objective of planning and management.

1. 1:10,000 scale GIS with parameters of spatial and attribute information that will be the core of Master Planning and Zonal Planning exercises in urban settlements.
2. 1:2,500 scale GIS database with parameters of spatial and attribute information in support of detailed town planning schemes and urban administration.
3. Establishment a 1:1000 scale utilities GIS on a pilot basis with inclusion of power, water-supply, sewerage and other utilities that will Support Utilities Planning and Management in urban settlements.
4. Develop automated integration/application techniques in GIS to provide inputs to Master/Zonal Planning and utilities management - to be utilized by the urban administration/planners.

❖ **National Urban Databank and Indicator (NUDBI):** The aim of NUDBI is to design a standard set of data parameters to be collected to support planning, and routine municipal functions listed in the 12th Schedule of the 74th CAA. The guidelines of TCPO, MUD will be useful for this design.

1. Design a database for NUDBI and also develop front-end and integration software that will provide the indicators. This design can also link the USIS and NUDBI database, as required.
2. Develop town level NUDBI database for each town.
3. Enable the establishment of a Local Urban Observatory (LUO) in each state which will integrate the NUDBI database for all towns within the state.
4. Support the National Urban Observatory (NUO) by integrating the NUDBI database of all states and for each town at TCPO, MUD.
5. Provide necessary inputs/report on the health of urban settlements to MUD, planning Commission, State etc.

❖ The data and the contents of the NUDBI has been identified by Standards Committee is given in Appendix II. For effective urban planning management, a variety of data, are required and these includes:

1. **Physical Environment:** Land use disposition by major types, intensity of use (low, medium and high density patterns) ownership (public, semi-public and private), quality of development (area under slums, squatter settlements well planned localities etc.), extent of air and water pollution and conservation of important environmental assets, besides other resources such as water availability, agriculture, wastelands, slopes, relief, drainage etc.
2. **Human and Econimic Environment:** Population change including migration, size and distribution of households, literacy and education, employment and production structure, including employment in the normal sector, distribution of income and land assets (particularly land and property), trends in local revenues, expenditures and land values.
3. **Services and Amenities:** Range, level and distribution (i.e. accessibility) of amenities and services - water, shelter, health, sanitation (including sewerage), educational, recreation, law and order, electricity, transport and telephone etc.

❖ The NUIS, consisting of spatial and non-spatial data, will be a set of GIS database - catering to the different levels of urban hierarchy. The GIS design parameters for the UIS has been worked out - specifically pertaining to scales, accuracies, linkages etc. and is given in necessary table for the different levels of NUIS.

❖ It is proposed to develop standardized GIS-based application packages that will allow users in towns/state to extract specific and meaningful input for their planning process. The actual requirements of application packages will be defined based on detailed consultation between TCPO and State/Town authorities.

3.5 Inferences

(i) Project studied in this research shows tremendous potential of technology to handle the problems generated due to rapid urbanization.

(ii) GPS and photogrammetry techniques are integrated in GIS environment to prepare the base map with higher positional accuracy for Utility Mapping Project, New Delhi. While, preparation of base map for ICDP project is based on the existing records and field surveys. This project illustrates the potential of GIS to solve real world problems.

(iii) ICDP project mainly highlights the revenue aspects of the municipality through the adoption of new technology, while Urban Mapping Project has concerned with the mapping of basic infrastructure. But, in both case studies, base maps are not linked with the planning data. It is under process as an extension of Urban Utility Project.

(iv) Urban Utility Project is carried out for the metro city, while ICDP is a case study developed for the small and medium sized town. These studies show the capabilities of technology to solve the problems of cities of all sizes, from small sized town to metro city.

(v) Both the projects were developed by different institutes and afterwards database is transferred to the main organizations i.e. electricity board, water supply etc. Despite the successful implementation of these projects, most of the Indian cities are lacking the information about the basic infrastructure.

(vi) In the light of technological advancement, National Urban Infrastructure System project is started. This project is at the initial stage. The main issues addressed by this project are format of basic data sets, standards, finalization of cities for the different phases of the project. Fundamental requirements for the implementation of technology among different agencies are database organization and restructuring of existing institutional setup. These issues are still not addressed in the NUIS documents.

CHAPTER IV

STUDY AREA

4.1 Location

The Dehradun city, the capital of newly formed Uttaranchal state, is situated in the south-central part of Dehradun District and is one of the major urban center of the region. It is located in Uttaranchal State 250 km. north of New Delhi. The study area lies between 77° 05' E to 78° 00' E and 30 ° 15'N to 30 ° 25' N latitude (figure 4.1).

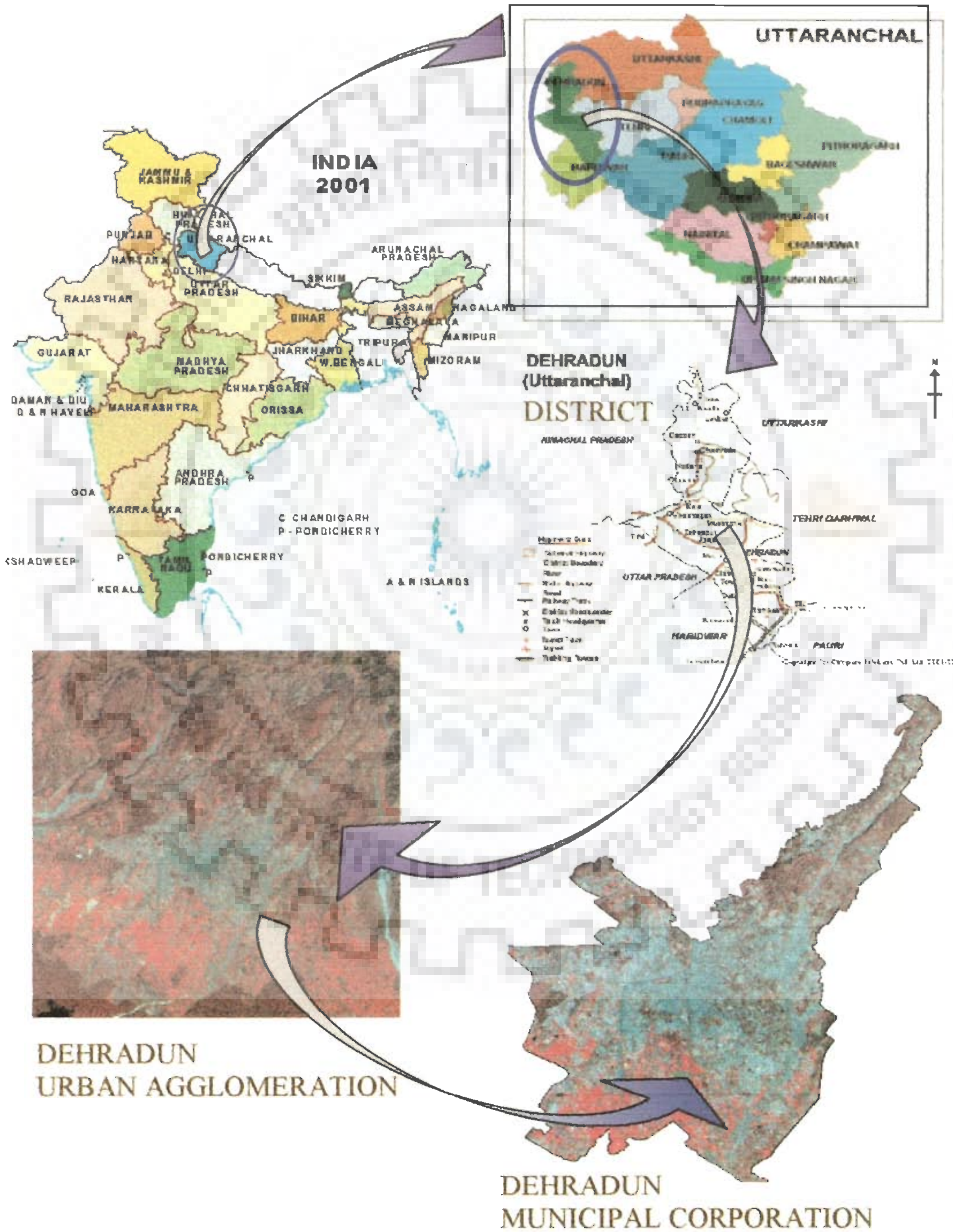


Figure 4.1: Location of Dehradun, Uttrancal in India.

Surrounded by lush green forests and hills, Dehradun has always been a favorite destination with the tourists. It is endowed with a pleasant, moderate, climate and is well connected with other important places such as Delhi, Haridwar. Dehradun is a gateway and base camp for tourists and pilgrims headed for Gangotri- Jamunotri- Kedarnath-badrinath- valley of flowers and famous hill queen Mussoorie.

Dehradun is one of the beautiful towns in the northern India. It boasts of a number of reputed educational institutions such as the Forest Research Institute, Wildlife Institute of India, Forest Survey of India, Indian Military Academy, The Doon School etc. The entire Dehradun Valley has numerous places of scenic beauty and picnic spots such as Robbers Cave, Rajaji National Park, etc.

Dehradun is strategically located in the foothills of the Himalayas in the north, the Shiwalik hills in the south, the Ganga in the east and Yamuna River in the west. The Doon valley is a longitudinal valley, which extends about 80 km. in the length and 20 km. in width, lie between the rivers Ganga and Yamuna. The pre-tertiary rocks of the mid Himalayan range rise up to 2200 m. above MSL bounded the north and the Shiwalik range, which rises up to 900 m. above MSL, bound Doon valley in the south.

4.2 Origin and Historical Background

The name of the city is composed of two words "Dehra" and "Doon". "Dehra" was derived from 'dera' signifying a temporary abode or camp of a religious saint cum preacher. "Doon" or "dun", in Sanskrit and Hindi means an elongated valley, hence the name "Dehradun". The Oxford dictionary defined it as "Valley in Shiwalik Hills". Among the number of large and small valleys between the Lesser Himalaya and Shiwalik Hills , Dehradun is one of the largest and best known of them all.

There are a number of myths related to the naming of "Dehradun" city. According to Skanda Purana, an ancient text, "Dun" formed part of the region called "Kedar Khand". It was included in the kingdom of Lord Ashoka by the end of the 3rd century B.C. History reveals that for centuries the region formed part of Garhwal kingdom with some interruption from Rohillas.

However, most popular myth is that the city derived its name from the local tradition. During the 17th century, the Sikh guru Ram Rai, (a sent in Udasi fakir sect) took up his residence in the Dun. History connects the event with Guru Har Rai, the leader of the famous Sikh sect who died in 1661 leaving behind two sons, Ram Rai and Har Kishan. After the death of Guru Har Rai, emperor Aurangzeb, confirmed the election of guru Har Kishan and direct Ram Rai to retire to the wilderness of the Dun. In obedience to the emperor's command, Ram Rai retired to the Dun at Kandli on the river Tons. Later on he moved from the Dun and settled down in Khurbura, now included in the city of Dehradun. Guru Ram Rai built a temple at the village Dhamanwala, which became the nucleus of the present city and even today his Darbar Saheb is the heart of the city's cultural and spiritual life.

For about two decades till 1815 the city was under the occupation of the Gorkhas. In April 1815, Gorkha rulers were ousted from Garhwal and Garhwal was annexed by the British. In the decades that followed, the British Government felt that the material progress of Dehradun and adjoining hill towns of Mussoorie and Landour was dependent upon colonization and reclamation of the wastelands. This led the government to encourage capitals. The growth of tea industry and the extended operations of forest department, the establishment of two military Cantonments (in 1872 and 1908), increasing popularity of Mussoorie and Landour, as a retreat of well to do pensioners and opening of the railway in 1900 have all contributed towards growth of Dehradun.

Later on, the construction of 1.6 km. long Paltan Bazar (from Clock Tower to Gurudwara) led to the trade transaction and thus led to a very rapid growth of the city. This development was further aggravated after the second world war, through the establishment of new Cantonment, Ordinance Factory, Indian Institute of Petroleum, Indian Photo Interpretation Institute (renamed as Indian Institute of Remote Sensing), Oil and Natural Gas Corporation, Survey of India, Doon School and many other institution, offices and the growth of ancillary activities and other infrastructure facilities have contributed considerably to the growth and physical expansion of the city.

Thus this unprecedented growth of institutions, offices, large and small scale industries, lime based industries at Dehradun have triggered the problems of congestion in the central core of the city and crippled the transportation system have resulted in overall environmental degradation. However, till 1960, there was no effort to channelise the haphazard growth of the city. Under this circumstances the city at present is suffering from a number of problems of uncontrolled and haphazard development, severe traffic congestion, rapid growth of slums on low lands, particularly at the beds of the seasonal streams and encroach of commercial activities.

4.3 Physiography

The general physiography of Dehradun city is located on a gentle undulating intermountain valley at an average altitude of 640 m. above mean sea level. The lowest altitude is 600 m. in the southern part, whereas highest altitude is 1000 m. on the northern part. The northern slope (south facing), at the base of Mussorie hills, has gentle gradient of about 8° which mostly comprises of coarse detritus boulders, pebbles, gravels derived mainly from Pre-Tertiary and Siwalik rocks with top soil and silt /sand. The north facing southern slope of Siwalik hill range is steeper in gradient of about 10° formed mainly of reworked Upper Siwalik boulders and gravels with sand and silt. The drainage of the city is borne by two river namely: Bindal Rao and Rispana Rao. The direction of flow of these seasonal streams and nalas in the eastern part is north to south and western part it is north to southwest. The whole area is heavily dissected by a number of seasonal streams and nalas, which are locally known as "Khalas". Dense patches of forests exist along the north and in the outer limit of regulated areas.

4.4 Climate

In general the climatic conditions of the study area is subtropical to temperate. Dehradun experiences four seasons, namely, winter, summer, rainy and post monsoon seasons. The period from November to February is the winter season. The summer season followed continues up to the end of June. The rainy season is from July to about third week of

September. The following period, till the middle of November is the post monsoon or transition period.

Table 4.1: Rainfall and Temperature Distribution in Dehradun Municipal Area (2000-01)

Year / Month	2000			2001		
	Rainfall (mm)	Mean Max Temp ^{0}C	Mean Min Temp ^{0}C	Rainfall (mm)	Mean Max Temp ^{0}C	Mean Min Temp ^{0}C
January	60.6	18.8	5.1	39.3	19.5	4.5
February	107.6	19.0	5.1	3.1	24.8	5.3
March	67.8	26.1	9.4	23.4	28.5	8.9
April	45.2	34.8	13.8	32.2	33.2	14.2
May	108.2	36.5	20.7	49.8	35.9	20.3
June	214.8	31.9	23.0	301.2	31.7	22.8
July	544.2	29.8	24.1	664.0	31.0	24.6
August	215.0	31.1	24.1	307.3	31.3	24.1
September	156.7	31.2	24.4	16.4	32.6	20.5
October	0.0	31.7	15.2	0.9	32.2	16.0
November	1.2	27.0	9.7	2.4	27.4	8.6
December	0.0	22.9	3.6	8.4	22.5	5.0

(Source: Soil and Water Conservation Annual Report by CWCRTI, Dehradun)

4.4.1 Temperature

The maximum average temperature is 36± 6 ^{O}C and the minimum is 5 ± 2 ^{O}C. In summers maximum temperature i.e. 36 ± 6° C and the minimum temperature is 16 ±7° C whereas in winters it varies from 23± 4° C and 5 ± 2° C respectively. In summers, the heat is often so intense and on individual day, the maximum temperature rises to over 42° C. January is generally the coldest month and the maximum temperature sometimes falls down to about a degree below freezing point of water. Inversion of temperature is a conspicuous phenomenon, owing to the location of the city in the valley.

4.4.2 Rainfall

The average annual rainfall of Dehradun City is 2183.5 millimetres. About 87% of the rainfall is through monsoon and is received during the months from June to September, July and August being the rainiest months. The following table shows the monthly total rainfall (mm) and monthly mean minimum and maximum temperature (°C) during the year 2001and 2002 are given bellow.

4.4.3 Humidity

The relative humidity is high during the monsoon season normally exceeding 70% on an average in the city of Dehradun. The mornings are generally more humid than the afternoons. The driest part of the year is during the summer season, with the relative humidity becoming less than 45%.

4.4.4 Prevailing Winds

In the Doon valley, winds are mostly from direction between south-west and north-west throughout the year except in October and November. The annual wind speed is 3.2 km / hour. Mountain and valley winds are common throughout the year.

4.5 Major Function of the City

Cities are attached with intangible values like status, character and function. Activities of the city dwellers, which emerge from the city functions, are manifested in the physical development of the city. A harmonious integration of the function and the activity can lead to a healthy and orderly development of the city. These are the major functions of Dehradun City –

Administrative: Administration is one of its important functions of Dehradun being the interim capital of state. In addition, district headquarters and headquarters of a number of all India organizations are also located in the city.

Educational and Institutional: Dehradun, besides being seat for prestigious educational institutions (e.g. Doon school) and other technical institutes, is famous for national level institutes such as Forest Research Institute, Wadia Institute of Himalayan Geology, Oil and Natural Gas Corporation, Wild Life Institute, Indian Institute of Remote Sensing and many others.

Commercial: Dehradun is the largest service center in Uttranchal State. It meets the trade and commerce requirements of this region. With the establishment of national level institutes and offices and the expansion of Cantonment area, the commercial activity has gained momentum.

Industrial: Establishment of Industries based mainly on Limestone and Forests have attracted ancillary industrial units and other industries. Development of industries is likely to play a vital role in building a sound economic base of the city.

Tourism: Dehradun is endowed with immense potentialities to be place of tourist attraction besides being gateway to Mussoorie. There are number of tourist places and recreational spots within short distance of the city, which are developed and landscaped for tourist attractions.

Defense: Dehradun is the headquarters of Indian Military Academy. A number of other defense establishments viz., Doon Cantonment, Clement Town, Ordinance Factory, Indo-Tibet Border Police, President's Body-Guard etc. are located in Dehradun. The defense function has played a vital role in shaping the development of the city and it will continue to influence the future development and economy of the town.

4.6 Environmental Status of the City

Large-scale ecological degradation has taken place in urban Dehradun triggered by human activities. Increase in population pressure, forest clearing, unplanned stone mining, lack of planning and other uncontrolled environmental impacts have lead to mentally stressful life in the city and threaten the very existence of life in Dehradun City. The air is thick with smoke and pollutants from over 200 lime kilns (Dehradun District). One of the major contributors to air and noise pollution is a cheap public transport, a three-wheeled, diesel operated vehicle, commonly named as 'Vikram'.

The secondary data compiled on the present environmental conditions prevailing in the city is enumerated below –

- Dust concentration (SPM) was found ranging from 266 µg /m^3 to 972 µg /$m^{3;}$ where as permissible limit of 100 µg /m^3.
- Sulphur Dioxide concentration ranging from 8 µg /m^3 to 60 µg /m^3, against the pern1issible limit of 30 µg /m^3.
- Nitrogen oxide concentration ranging from 4 µg /m^3 to 102 µg /m^3, against the permissible standard of 30 µg /m^3.
- Drinking water data compiled revealed acceptable hardness but fecal coliform contamination varying from 240-9080 /100 ml, against a standard tolerable limit of 10 / 100 ml.
- During summers water supply situation becomes grim with demand increasing as much as 15 gallons/day/capita than the average supply of 30 gallons/ day / capita.
- Some of the disturbing facts are-
- Dust concentration is 3 to 10 times higher than permissible limits.
- SO_2 and NO_2 are two to three times higher than acceptable levels.
- Alarmingly poor quality of water whim hosts 24-900 times high of fecal coliform
- Drastic reduction in water availability during summers often only a third.

The problem of water contamination occurs due to lack of adequate chlorination. The fecal coliform counts found to be higher during the rainy season, as the rainy water brings in all sullage and unwanted things in the surface streams. The growth of algae in the distribution line as well as the tube well walls may also lead to the increase of pathogens in the water.

Dehradun used to be regarded as a green lung but now it is fast converting in to black lung. During the last few decades there is a frightening increase of various stress related disorders, hypertension, coronary artery disease, duodenal ulcer etc. Gastro-intestinal disorders are on rise. There is an ever-increasing incidence of throat irritation, infection, allergy, bronchial asthma and bronchitis with emphysema. The rate of incidence of Enteric fever and jaundice are also recorded to be high.

4.7 Trends of Urbanisation

The past heritage of Dehradun, concentration of national and regional level institutions, economic activities and availability of infrastructure will invite further influx of population from the valley and outside, in addition to its own natural growth. Also the regional linkages by rail and road, the climate and feasibility of spatial expansion of Dehradun will be instrumental in stimulating future growth. The rural growth centers within the valley and close to the vicinity of Dehradun city, which though not fully urbanized but are very much likely to merge. Rural-urban migration due to relatively more employment opportunities will also add to its expansion.

Dehradun is the second most populated district of Uttranchal after Haridwar and accommodates 15.08% of state population. It is also second highly urbanized district consists 9 cities and towns after Udham Singh Nagar. Increase in population density at district level is also an indication of urbanization. According to Census of India 2001, population density of Dehradun district increased to 414 persons per square kilometer in comparison to 332 persons per square kilometer in 1991. With successive physical growth, Dehradun has been developed into a group of townships belonging to different periods. The parent township along with its urban out- growths and the cantonment; forms an urban agglomeration (table 4.2).

Table 4.2- Population of Dehradun urban agglomeration

Name of development	Population
Dehradun Municipal Corporation	4,26,674
Dehradun (C.B.)	53,675
Forest Reserch Institute	5,424
Clement Town (C.B.)	19,569
Rajpur (CT)	24,921
Doiwala (N.P.)	8,043
Total	

(Source: Census of India, 2001)

To conceive and develop a functional and integrated city structure for Dehradun, it is necessary to understand the existing land use pattern or disposition of various activities in all its intent, growth trends and physical limitation etc. Physical expansion or Dehradun has been strictly governed by the physiography of its site. Existence of a number of seasonal streams, dissected topography, hills in the north, east and north-west and other undulations have resulted in a sporadic growth especially in the northern parts. This topography has not only influenced the direction of growth but also conditioned the shape of the city. The main city sand witched between Bindal river and Rispana Rao, spreads around the Gurudwara and the clock tower. Restricted ribbon growth has resulted along Rajpur Road and Sahastradhara road. During the past decade the city has been expanding towards Haridwar road, Saharanpur road and Chakrata road where terrain is relatively plain and accessibility is easier. In general, the development of the city will have to be guided in such a manner that it fits in the topography of the city and enhances the scenic beauty provided by rivers, streams, hillocks and forests.

The quality of urban life and functional efficiency of a city is dependent on proper disposition of activities, the -inter-relationship it establishes between the work centers, living areas, community facilities and recreational areas. The inter-relationship among various land uses suffers from a break-down because of piece-meal and unrelated growth of the city. The wholesale and retail trades have mixed up in a haphazard manner causing inter-mixing of goods and passenger traffic. The road widths within the main city do not allow proper functioning of activities in this area. Scattered location of industries, housing of government offices in rented residential buildings, lack of residential accommodation near the industrial sites and office areas, growth of slums on low lands are leading the city to a chaotic situation.

Existing land use survey (table 4.3) has reflected some uses as incompatible uses on the basis of their performance characteristics, traffic hazards and harmony with the surrounding areas. Dehradun Master Plan for 2001 proposed the land use pattern of about 7046.13 hectare land. Out of which, about 4836.35 hectare land has been developed as per the proposed use while 2209.78 hectare land, which is about 31.36% of total land developed in other uses than the proposed.

Table 4.3: Deviation in Land Use Pattern in 2003-04 in comparison to Master Plan proposed for 2001

S.No.	Land Use	Area in hectare	Percentage
1.	Residential	1157.06	52.36
2.	Commercial	139.35	6.31
3.	Industrial	165.09	7.47
4.	Public & Semi-public	77.21	3.49
5.	Parks, open spaces and recreational areas	11.52	0.52
6.	Agriculture	355.14	16.07
7.	Orchards and Gardens	172.58	7.81
8.	Forest	19.36	0.88
9.	Circulation	21.49	0.97
10.	Unidentified Uses	90.98	4.12

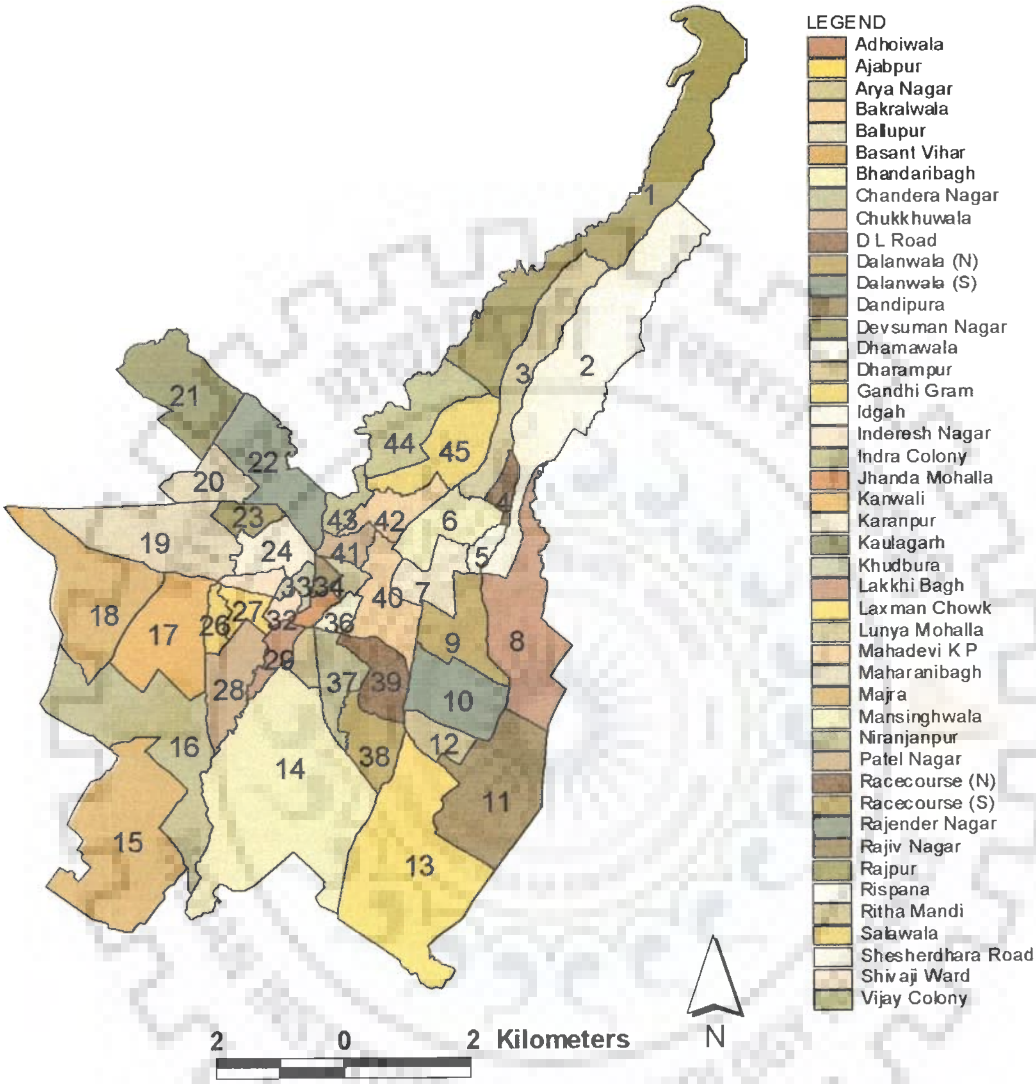
(Source : Dehradun Master Plan, 2005-2025)

Planning and development of facility for water supply, sanitation and transportation are essentially required to cater the need of city. Other important infrastructure facilities, which require careful study and attention for finding proper solution in the present context, are parks, playground, parking space, drainage etc. for aesthetical value of the city.

4.8 Dehradun Municipal Corporation

The area under the administrative control of the Dehradun Municipal Board is 65.85 sq. km. The Dehradun municipal board area was divided into 34 wards according to the 1991 provincial data. In 1995, wards were reduced to 33 only at the time of municipal election. Recently in 2003 during the preparation of voting list for municipal election, the wards were again revised and increased to 45 in number. Presently, the municipal limit of the city is divided into 45 wards (map no. 4.1). Wards are divided on the basis of population but differ in area (Appendix III). This table is based on the secondary data taken from the

Dehradun Municipal Corporation regarding the ward boundary and area as well as ward wise population. Wards are the smallest administrative unit in the city at which different types of data are collected.



Map no. 4.1: Municipal Ward Map, Dehradun,
(Source: Town & Country Planning Department, Dehradun)

The total population of the municipal area is 4,26,674 according to 2001 census. The physical limit of Dehradun Municipality is marked by two intermittent streams namely Rispana River in the eastern part and Bindal River in the western part.

4.9 Population Characteristics

The population of Dehradun was 2,100 in 1817. During 1981-91, its population has increased from 2,11,838 to 2,70,159. Taking this figure on an average, everyday 17 persons were assumed to be added to Dehradun Municipal Board population during last decade. The growth at this rate, population predicted for Dehradun Municipal Board to 4,20,271 by the year 2011. While population of Dehradun Municipal Corporation reached to 4,26,674 in 2001 census itself. The following table 4.4 shows the absolute figures of population; increase of population and the percentage increase for each decade from 1901-2001 for Dehradun Municipal Area.

Dehradun is the largest and capital city of Uttranchal State. During the census year 1931, the population figure showed a decrease due to the outbreak of *Plague*. The migration of people from west Punjab after the partition in the late 40's was the main reason for the sudden increase in population (95.52 %). Since early 60's, the establishments of many government agencies, prestigious research and educational institutions and public schools have increased the population.

Table 4.4: Population Decadal Growth in Dehradun Municipal Area (1901- 2001)

Year	Population	Decadal Variation	% age Decadal Growth
1901	30,995	---	---
1911	42,568	+ 11,573	+ 37.34
1921	50,858	+ 8,290	+ 19.47
1931	43,206	- 7,652	- 15.05
1941	59,535	+ 16,329	+ 37.79
1951	1,16,404	+ 56,869	+ 95.52
1961	1,29,764	+ 13,360	+ 11.48
1971	1,69,827	+ 40,063	+ 30.87
1981	2,11,416	+ 41,589	+ 29.86
1991	2,70,159	+ 58,743	+ 27.78
2001	4,26,674	+ 156,515	+ 57.93

(Source: Census of India)

4.9.1 Age and Sex Composition

The comparative figure of age groups for the city and the State reveal close similarity in the percentage distribution among various age groups. The large population lies within the age group of 25-59, because of employment in various government and semi government organizations. About 11% of population is under the age group 0-6 years, while sex ration is 900.

4.9.2 Literacy

According to 1971 census, in Dehradun city the percentage of literates were 61.2 percentage as against 58.5 percent in 1961. The percentage of literates exceeds by 17.6 percent in Dehradun City when compared to the Urban Areas of Uttaranchal and Uttar Pardesh. Dehradun's positive factor that contributes the high rate of literacy is numerous educational institutes. According to 2001 provincial census figures the percent of literates in Dehradun has increased to 85.9% as compared to the 70% of 1991.

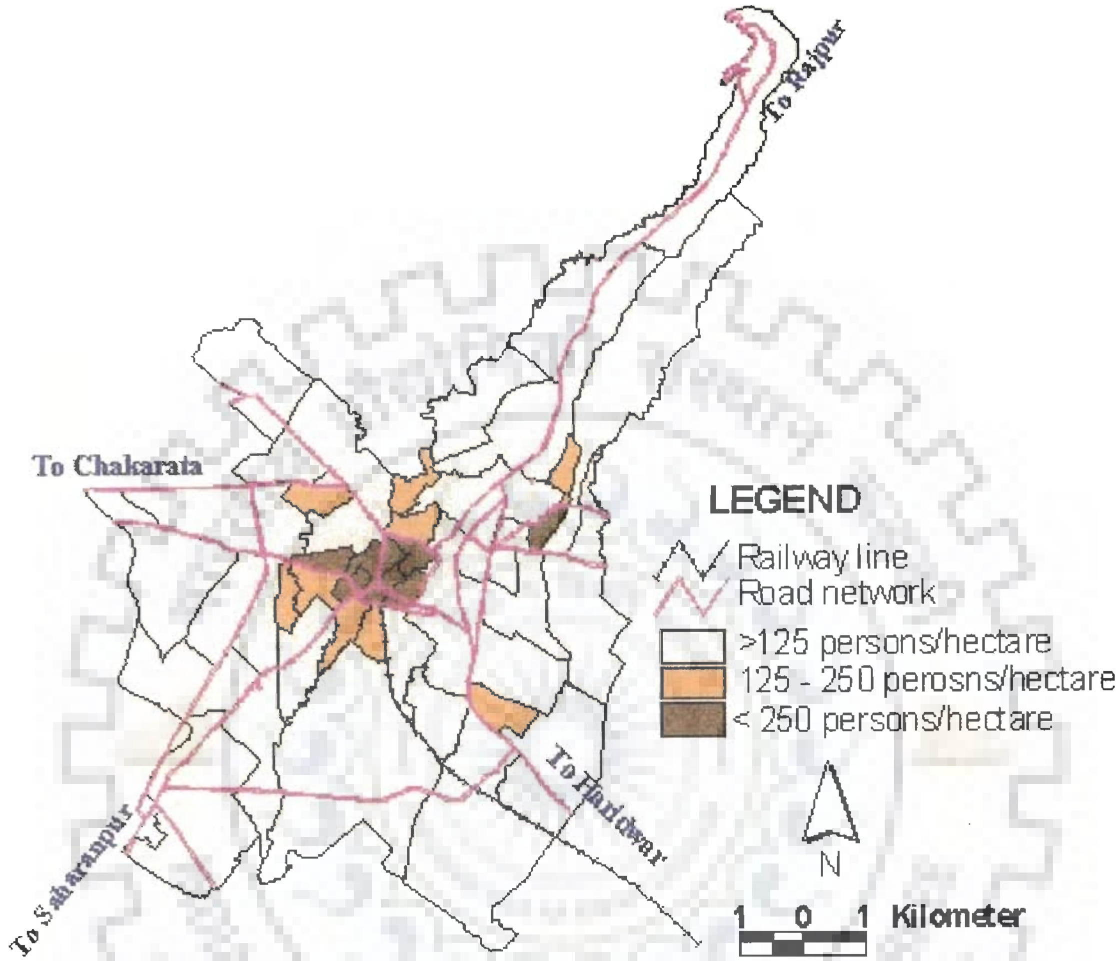
4.10 Socio-Economic Profile

<u>Density Pattern</u>

A study of density enables us to understand various aspects such as intensity of the use of urban land, problem of overcrowding arising out of congestion and high occupancy rate, adequacy and inadequacy of open space etc. Gross density within Dehradun Municipal Area is 7,109 persons per square kilometer according to 2001 census. Presently the Average Population Density of Dehradun Municipal Area 133 persons per hectare (map no. 4.2).

<u>Housing</u>

Housing areas, which cover large portion of an urban settlement, influence the quality of urban life, which in turn attacks, the efficiency of the settlements. The main housing areas are Govindpur, Rest Camp, Dharampur, Dalanwala, Karanpur, Rajpur, and relatively new colonies like Satya Bihar, Rajendra Nagar etc. Though in the localities like Jhanda Mohalla, Dandipur, Dhamawala, Balliwala, Kishanpur etc., most of the housing areas especially in the central core of the city have zigzag narrow roads, which are difficult to be widened, and there is a general lack of parks and open spaces. The relatively new housing areas are in the form of developed colonies which are located along Haridwar Road, Mussoorie Road and Chakrata Road. The areas beyond Bindal River are relatively better planned like Vasant Vihar.



Map no. 4.2: Population density map of Municipal Wards, Dehradun.

<u>Housing Shortage</u>

According to 1971 census figures, the total number of housing shortage within Dehradun Municipal area was 10605, which decreases to 7371 persons in 1981 census and 880 in 1991 census (table 4.5). While, housing shortage increases to 3288 in 2001 census. There are 1.4 households per residential house, i.e. more than one family is living in one house, which implies high occupancy rate. Household size while related to number of habitable rooms gives an idea about occupancy ratio and the degree of congestion. It is helpful in estimating future housing requirements of the city. On an average, there are 5 members/household.

Table 4.5: Housing shortage and occupancy rate in Dehradun MunicipalArea 1971-01

YEAR	Household Size	Housing Shortage	Occupancy rate
1971	5.34	10605	0.74
1981	5.22	7371	0.87
1991	5.10	880	0.98
2001	5.11	3288	0.97

(Source: Dehradun Master Plan 2005-2025)

Housing and Slums

The slums in Dehradun come under the jurisdiction of Municipal Corporation. Slums and squatter settlement have become inseparable parts of present urban scene in Dehradun. The problem is attaining serious proportion with slums growing at almost double the rate of the city. The increasing poorer community in slums and their housing requirement are not reflected by the government or commercial housing policies, which forms basis on the economic prospective.

Table 4.6: Area occupied by Dehradun slum settlements

S. No.	Ownership of land under slum settlements	No. of Slums	Present and projected population			Area under encroachment (in hectare)
			1991	2001	2003	
1.	Municipal Corporation	62	86802	132330	144093	237.384
2.	Guru Ram Rai	9	22050	33615	36603	15.234
3.	Waqf Board	4	6378	9723	10587	8.666
4.	Not available	3	4570	6967	7586	9.036
5.	Shri Badrinath Temple	1	1250	1906	2076	7.530
	Total	79	121050	184541	190358	277.850
	Population density		436	664	685	

(Source : Dehradun Master Plan, 2005-2025)

The increasing population of Dehradun and lesser housing activities for the economically weaker section of the society is resulting in the proliferation of slums on public lands (table 4.6). The area occupied by the slums is 6.05 % of the total area of Urban Dehradun. These slums are interspersed throughout various parts of the city and have grown mostly on the beds of Bindal river and other small seasonal streams, low lying areas and vacant parts of the city. Insanitary conditions, lack of drainage, water supply, paved streets and poor lighting facilities are the major problems prevailing in the slums.

4.11 Criteria for the Selection of Wards

The municipal limit of the city is divided into 45 wards. The selections of wards for detailed study are based upon mainly following parameters-

- Type of development (planned/ unplanned),
- Phases of development (old/ new),
- Population density and
- Land use pattern.

Care has been taken to select the wards within the city where most of the area is developed with the characteristics of different development patterns, representing the old and new parts of the city, different land use pattern with varying population density. For detail study, six wards (figure 4.2) of varying characteristics are selected considering above parameters namely, ward no. 39 - Race Course (N), ward no. 23 - Devsuman Nagar, ward no. 4 - D.L. Road, ward no. 34 – Dandipura, ward no. 36 – Dhamawala and ward no. 12- Dharampur. It is about 13% of the total wards of Dehradun Municipal Corporation. Characteristics of different ward are given in table 4.7. These wards covers about 258 hectares and accommodates about 11% of the total population of Dehradun Municipal Corporation.

4.12 Wards' Characteristics

Among selected wards, ward no. 39 - Race course (N) has lowest density 90 persons per hectare and ward no. 34 - Dandipura with highest density 474 persons per hectare because of old development with narrow lane and multifamily small size housing units. Characteristics of different wards are discussed as follows-

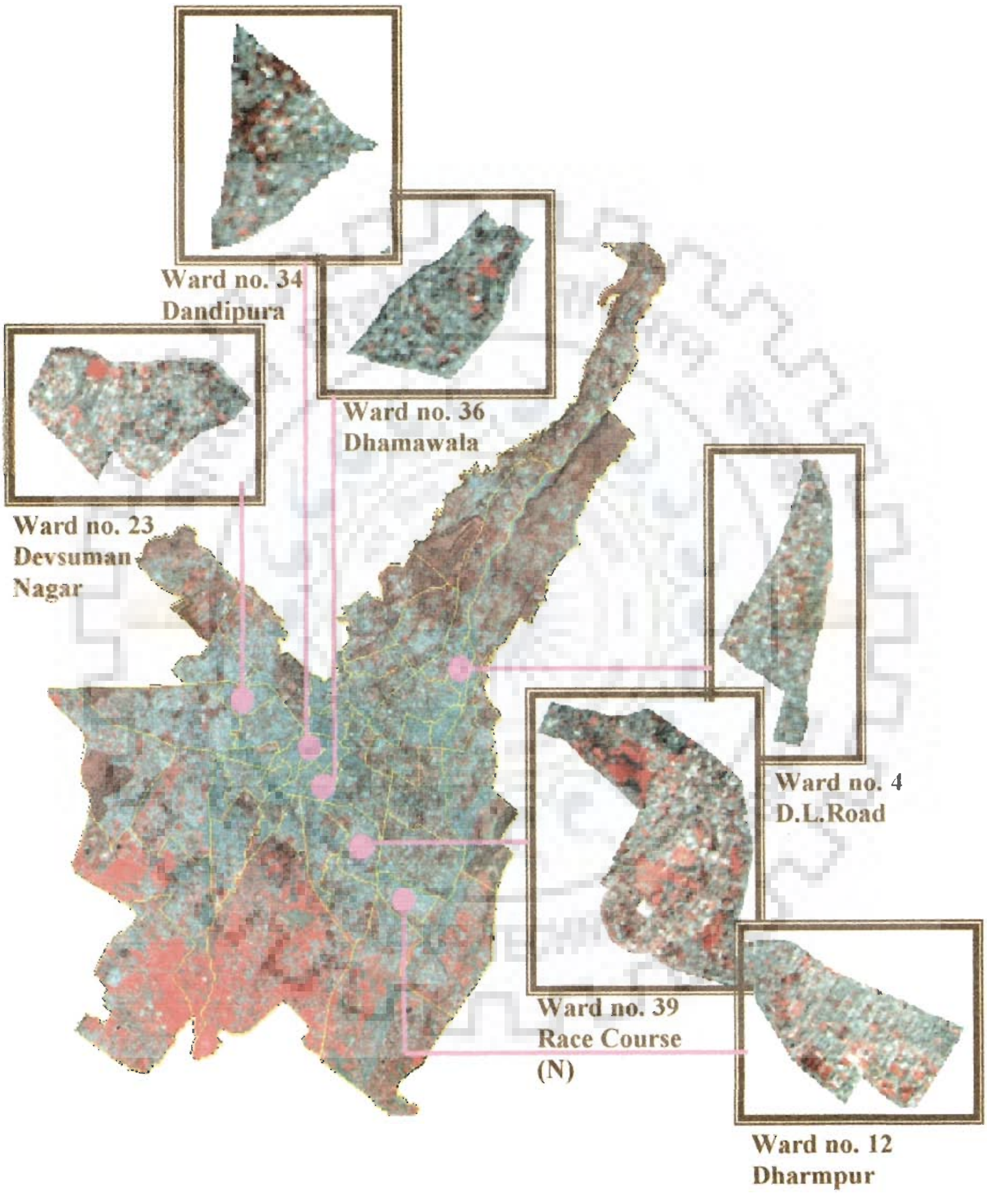


Figure 4.2: Location of wards selected for detailed study.

4.12.1 Ward No.39: Race Course

This ward is situated on right side of Haridwar road while going from the city center, adjacent to central business district towards the south-east direction of the city. Haridwar road provides the main access to the ward from north and east directions. It is a planned development and occupies 91.73 hectare of the area with population about 8249 persons. It has very low population density about 90 persons per hectare. The migrant from Punjab have developed it after the independence during the early 1950. Due to pressure of market, now it is in the phase of transition from residential to commercial land use. It also comprises private institutions and offices of companies /individuals.

Table 4.7: Characteristics of different wards selected for detailed study

Ward Name	Area (hectare)	Population	Population Density (persons/hectare)	Remarks
Race course (N) W.No. 39	91.73	8249	90	Consists of mainly HIG and MIG type housing
Dharampur W.No. 12	52.12	7932	152	New planned area with HIG and MIG housing
Devsuman Nagar W.No. 23	42.31	6935	164	Mainly MIG and LIG type housing
DL Road W.No. 4	29.72	7107	239	Characterized by slum areas with MIG and LIG type housing
Dhamawala W.no.36	25.56	7654	300	Old development with irregular street network and dominance of commercial activities
Dandipura W.No. 34	16.33	7745	474	Old development with multifamily small size housing units and along main streets some commercial activities

(Source: Dehradun Municipal Corporation)

4.12.2 Ward No. 12: Dharampur

This ward is also situated on left side of the Haridwar road while going from the city center, towards the south-eastern part of the city. This is a new planned area with population density 152 persons/ hectare. Impact of planning regulation is clear from the pattern of development with regular street network and large amount of planned public spaces. It occupies an area of 52 hectares with the population of 7932 persons. Most of the area is occupied by the middle-income group residential units. Main street has dominance of commercial activities.

4.12.3 Ward No. 23: Devsuman Nagar

It is located on the left side of the Chakarata road, towards the western part of the city. Undulating topography plays an important role in the development pattern of the area. It comprises planned as well as unplanned developments with population density 164 persons /hectare. It covers an area of about 42 hectares with population about 6935 persons. It comprises residential units mainly of middle-income group. Commercial activities can be observed along the main access road.

4.12.4 Ward No 4: D.L. Road

This ward is situated along the river Rispana, which is one of the main seasonal drains of the city towards the north-eastern part of the city. The D.L.Road provide main accessibility to this ward from Old Survey road, which can be approached through Rajpur road. About 50% of ward area has unplanned development mainly along the seasonal river. Organically, a seasonal river allows un-built spaces, along which slum/ squatter development has taken place. It occupies an area of about 30 hectare and accommodates 7107 persons. It has population density 239 persons per hectare.

4.12.5 Ward No. 36: Dhamawala

It consist a part of old city and comprises main market area, Paltan Bazar. This ward is surrounded with three major city level roads towards, Gandhi road towards east, railway station road towards south and main Paltan Bazar road towards west. The three major junctions namely Tahsil Chowk, Prince Chowk and Thana Chowk form boundary of the ward. This ward is covered with the main city level roads from three sides, This ward covers about 26 hectare area and population about 7654 persons. It has population density about 300 persons/ hectare. It is in very close proximity to the railway station, which is towards the south direction of the ward. Old bus stand is also falls within the limits of this ward. Due to its strategic location it comprises big commercial complex and hotels.

4.12.6 Ward No. 34: Dandipura

This ward is situated at left side of the Tilak road while going from Bindal Pul to Saharanput Chowk. It is adjacent to city center near clock tower with highest population density 474 persons/ hectare. Total population of the ward is about 7745 while it occupies area just about 16 hectare. It consist a part of core area and main streets are dominated by commercial land use. The main commercial area, Paltan Bazar, is towards East direction. Main streets are flanked by commercial activities with residential unit in the back or on above floors. Old development with multifamily small size housing units and narrow streets is caused for very high population density.

CHAPTER V

CREATION OF SPATIAL DATABASE

5.1 An Overview

In this chapter, potential of high resolution satellite data and GIS has been evaluated for the preparation of large scale base map at the scale of 1:2000 and its integration with the attributes related with physical, social, fiscal, environmental and legal aspect in GIS environment to investigate the existing scenario at micro level. For this purpose, evaluation of remote sensing is carried out in different aspects. First part of the chapter (section 5.2) is related with the characteristics of the remotely sensed data used and its quality considering the sun angle and elevation angle. It is followed by need and techniques used for the image fusion of satellite data of different spatial and spectral resolution and its results (section 5.3).

In the second part of the chapter (section 5.4), potential of high-resolution satellite data has been evaluated for the preparation of base map at the scale of 1:2000 through visual interpretation supported with the field verification. While, in section 5.5, potential of high resolution satellite data has been evaluated to extract the information related to various aspects-

- Physical scenario has been discussed through the land use classification, description of different categories of land use and road network.
- Social scenario has been studied through calibration of homogeneous housing areas on the basis of different housing types such as High Income Group (HIG), Middle Income Group (MIG), Low Income Group (LIG) and squatters.
- Various parameters considered for the calculation of property taxation and role of high-resolution satellite data to extract these parameters has been discussed in fiscal scenario.
- While environmental aspect has been explored through the classification of the imagery. In this section, an attempt is made to classify the imagery into 3 categories- hard surfaces, soft surfaces and green cover. It helps to understand the physical interrelationship of man-made as well as natural environment at micro level.
- The legal scenario has been studied to find the potential of high-resolution satellite data to extract and quantify the extent of temporary structures.

5.2 Data and Software Used

Generally, the features in the residential area (buildings, gardens, lawns etc.) are considerable small. High spatial resolution satellite data are highly beneficial in the context of complex urban areas where relatively small size and complex spatial patterns of the component scene elements (e.g. buildings, roads and intra-urban open space) have restricted the use of the low-resolution space borne sensors. These new images thus increase the amount of information attainable on urban form at local level.

Different kinds of data acquired from various sources have been used to investigate the existing scenario, which include-

1. IKONOS panchromatic image with 1 m spatial resolution of 19th April, 2001,
2. IKONOS multi spectral image with 4 m spatial resolution of 19th April, 2001,
3. Topo sheet No. 53 J/3 of Survey of India at 1: 50,000 scale published in 1972,
4. Guide map of Dehra Dun published in 1982,
5. Ward map of Dehra Dun municipal area of 2001,
6. Published and unpublished reports of different (central, state governments) departments.

Table 5.1: Instrumental characteristics of IKONOS sensors

SENSOR	BAND	SPECTRAL RANGE	SPATIAL RESOLUTION	RADIOMETRIC RESOLUTION
IKONOS (PAN)	Band 1	0.45 - 0.90 µm	1 meter	11 bits
IKONOS (MS)	Band 1	0.445 – 0.516 µm (Blue)	4 meter	11 bits
	Band 2	0.506 – 0. 595 µm (Green)		
	Band 3	0.632 – 0.698 µm (Red)		
	Band 4	0.757 – 0.853 µm (NIR)		

Panchromatic (PAN) and multi spectral (MS) imagery of IKONOS satellite has been used to prepare large-scale base map. Table 5.1 shows the characteristics of sensors installed on IKONOS satellite. Remote sensing data acquired for the research is in .geotiff format with UTM projection having spheroid and datum WGS 84, which is imported in .img format through ERDAS imagine (version 8.6). Figure 5.1 shows the panchromatic image and figure 5.2 shows the multi-spectral image of central part of ward no. 39, Race Course (N).

Figure 5.1: IKONOS panchromatic image

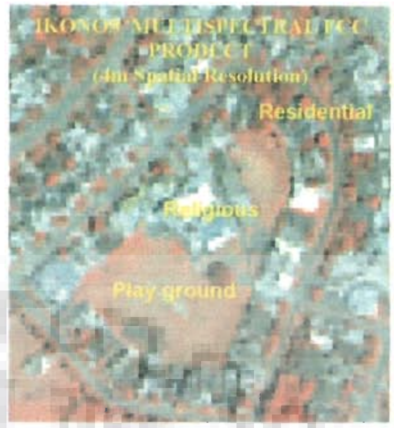


Figure 5.2: IKONOS multi-spectral image

As shown in table 5.1, IKONOS sensors record energy in the two regions of electro-magnetic spectrum- visible and near infra-red (NIR). IKONOS panchromatic image covers wider region of electro magnetic spectrum in comparison to multi-spectral image but the overall spectral signature of various surfaces in the PAN image is the resultant of average of energy recorded in visible and near IR region. Another factor, which controls the quality of the image, is the position of the sun. Sun elevation and azimuth angle play an important role in the information content of satellite imagery. The lower sun angle will result in larger shadows, which may hide some useful information. Satellite had sun angle azimuth 134.79 degree and elevation 64.74 degree at the time of data acquisition. Azimuth angle 134.79 degree means that the position of the sun with respect to north of the earth is towards south-east direction, which causes considerable small shadows of objects towards north-west direction. Elevation angle 64.74 degree is an indicator of sun position with respect to horizon of earth and results in relatively small shadow towards north-west. It means that a building of 3 meter height will cast about 1.46 meter long shadow. Research also shows that there is an optimum sun angle for almost all conditions at approximately 45 degree above the horizon (Manual of Photogrammetry, 1980). Since, sun angle is relatively higher from 45 degree, the shadows of the buildings are slightly smaller than the height of the buildings. Thus, sun position is ideal for such type of study. Small shadows tend to delineate some detail effectively and are generally advantageous in increasing the apparent quality of the image. However, the operational potential of high-resolution satellite data depends on its capacity to respond to the requirements of the planners and its integration with other secondary data related with day-to-day activities.

In this research, ERDAS Imagine 8.6 is used for image processing operations, while Arc GIS 8.2, Arc View 3.2 are used for the database creation in GIS environment and related analysis. MS Office is used for the report writing and presentaion of the research work.

5.3 Fusion of Multi-spectral and Panchromatic image

> *"For the upcoming very high-resolution satellite data, fusion of multispectral and panchromatic data will be necessary to further enhance classification accuracy and spatial feature classification will be indispensable."*
>
> ……………… *Zhang (2001b).*

The majority of the highest resolution images are presently recorded in panchromatic mode only (Donnay *et al.*, 2001b). Generally, multi-spectral imagery provides more land cover information than panchromatic imagery, since each spectral waveband provides specific information about land cover features (Ben-Dor *et al.*, 2001; Roessner *et al.*, 2001; Aplin, 2003). The challenges now are to find the ways to derive the maximum information from the data that these new sensors provide. This requires combined use of (i) the high spatial resolution panchromatic data to provide an accurate description of the size, shape and spatial structure of the principal objects/entities found in towns and cities, (ii) the slightly coarser spatial resolution multi-spectral data to classify different types of urban land cover/land use.

The solutions suggested to solve this problem revolve around the use of various methods of data fusion; merging the higher resolution panchromatic data with lower resolution multi-spectral data (Jones *et al.*, 1991; Ackerman, 1995; Ranchin and Wald, 2000; Donnay *et al.*, 2001b). Fusion of remotely sensed imagery of different spatial and spectral resolution enhances the interpretation capabilities for the preparation of base map.

In this research, image fusion is used as a technique to combine the data sets of different spatial and spectral resolution i.e. panchromatic and multi-spectral imagery to get the advantages of spatial as well as spectral resolution of different sensors. The output of fused image has finer spatial as well as spectral resolution.

Numerous approaches to data fusion have been proposed in the literature, though few can be considered satisfactory in terms of preserving the (spectral) information content of original images (Ranchin *et al.* 2001). A number of methods are used to fuse the data set in this research out of which, fused image output obtained through IHS to RGB transformation and Brovey transformation are used to study the different aspects of urban scenario.

5.3.1. RGB/IHS Transformation

Fusion is carried out using Intensity, Hue and Saturation (IHS) transformation to red, green and blue (RGB) technique. "Intensity" refers to the total brightness of a color; "Hue", generally refers to the dominant or average wavelength of light contributing to a color; and "saturation" specifies the purity of a color relative to gray (Dwivedi *et al.*, 2001). The standard false colour composite, band 4 (0.757 – 0.853 μm), band 3 (0.632 – 0.698 μm) and band 2 (0.506 – 0.595 μm) of IKONOS MS data are used for spectral resolution merging with panchromatic image. Intensity is replaced by high resolution panchromatic image. Finally, the image is resampled using nearest neighbor method with output pixel size 1m x 1m. This fused image is stretched to unsigned 8 bits, which consists of 3 layers. Pixels with zero values were ignored while calculating the statistics of the output image. The false colour composite from output fused image is created by displaying

Figure 5.3: Image fusion through IHS to RGB transformation

layer 1 in red, layer 2 in green, layer 3 in blue, on which various surface covers are clearly identified as shown in figure 5.3. As the parameter Hue is not modified, it largely defines what we perceive as color, and the resultant image looks very much like the input image (ERDAS field guide, 1999).

5.3.2. Brovey Transformation

Image fusion using Brovey transformation helps to improve interpretation in darker and lighter region of the image, which results in better spectral separability in the tails of the histogram. In this research, Brovey Transform method is used to create a new merge image (figure 5.4). Since the Brovey Transform is intended to produce RGB images, only three bands at a time should be merged from the input multi-spectral scene. Selection of bands from multi-spectral image plays an important role in the resultant fused image. It is observed that combination of band 4, band 3 and band 2 of MSS imagery provides better result than any other combination used for fusion using Brovery Transform. In this method, new image is created according to the following formula:

[DNB1 / DNB1 + DNB2 + DNBn] x [DNhigh res. image] = DNB1_new

[DNB2 / DNB1 + DNB2 + DNBn] x [DNhigh res. image] = DNB2_new

etc.

where B = band

Figure 5.4: Image fusion through Brovey transformation

Image fusion using Brovey Transform, which visually increases contrast in the low and high ends of an images histogram (i.e. to provide contrast in shadows, water and high reflectance areas such as urban features) results in improved interpretation (ERDAS, field guide, 1999). But consequently, it does not preserve the original scene radiometry. However, it is good for producing RGB images with a higher degree of contrast in the low and high ends of the image histogram and for producing "visually appealing" images.

5.3.3. Comparing Brovey Transformation vs. IHS to RGB Transformation

As discussed earlier, image fusion using Brovey transformation increases the contrast in the lighter and darker region of the histogram, thus it is used for the visual interpretation of the imagery to study the physical, social, fiscal and legal aspects. It provides better contrast between different man-made features. Since, it does not preserve the original scene radiometry, digital classification to study environmental scenario is not preferred. While image fusion using IHS to RGB transformation does not changes the hue component and preserves the original colours of the MS image. It gives better contrast between natural and man made features. Hence, it is used to study the environmental aspect of the study area. Figure 5.5 shows the comparison between these two outputs. Variations in color and tone of playground as well as built up areas in these two outputs are given in insat A, A' and B, B' respectively.

Figure 5.5: Comparison of Brovey vs. IHS to RGB transformation

5.4 Base Map Preparation

In this step, first the municipal ward boundary map of Dehradun city was transferred on IKONOS fused image through digitization in the GIS environment. Then, the study areas were extracted using ERDAS Imagine version 8.6, including six municipal wards namely, ward no. 39 - Race Course (N), ward no. 23 - Devsuman Nagar, ward no. 4 - D.L. Road, ward no. 34 – Dandipura, ward no. 36 - Dhamawala, ward no. 12- Dharampur.

The spatial variations and spectral responses as well as the size, shape and spatial arrangements of buildings, roads and various types of land covers are used to prepare base map from the high-resolution satellite data. Identifying urban phenomena and preparation of base map by means of remote sensing involves three key steps:

i. Pre field interpretation
ii. Field verification and primary data collection
iii. Post field updation

5.4.1. Pre field interpretation

Pre field interpretation of fused images (Brovey transformation) has been carried out on the basis of shape, size, tone and color with special emphasis on the textural and structural information. The interpretation key developed for the visual interpretation for the preparation of base map is given in Appendix IV. The details of these elements in identifying and delineating building areas are –

Shape: It is used to discriminate the various categories of the man made features having about similar spectral characteristics such as building, roads etc. It refers to the general form, configuration or outline of man made and natural objects.

Size: This element of visual interpretation is used to separate the buildings of different income groups. It is also used to identify the different types of land uses, as public areas are comparatively larger than the private residential buildings. The minimum parcel size at which mapping takes place using IKONOS imagery is considerable small, which helps in the detailed mapping at ward level.

Shadow: As discussed earlier in section 5.1, due to sun and azimuth angle at the time of data acquisition, shadow of the buildings are relatively smaller than the building height, it has been used to separate the individual buildings and to determine the height of the building. Shadow of the building has been also used to identify the land use.

Pattern: The spatial pattern of the various man made objects has been used for the grouping of the homogeneous housing types. Especially, pattern of development played an important role in discriminating the different housing types. It is observed that the topography of the area is an important factor, which governed the development pattern.

Tone: Tonal difference has been observed in the buildings with different roof cover and constructed over different time periods. Without the tonal differences, the shape and pattern could not be discerned. This is the most important quality of the objects, which helped in the accurate mapping of adjacent are the most important as they attract most of attention.

Texture: Texture is the result of uniform tonal changes caused by objects, which are too small to be clearly distinguished individually. Texture ranges from smooth or fine to coarse depending upon the scale of the image. With the help of this property, buildings having various roof-types and time of construction can be roughly interpreted.

Location and Association: These are not object characteristics but denote its immediate surrounding. Association is a skill developed by the interpreter, which involves a reasoning process, which uses all the principles of interpretation to relate an object to its surroundings.

Figure 5.6: Typical urban morphology observed in ward no. 23, Devsuman Nagar

Use of information on the size, shape, relative proportions, spatial arrangement of objects and other scene elements are used as 'cues' to identify different types of urban land use. Obviously, the cues employed have been adapted to the specific land use categories found in the wards being examined.

Wards selected for detailed study comprises different types of land use/ land cover arranged in different spatial patterns. In most of the wards, it was observed that planned and unplanned areas closely interlinked with each other, which were easily discriminate in fused image. Figure 5.6 shows the typical urban morphology in ward no. 23, Devsuman Nagar. Insat "A" shows that regular shape of the buildings of almost equal size with regular pattern, which is useful for the discrimination of individual buildings from each other in planned developments. While, insat "B" shows that interpretation of

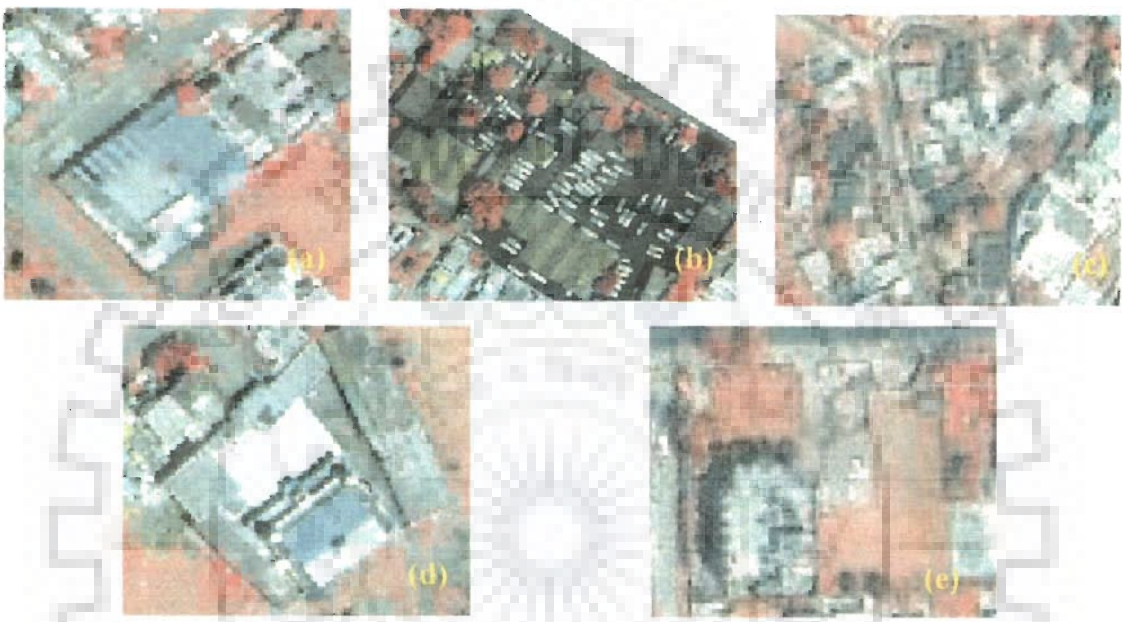


Figure 5.7: Spectral dimension of different materials in FCC created from fused image

informal settlements was comparatively difficult due to the small and unequal size of the buildings and accessibility from narrow lanes. Used in conjunction with the spectral and spatial properties of the constituent scene elements, interpretation keys helped to delineate area of different urban land use by predicting their appearance in remotely sensed images.

During the interpretation, it was observed that the spectral dimension of the materials used for large public buildings are different than the residential buildings. Despite the inherent limitation of remotely sensed data in respect of spectral dimension of different materials, several broad categories of land use in these wards are determined from measurements of spectral reflectance of roof cover. The detected spectral reflectance is primarily controlled by the nature of materials used to construct the roof, as well as its physical condition and geometric structure (e.g. pitched roof). These buildings were identified on the imagery while the material of the roof cover has been explored during the field visit. Figure 5.7 shows the spectral dimension of different materials in false colour composite (FCC) created from fused image. Figure 5.7 (a) is the community center with the Regular Modified Polyster (RMP) sheets in the ward no. 39, Race Course (N) while figure 5.7 (b) is also a part of ward no. 39, Race Course (N) shows the Uttranchal roadways workshop with galvanized roof cover. Temporary structures with plastic roof cover dispersed between the RCC roof buildings are shown in figure 5.7 (c). Figure 5.7 (d) is a religious building with RCC and RMP roof cover in the ward no. 39, Race Course (N) while long shadow of the hotel as shown in figure 5.7 (e) has been used for predicting the land use in a part of ward no. 23, Devesuman Nagar.

Problems were encountered while interpreting the ward no. 34, Dandipura and ward no. 36, Dhamawala, because about 40-50% of ward area comprises the old developments. In these wards, inner parts of old developments accessed through the very narrow lanes were difficult to interpreted directly from the satellite imagery. Same problem was also faced while interpreting the right side of the main accessed road in ward no. 4, D.L.Road, which comprises informal settlements. Thus, it generated the need to prepare the detailed road network map of the wards for the field check. On the basis of the functions and width, road network is classified into three categories- primary, secondary and tertiary roads. While, parcel having access from the primary and secondary roads was easy to interpreted in these wards also.

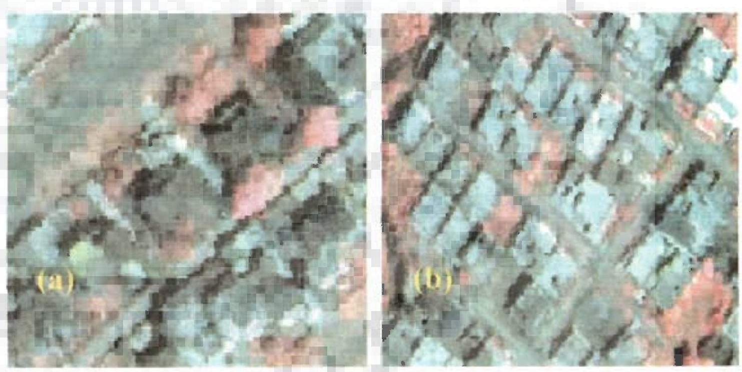


Figure 5.8: Building constructed over different time periods (a) Old developments (b) new developments

Another remarkable feature observed during the interpretation of the images is variation in tone of building constructed over different time periods. Buildings constructed over different time periods give different tones in merged imagery as shown in figure 5.8. Patterns of urban land use vary across space and time. Remote sensing imagery distinguishes between different physical forms associated with different time periods. The way in which the city physical forms assemblage from the past is immediately clear from multi-spectral imagery.

Thus, base maps prepared for different wards have been based on scientific analysis and evaluation of the form, structure and composition of urban areas through direct or indirect identification. Small and large buildings and small accumulations along roads were mapped carefully in order to retain the fundamental information on settlement structure. Background knowledge of the study area and the context of analysis improved interpretation of remotely sensed images.

Finally, using the visual interpretation parameters, the large-scale base map and roads were digitized and unique ID had been assigned to each parcel for field data collection.

5.4.2. Field Verification and Primary Data Collection

The identical spectral reflectance values correspond to very different land uses and diverse functions in urban areas poses limitation in interpretation of high-resolution satellite data – which demands the use of ancillary information as well as field verification in addition to usual remote sensing data. In this process, six wards were surveyed.

Field verification was carried out to improve the interpretation as well as to collect other primary information. Since, large-scale base maps are not available for Dehradun city except the ward boundary map, therefore, fieldwork played an important role in this study. In most of the cases, parcel boundary were identified directly from the fused image, while their actual function was determined during the field survey. For this purpose, large scale color print outs of different wards under study were taken to the field. Large-scale print outs of base map along with IKONOS imagery were used to set up sophisticated field surveys. Extensive field survey potentially extends the scope to cataloging small-area activity patterns and it was observed that topography has a lot of influence in the development pattern in different wards. Field verification involved the aggregation of elements, none of which are important in isolation.

The primary data collected during the field to investigate the existing scenario at ward level includes-

- Land Use (Residential, commercial, educational etc.)
- Type of development (HIG, MIG, LIG, Squatters)
- Type of structure (Pacca, Semi Pacca and Kachha.)
- Phase of development

Field survey explored that ward no. 39- Race Course (N) comprises area mainly of Chandan Nagar colony towards the north west and Race Course colony in the central part of the ward. City jail and roadways workshop on the Haridwar road towards the north-west direction and Gurudwara in the central part of the ward are the major landmarks in the ward. During the field, maximum accuracy about 95% was observed in this ward because of the planned development with large size of dwelling units. Because of the variation in tones of each building, low income group areas were also showed high accuracy in this ward, which are towards the south east direction of the ward with undulating topography. Field visit also helped in the association of the large scale open spaces with the big houses towards the western side of the ward, some times which were not clear from the satellite imagery alone. Detailed land use of each building was identified during the field. It was observed during the survey that land transformation is taking place in this part of the city, due to its location and planned developments.

Ward no. 12, Dharampur and ward no. 23, Devsuman Nagar also reflected about 80-90% accuracy because of planned developments. Office of Life insurance Corporation on the main Haridwar road towards south direction, Jal Sansthan and Jal Nigam in the central part of the ward and residential colony for the employees of income tax department are some important landmarks in ward no. 12, Dharampur. This ward comprises mainly two residential colony namely Dharampur area towards the northwest portion and Nehru Nagar colony towards the southeast portion of the ward. Due to undulating topography, about 10% of the area towards the north west part of the ward is unplanned with the irregular street pattern. Planned developments with large size dwelling units showed about 90-95% accuracy in the interpretation. Due to absence of the changes in the tonal values, number of dwelling units interpreted from imagery was comparatively less than the actual in planned areas for the lower income groups towards the eastern and central part of the ward. The basic reason for the same is row houses with same material of the roofs, and constructed almost over the same period of time. Pre field interpretation of this ward was about 85% accurate.

While ward no. 23, Devsuman Nagar comprises Deeplok, Aakash Deep, Mitrra Lok, Mahendra Vihar, Saiyyad Mullah and a part of Vasant Vihar colonies. Htotel Surbhi on Chakarata Road, which provides main access to the ward, towards the north direction, is an important landmark in this ward. Development pattern of this ward is governed by the topography of the area. Due to difference in tone, shape and equal size of the large dwelling units, interpretation of these planned areas was about 100% accurate while small size dwelling units along the drainage channel required extensive field verification. Sayyad Mullah is located towards the eastern part of the ward, which is mainly occupied by the low income group people. During the field survey, it was observed that it is in the phase of transition from lower to middle income group and commercial activities are increasing along the road to meet the demand of the market due to change in city functions and increased land value.

Accuracy of pre field interpretations of ward no. 4, D.L.Road, ward no. 36, Dhamawala and ward no. 34, Dandipura was relatively less because a large portion of these wards is occupied by the informal settlements and/or old developments with narrow streets. Land use characteristics of these wards are different and influenced by the location of the ward. Ward no. 4, D.L.Road is located towards the left bank of the seasonal river Rispana Rao. Name of the ward is formed out of the main access road, D.L.Road. It provides the main access to the ward, which divides the ward into two parts. Left part of the ward is planned and mostly occupied by the dwelling units of medium size. While, right side of the ward is occupied by the informal settlements adjacent to the river Rispana Rao. Field survey explored that the informal settlements of this ward comprises mainly Arya Nagar, Chiriamandi and Nalapani Nai Basti areas while planned development comprises mainly the areas of Arvind Marg, Sevak Ashram road. Thus, accuracy of pre field interpretation towards the left side of the ward, which is comparatively planned, is higher in comparison to the left side of the ward, which comprises the area of the informal settlements. Overall accuracy of pre-field interpretation was about 80% in this ward. Most of the areas are occupied by the medium and small size dwelling units, which resulted in the high population density. This ward lack any land mark at city level except the big hospital towards the lower left side of the wards.

Ward no. 36, Dhamawala is located in the heart of the city with the dominance of the commercial activities. A large area of the ward is occupied by the old developments while during the survey, it was observed that some parts of old developments have got renovated. Railway station is located towards the south west direction and shared the boundary of this ward. Three important squares, Tehsil Chowk towards north east side, Prince Chowk towards the south east and Thana Chowk towards the south west side forms the three corners of this ward. Immamullah building in the eastern side and Kotwali on the western side of the ward are the important landmarks. Raja road towards the southern part of the ward divide it into two parts. Southern part of the ward is comparatively planned new development comprises the area of Raja Road, Laxmi park colony etc. Accuracy of the pre-field interpretation of this ward was about 75%.

Ward no. 34, Dandipura is also located in the central part of the city towards the western side of the main market Paltan Bazar area. Tilak road towards the western side of the ward provides the main access to the ward. During the field, it was observed that State Forest Department office is one of the important landmarks located towards the north of this ward. It comprises very old buildings towards the northern and western side of the ward and informal settlements towards the eastern side of the ward due to undulating topography. Drainage carrying the dirty water is the reason for the informal settlements in this ward located in the central part of the city. Most of the houses in this ward are multistoried with very small dwelling units. Old buildings towards the southern part of the ward are shared by large number of families. Due to its location, people employed in the adjacent commercial areas prefer to stay in these areas mostly in very small dwelling units on rent.

Through Rapid Visual Screening method, primary data for every parcel in the wards selected for detailed study were collected to investigate the existing scenario. The most important part of the field survey was segmentation of the observed scene into discrete, homogeneous spatial units. Large 'unbound' areas with single, specific functions e.g. cemeteries, jail and bus stand are delineated in this way. Planned development shows maximum accuracy in interpretation while, extensive field verification was required to update the interpretation in low-income group and squatter developments. In order to acquire physical characteristics, the significance of elements arises from their association with other elements, which may be more or less important in the scheme of things. Each parcel has been identified from the imagery while number of dwelling units and occupancy rate is verified during the field. Especially in the old developments, where more than one family shares one building, occupancy rate is usually very high, as seen during the field survey. Care has been also taken in case of unplanned areas as well as row housing, as it also form very small dwelling units attached with each other.

5.4.3. Post field updation

Changes observed during field survey in different wards were incorporated in the base map prepared prior to the field survey. Planned developments showed high accuracy of pre field interpretation, while, detailed field survey of the informal settlements and old developments resulted in the higher accuracy for mapping of these areas. Major changes were observed in the narrow lanes with less than 2 meter width and parcel/ building accessed through these lanes. Maximum corrections were made in ward no. 4, D.L.Road, ward no. 36, Dhamawala and ward no. 34, Dandipura, which attained least accuracy in some parts of the ward. Large-scale base maps prepared from satellite imagery supported by field verification results in higher accuracy in terms of location and attribute. Primary data collected during the field survey were attached as attributes with the base maps in GIS environment.

5.5 Generation of Thematic Map

Urban form has been related to function across a range of scales from the individual building to overall built-up form. It establish a basis for linking form to function, thus it become possible to appraise the extent to which different urban forms are sustainable in present scenario, according to a wide range of criteria. Digital data provided a means of exploring and exemplifying existing scenario and constructing new models of urban areas by defining and identifying relevant spatial entities and examining the relationships between them.

Base maps at the scale of 1:2000 has been prepared from IKONOS fused image, which are linked with attributes related with physical and social aspect, in order to permit efficient spatial analysis at ward level. GIS has been used to attach base map with other secondary attribute data. Moreover, high resolution satellite imagery of urban area helped directly or indirectly to support and inform a number of issues related with physical, social, fiscal, environmental and legal aspects, which includes-

- Nature and spatial distribution of different land use and accessibility/ road network,
- Location and extent of different types of houses i.e. HIG, MIG, LIG and squatters.
- Property tax contribution by different income groups,
- Availability of open spaces and green areas,
- Development pattern of informal settlements.

Attribute related with various parameters helped to analyze issues of physical, social, fiscal and legal issues.

5.5.1. Physical Scenario

Physical scenario has been investigated through the inventory of detailed land use pattern and road network in the six wards selected for detailed study. Land use pattern observed in different wards depicts the spatial distribution of city functions. In other terms, it has concerned with the location of each individual use in relation to every other use such that to the transportation and utility systems of the urban area and to health, safety, education and the general amenities of urban living. Land use is a product of activities likes residential, commercial, and public/semi public etc. Land use observed during the field survey shows that in each ward a large number of parcels are subjected to more than one different activities simultaneously, which results in mixed land use. Impacts of mixed land use have been observed on the city elements like transportation network, especially parking. As mixed land use generated, it attracts comparatively more traffic requiring adequate access and parking areas.

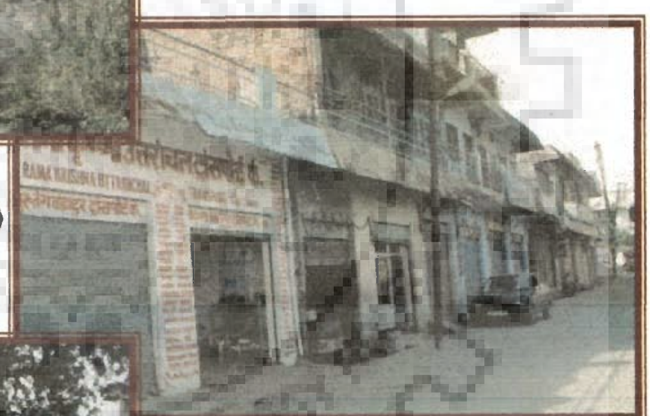
Detailed land use maps prepared from IKONOS fused image supported with field survey for different wards under study are shown in map no. 5.1-.6. About 12 categories have been mapped, which includes residential, commercial, educational, health, religious, public services, open spaces, vacant land, drainage, road network, others etc., while mixed land use is also segregated in different categories separately. Most common form of mixed land use observed in different wards is commercial activities with residential units, while clinic is another major activity associated with the residential units. In some wards, primary schools are present in residential buildings. A detailed inventory of the land use plays a guiding role as allowing us to create detailed inventories of existing land uses and provides the level of social infrastructure in different wards. The classifications used for the study are briefly described in the following paragraphs. Figure 5.9 shows some representative areas of a few land use classes in different wards under study.

Residential is the largest land use category comprises almost 40-60% of the total area, which occupies dwelling units mainly used for habitation. High-resolution satellite data is very useful to trace the individual dwelling unit in the residential areas. Dwelling unit is a structure or space, which is usually occupied by one household. *Commercial* activities have been identified during the field survey and mostly it is associated with the residential units.

Educational and health facilities are considered as fundamental social infrastructure, thus these are classified under separate category. Although these are separate land use, but many times during the field survey, it was found that these are associated with the residential dwelling units. Thus, these are classified as separate categories. *Institutional* class encompasses all large institutional areas such as government buildings, security institutions and large public facilities. *Public utilities* category comprises the land use activities related to basic physical infrastructure i.e. water supply, treatment plants,

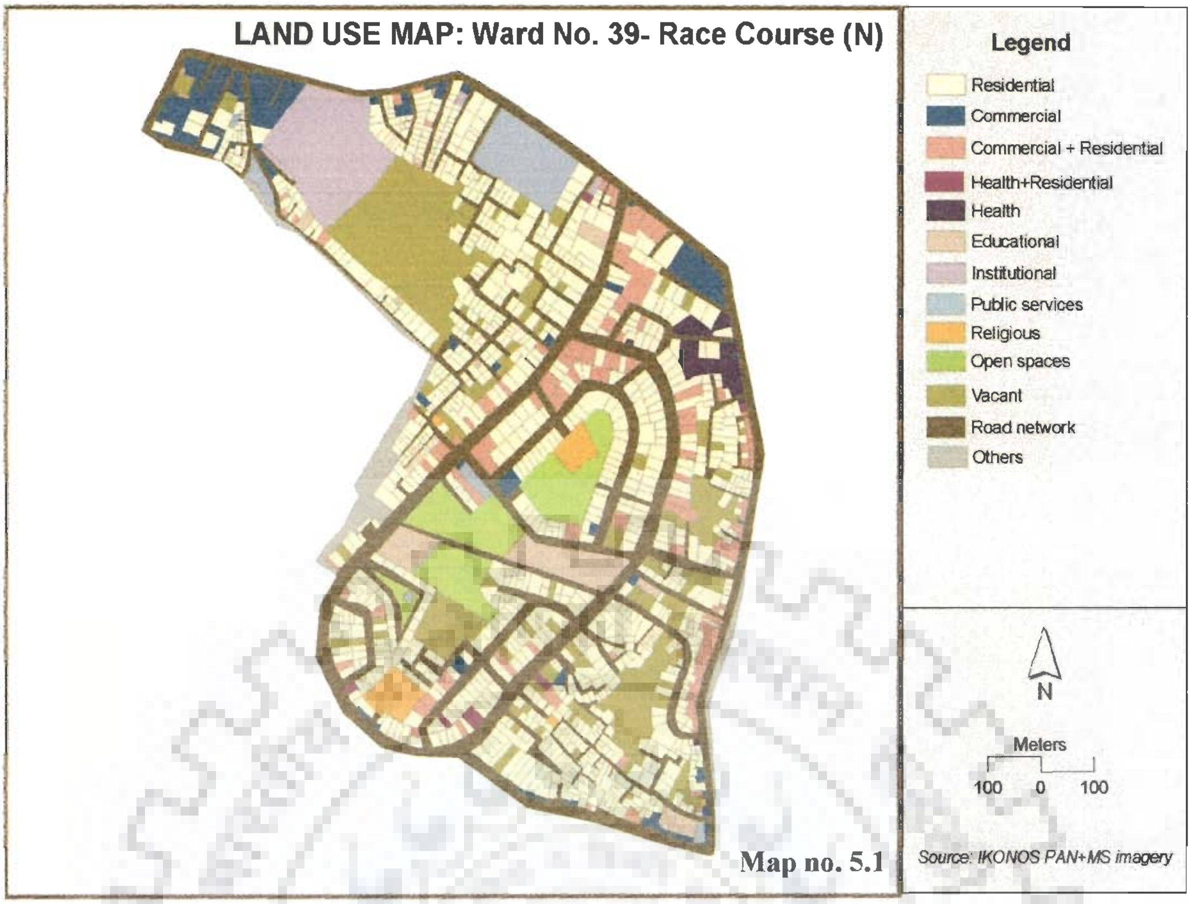
Residential dwelling unit in ward no. 39-Race Course (N)

Commercial area in ward no. 36. Dhamawala

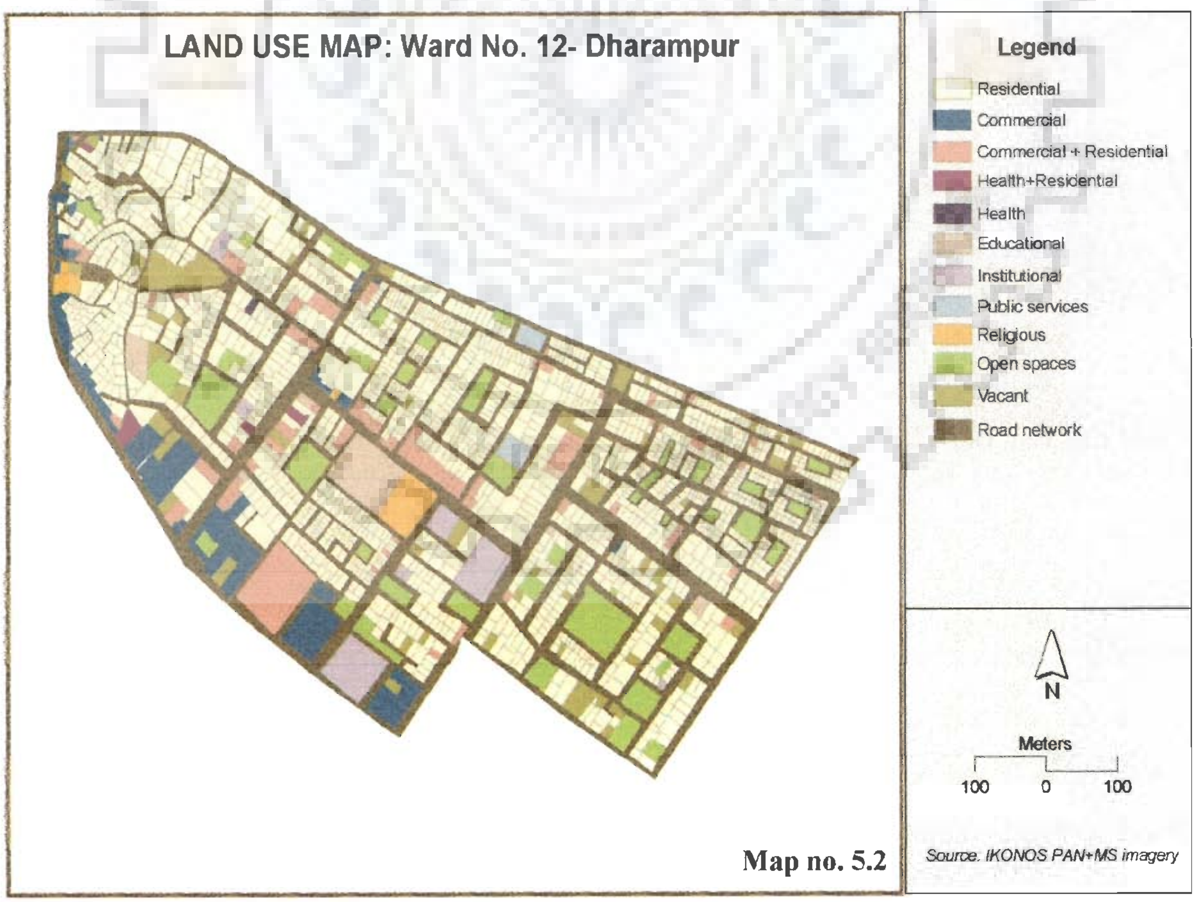


Planned open spaces in ward no. 12, Dharampur

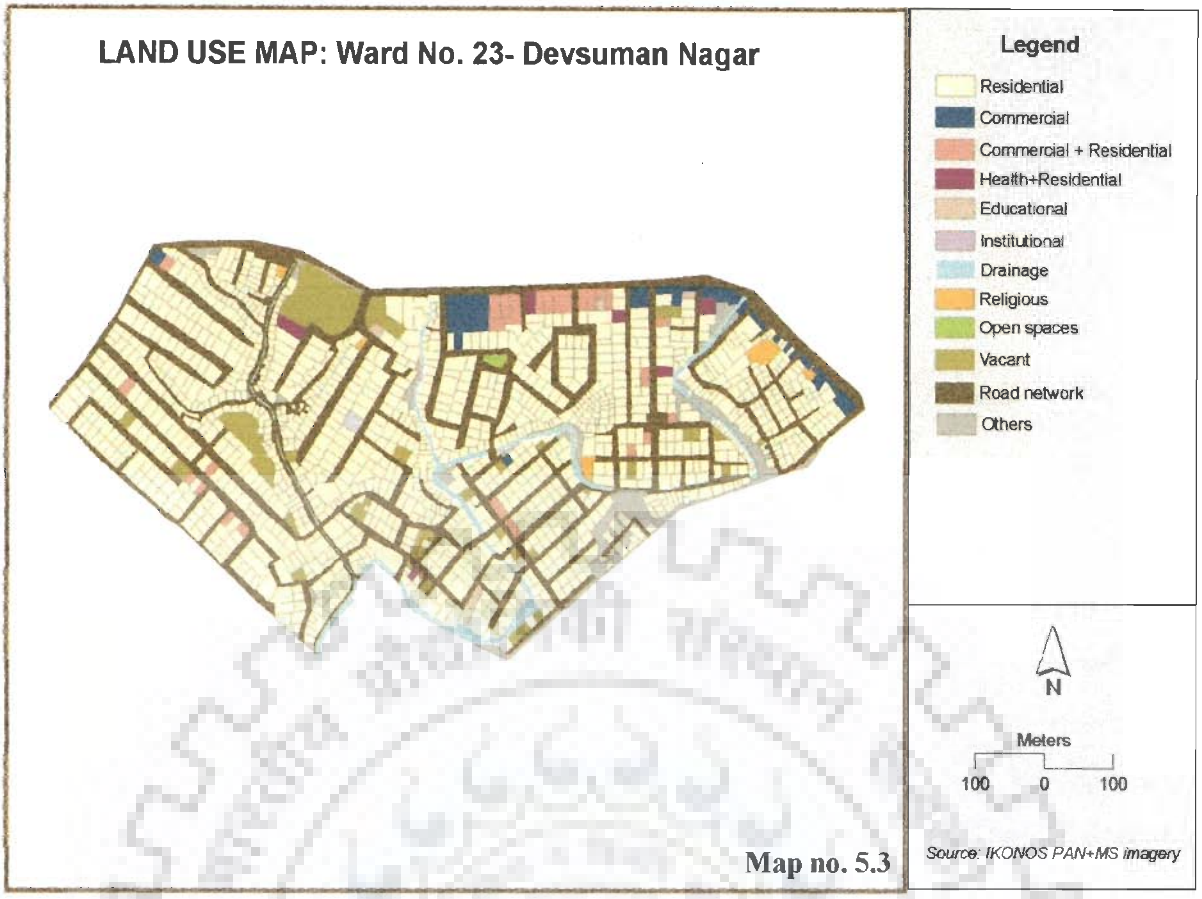
Figure 5.9: Some representative land use in study area.



Map no. 5.1



Map no. 5.2



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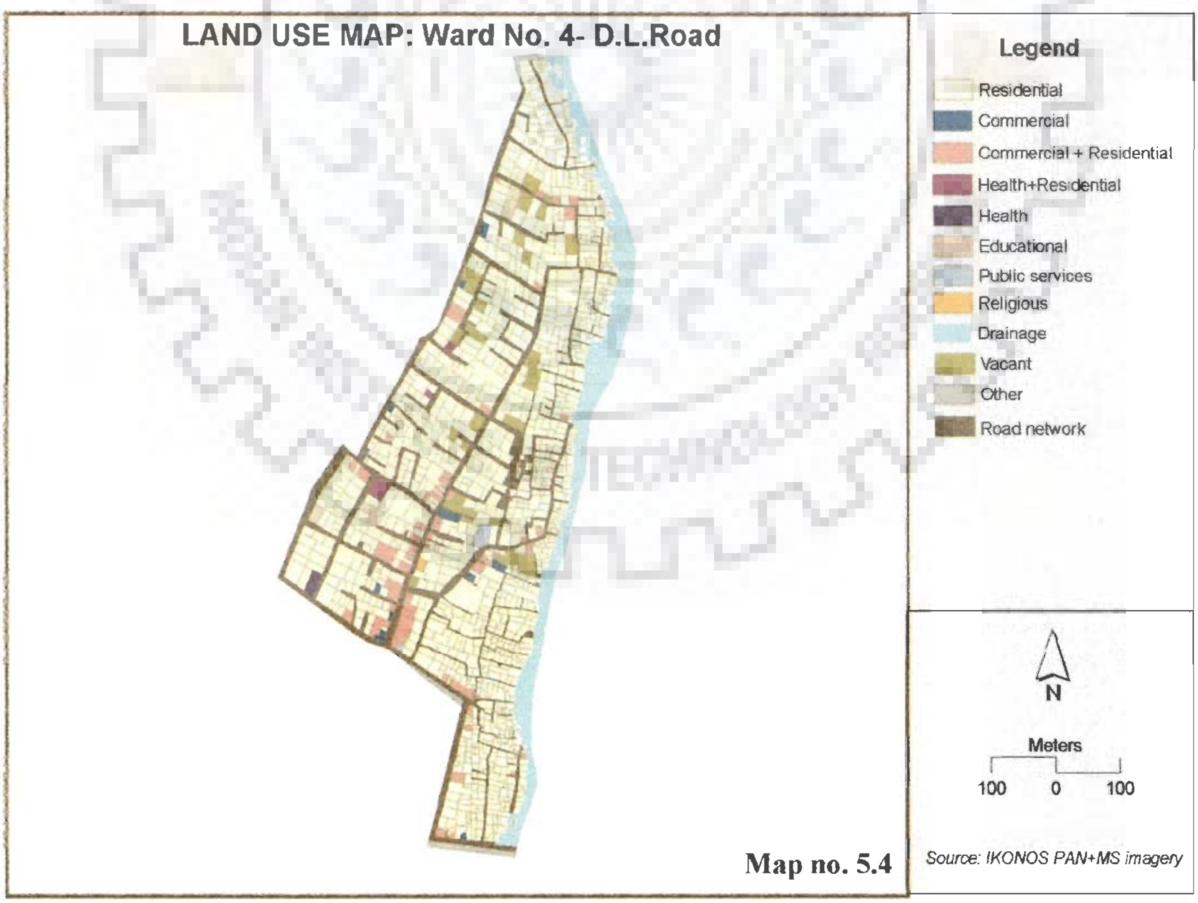

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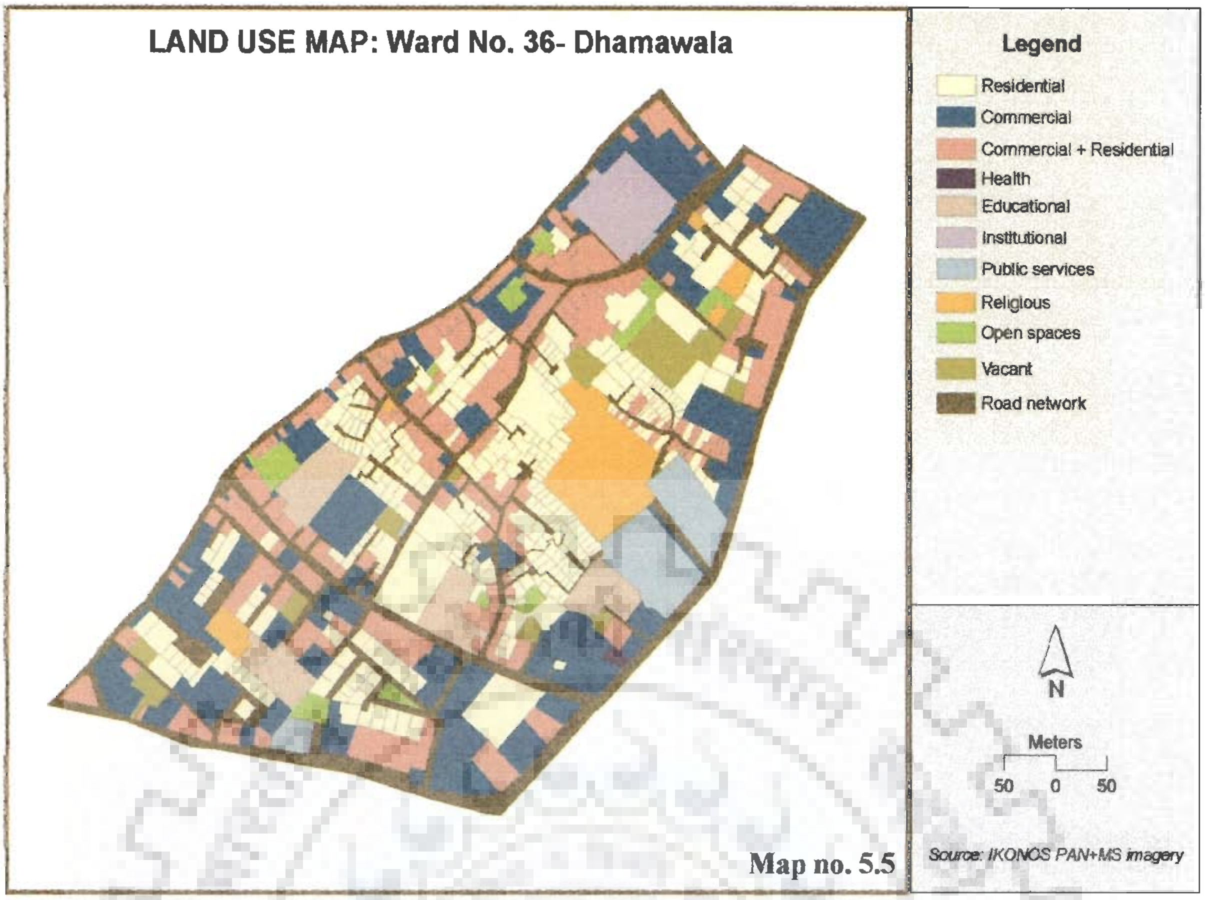
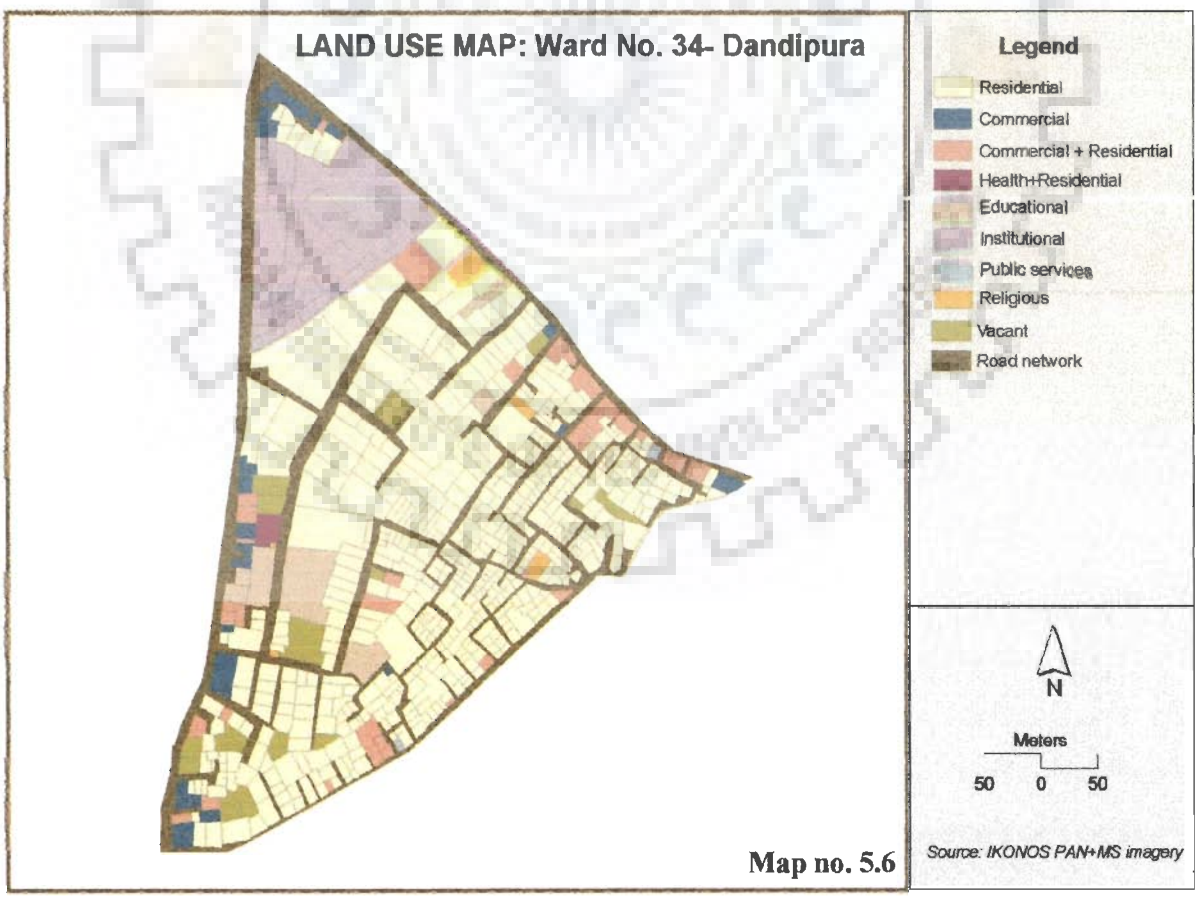
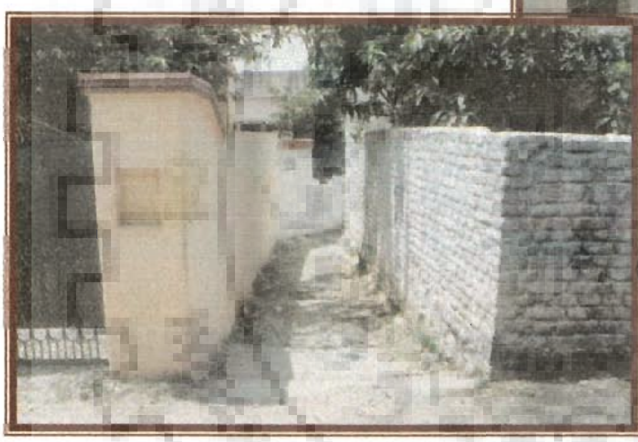

LAND USE MAP: Ward No. 36- Dhamawala
Legend
Residential
Commercial
Commercial + Residential
Health
Educational
Institutional
Public services
Religious
Open spaces
Vacant
Road network
N
Meters
50 0 50
Source: IKONOS PAN+MS imagery
Map no. 5.5


LAND USE MAP: Ward No. 34- Dandipura
Legend
Residential
Commercial
Commercial + Residential
Health+Residential
Educational
Institutional
Public services
Religious
Vacant
Road network
N
Meters
50 0 50
Source: IKONOS PAN+MS imagery
Map no. 5.6

Primary road in ward no. 39, Race Course (N)

Secondary road in ward no. 23, Devsuman Nagar



Access to tertiary road from Secondary road in ward no. 23, Devsuman Nagar

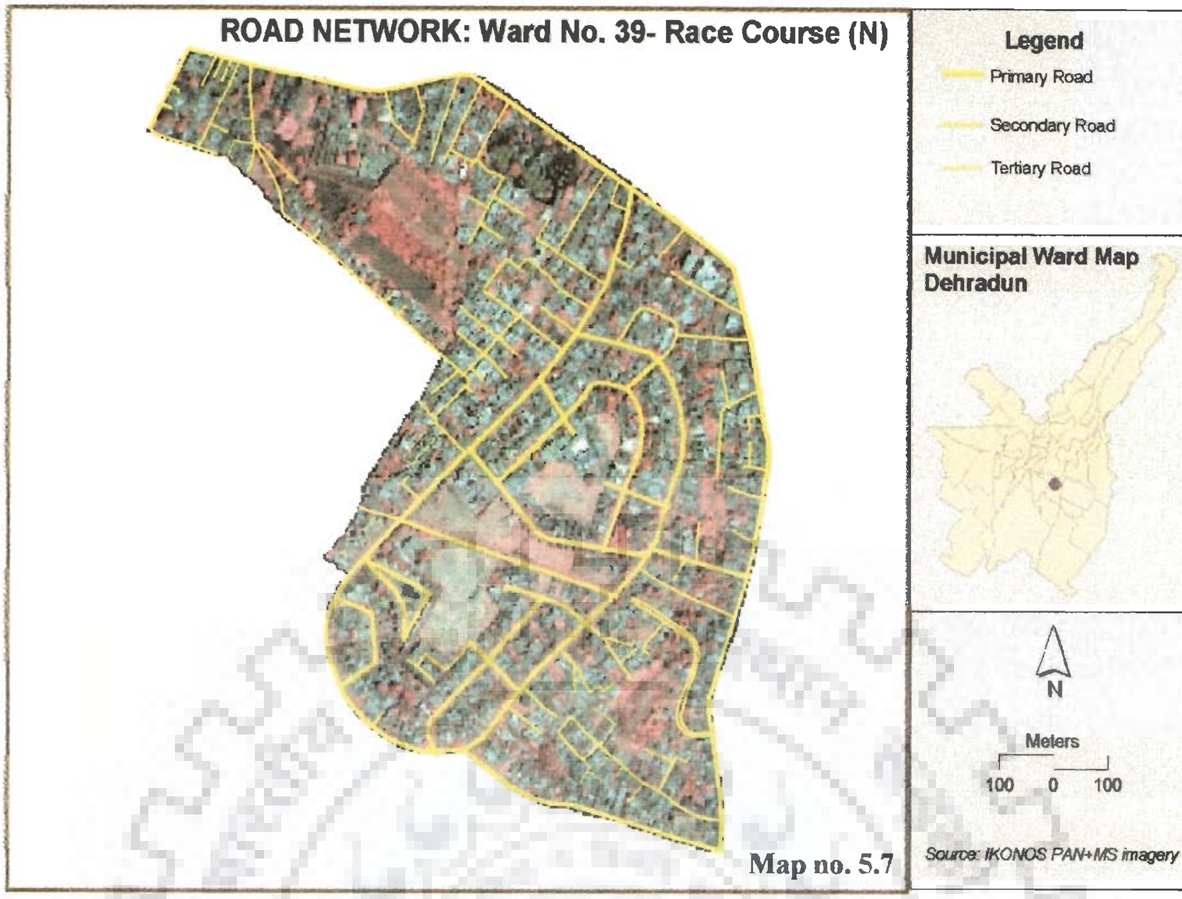
Figure 5.10: Different categories of road network.

drainage/ sewerage treatment plants/ soild waste disposal site, electricity/ power station etc.

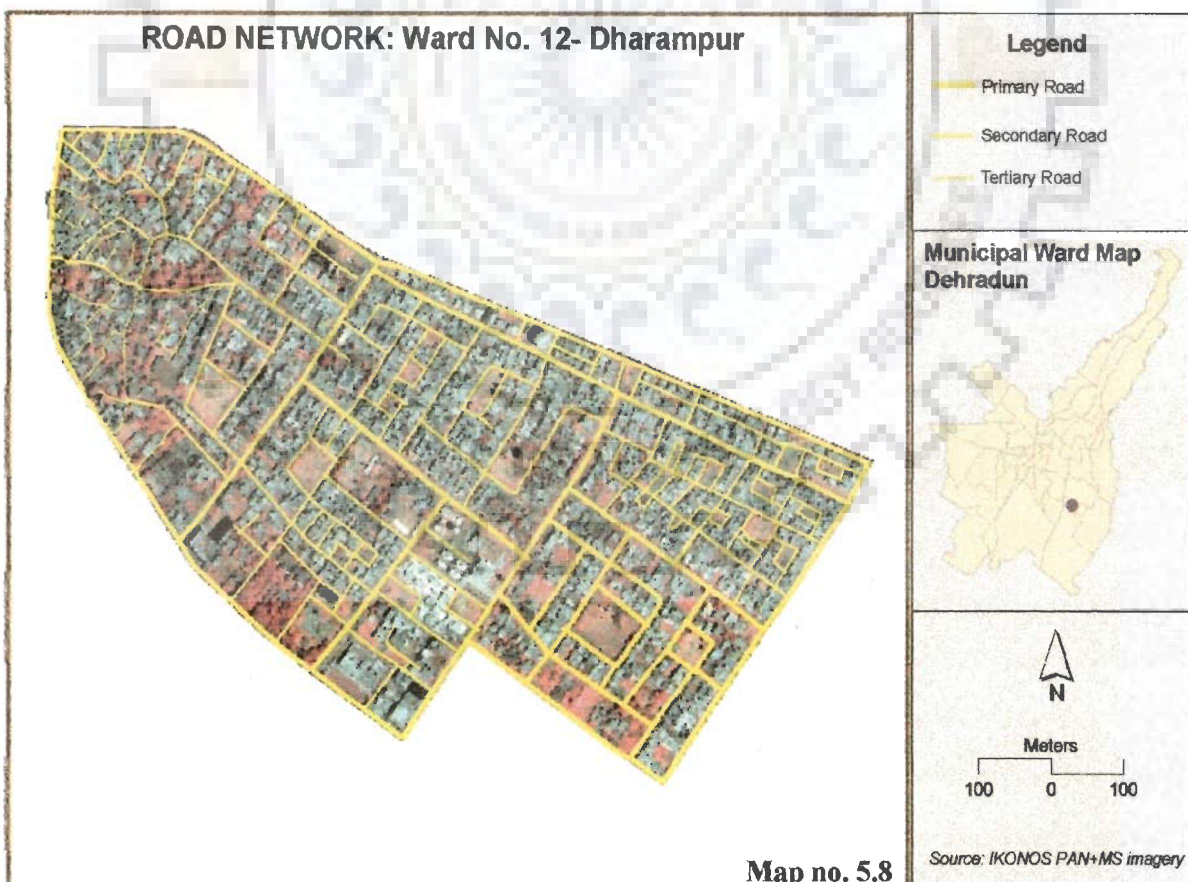
Open spaces include areas of planned open space used for public purposes, play grounds etc. *Road* is the circulation space forms the accessibility to the individual parcels. *Drainage* is a separate class given to the natural drainage system of the area formed due to undulating topography. *Vacant* category is comprises the land/plots preserved for future development. *Others* are given to incidental open spaces and other such unclassified land uses. Land use map prepared for the different wards are shown in map no. 5.1-.6.

Road network, which is another important parameter to study physical aspect in different wards, has been studied in detail to explore the existing scenario. Regular street pattern showed planned development in contrast to irregular pattern for the haphazard development. Thus, road network of the city has been mapped in three broad categories: primary roads, secondary roads and tertiary roads. Width of the roads varies according to the different levels. City level roads are primary roads, which are more than 8 meter wide, while roads with width between the 2-8 meters are classified as secondary roads. Roads having width less than 2 meters are termed as tertiary roads, which is commonly known as lane. Figure 5.10 shows the typical example of primary, secondary and tertiary roads. It was observed during the field survey that pattern of road

Figure 5.11: (a) Tertiary road in ward no 23, Devsuman Nagar (b) its location in the imagery.



Map no. 5.7



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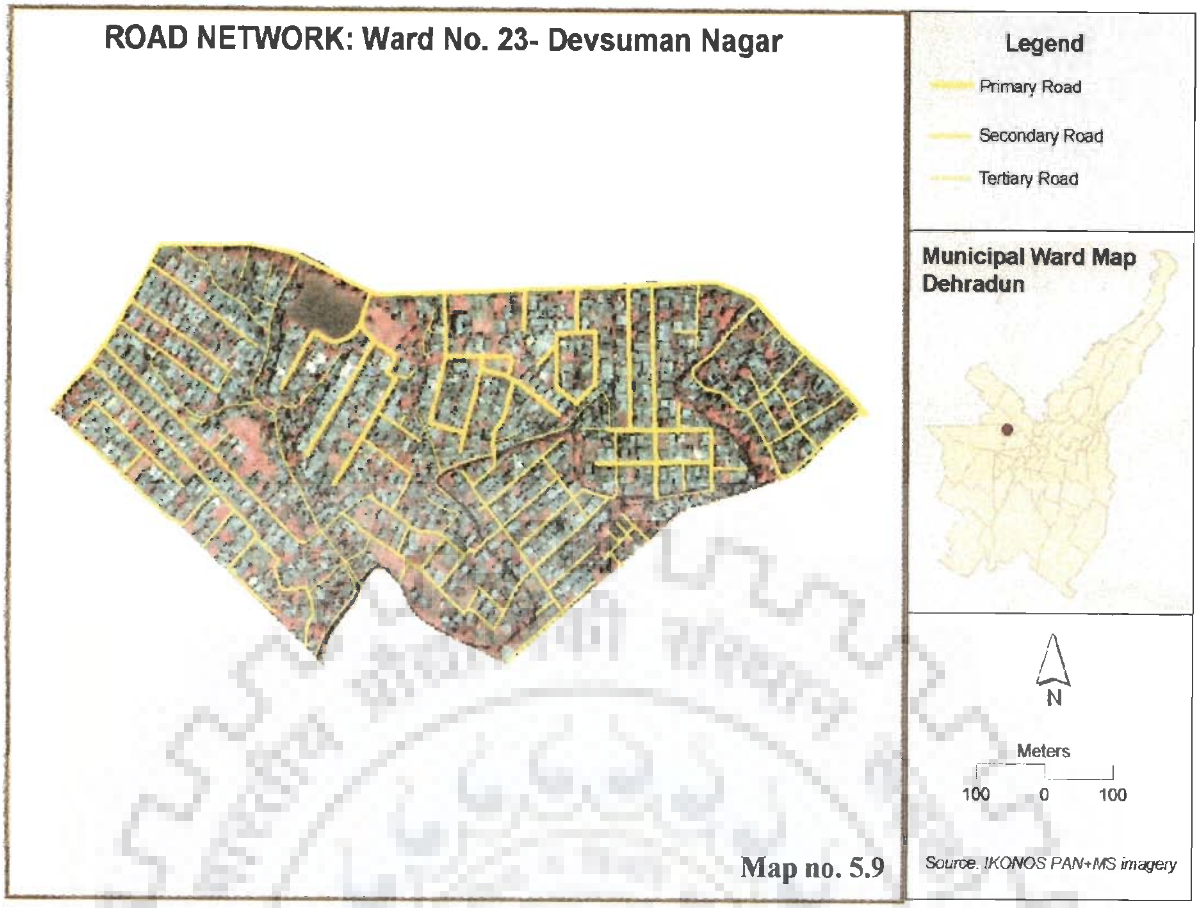
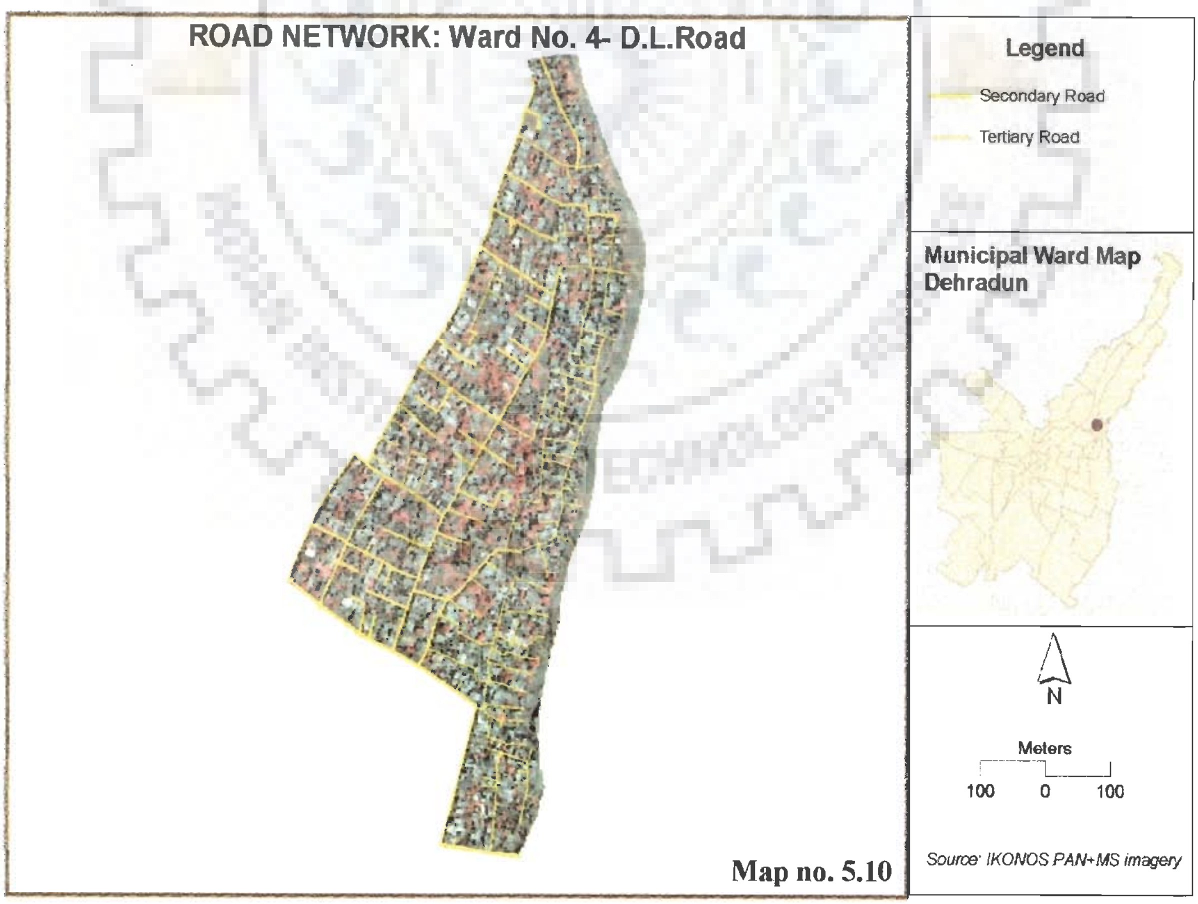
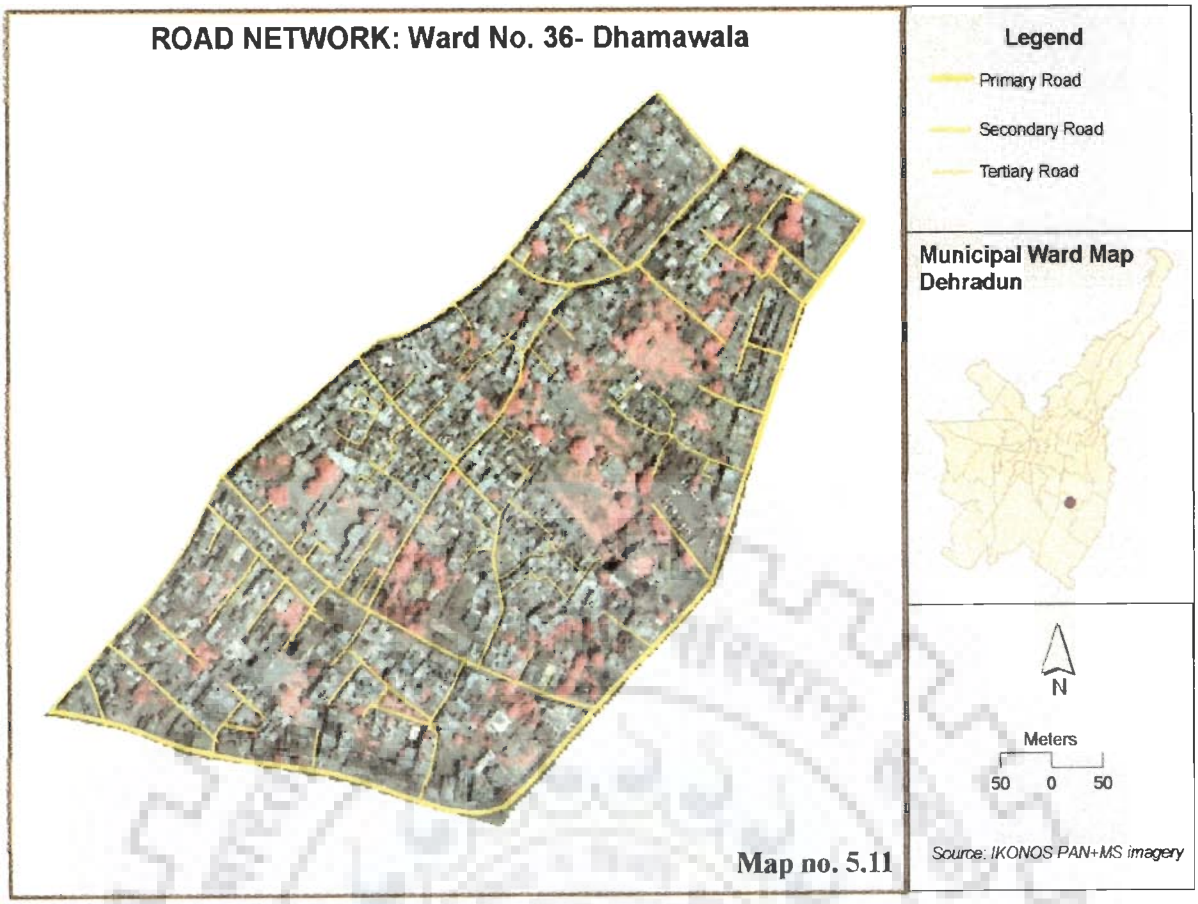


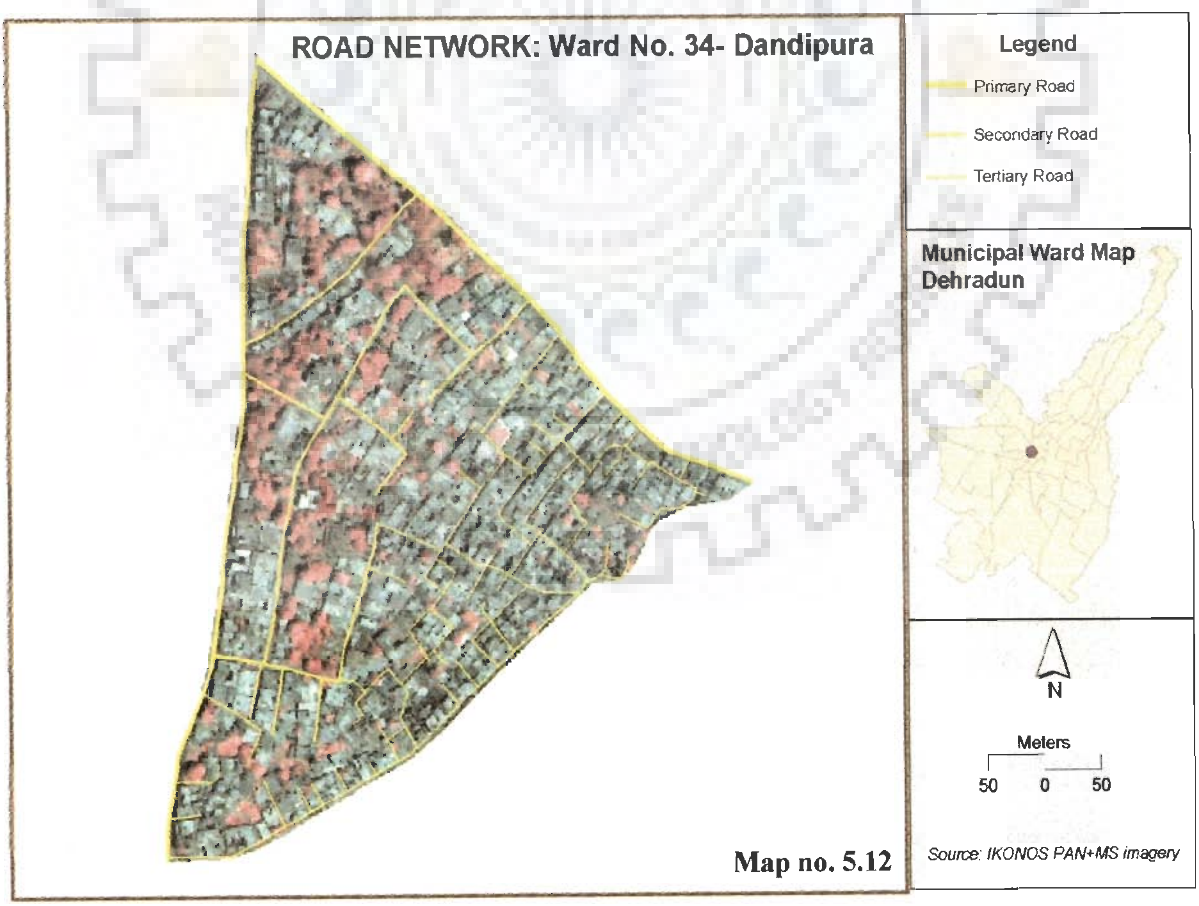
Map no. 5.9



Map no. 5.10



Map no. 5.11



Map no. 5.12

network is an indicator for the type of development and mostly governed by the topography. Figure 5.11 represents the tertiary road in the imagery. It shows that tertiary roads can be identified in association with the other features.

Road network maps prepared for the different wards area shown in map no. 5.7-.12. Primary and secondary roads are easily identifiable on the merged product but extensive field visit has been carried out for the mapping of tertiary roads in old developments and informal settlements.

5.5.2. Social Scenario

One major challenge of linking remotely sensed data to mainstream urban analysis is linking of physical form to socio-economic scenario. Physical form of the building as well as overall development is a representation of socio and economic condition of people. The approach is based on the hypothesis that the populations living in areas showing near similar housing conditions will have homogeneous social and demographic characteristics.

Social scenario has been studied through calibration of homogeneous housing areas on the basis of different housing types such as High Income Group (HIG), Middle Income Group (MIG), Low Income Group (LIG) and squatters in the different wards (figure 5.12). Maps have been prepared to show the distribution pattern of different income groups, which are usually closer to reality than those on administrative segmentation. It gives a precise representation of the actual distribution of the population, but above all, it gives the flexibility to analyze the information for planning and management. The depiction of social realities firmly defines the scope for their subsequent analysis. Interpretation key developed in previous section i.e. size, shape, location, association etc. have been used to group the homogeneous housing areas.

Conveying information on the distribution pattern of different types of houses i.e. HIG, MIG, LIG and squatters added social connotation to the mere physical infrastructure of roads and buildings. Grouping of different type of houses has been done on the basis of a number of criteria. In planned developments, large size dwelling units with accessibility from primary roads are grouped in HIG category, while medium size dwelling units with accessibility from secondary roads are grouped in MIG category. But in old part of the city, it was observed during the field survey that dwelling units of MIG with good physical conditions are also having accessibility from tertiary roads. In other words, physical condition of houses observed during the field is an important criteria for the grouping of houses in different categories. Map no. 5.13-.18 shows the housing type pattern in different wards.

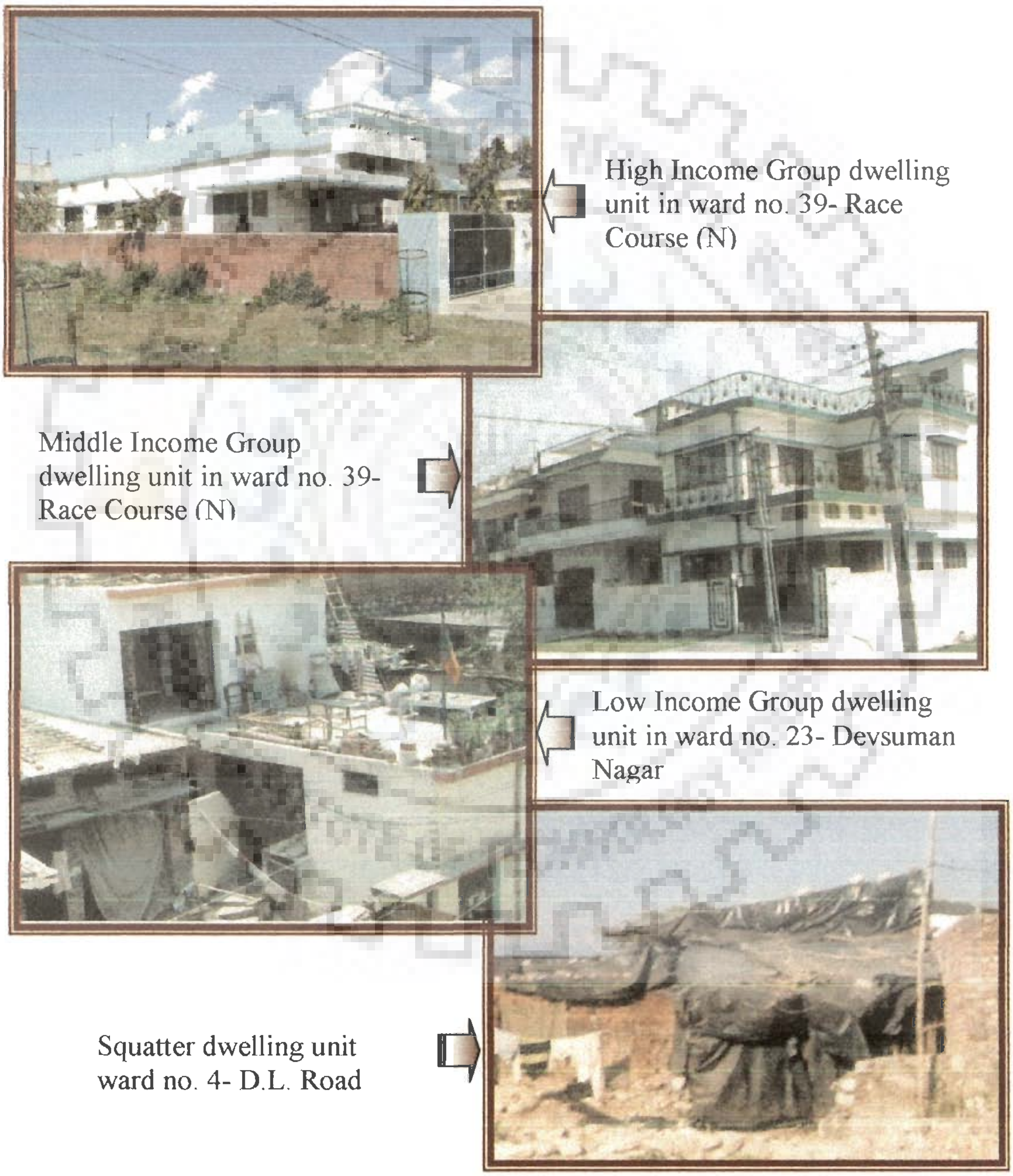
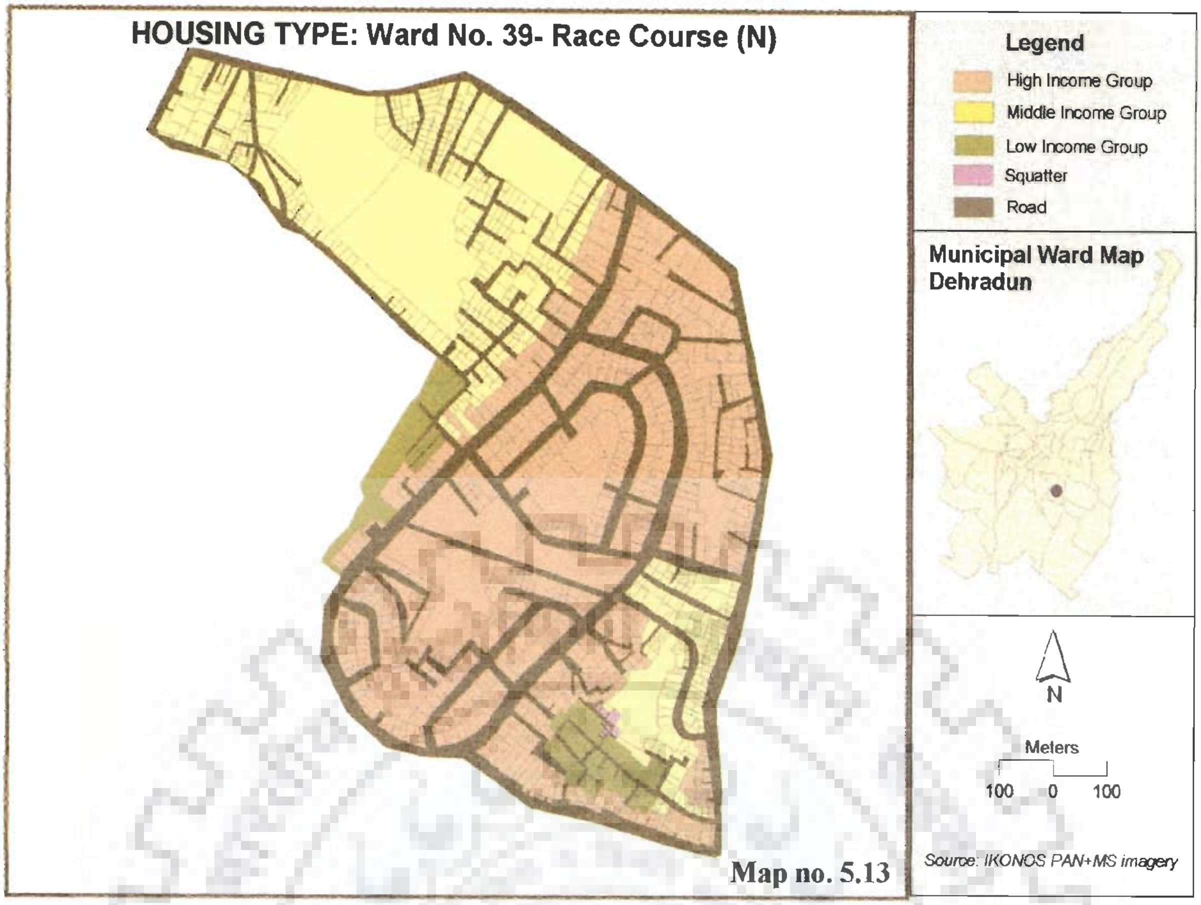
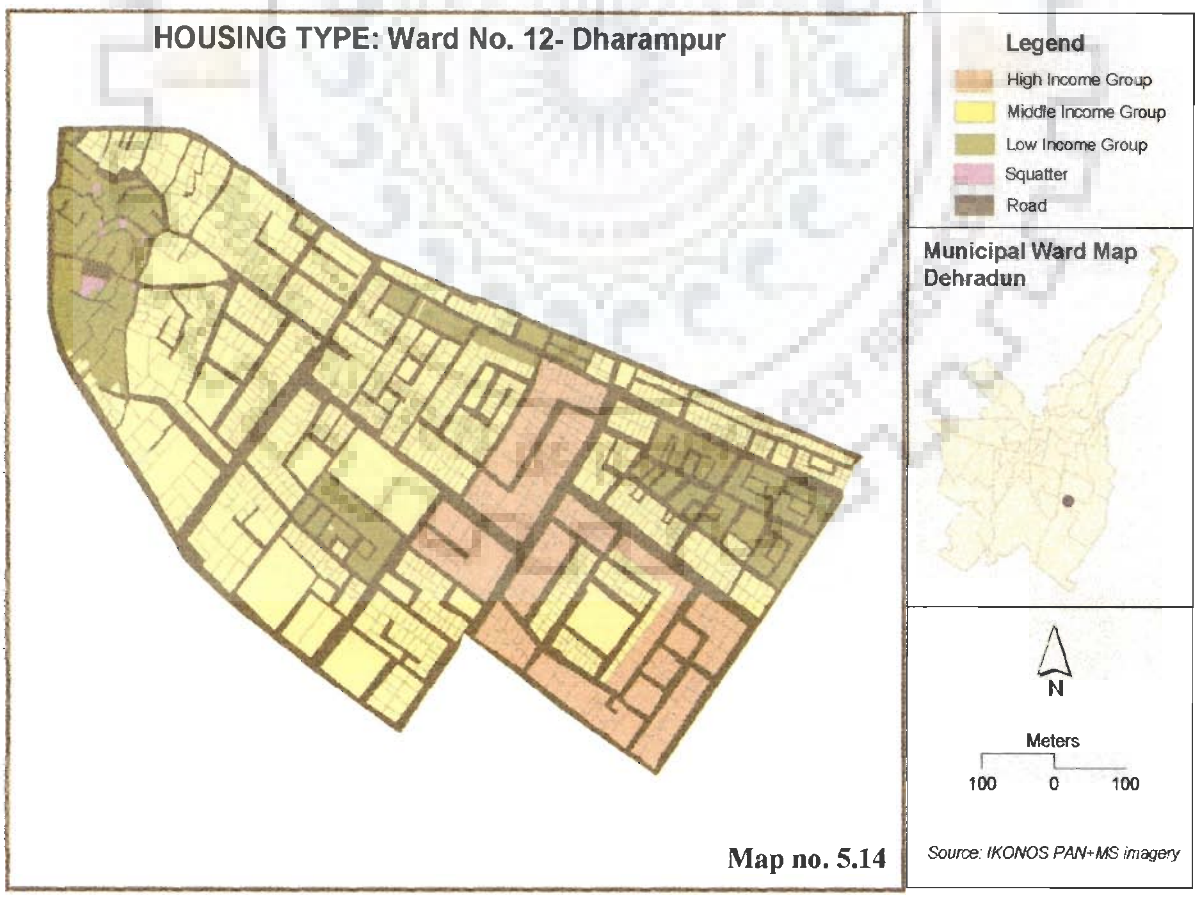


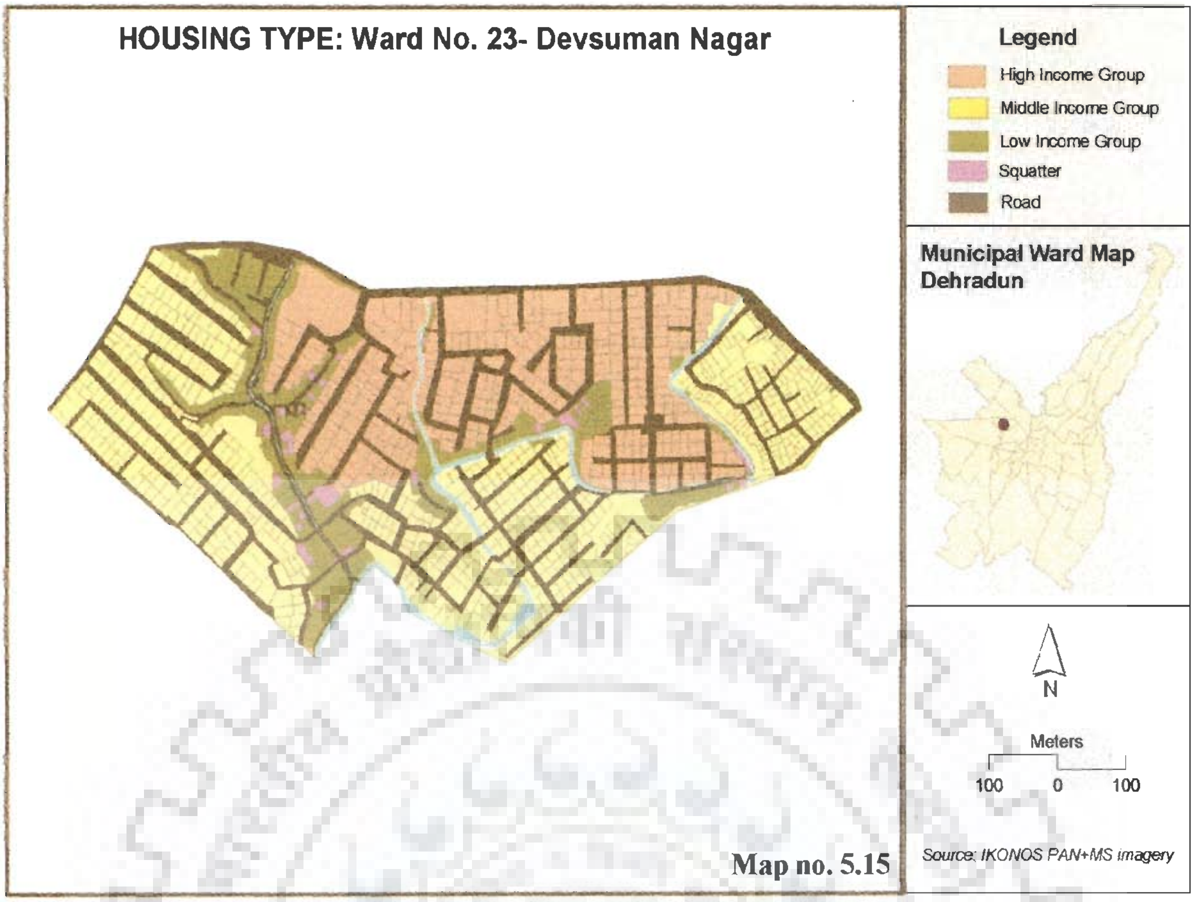
Figure 5.12: Dwelling units of different income groups in study area.



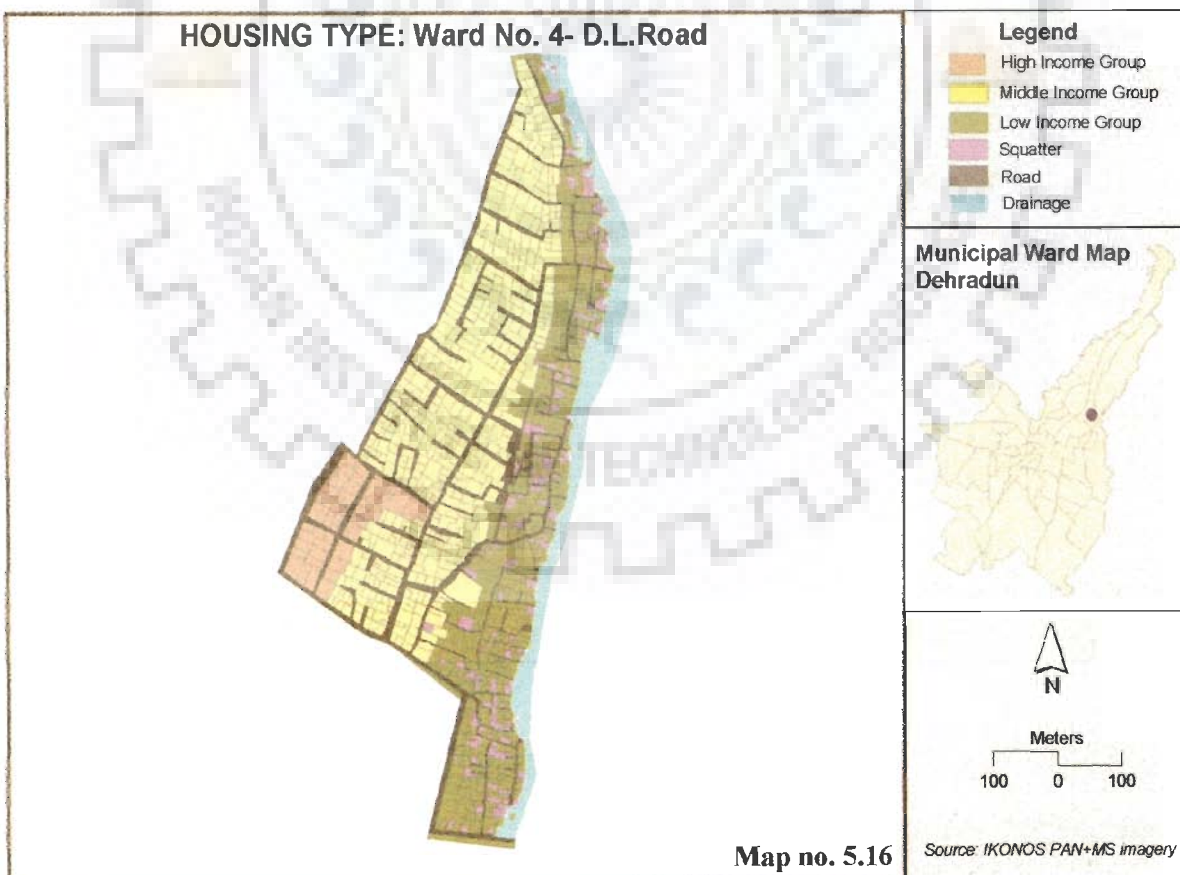
Map no. 5.13



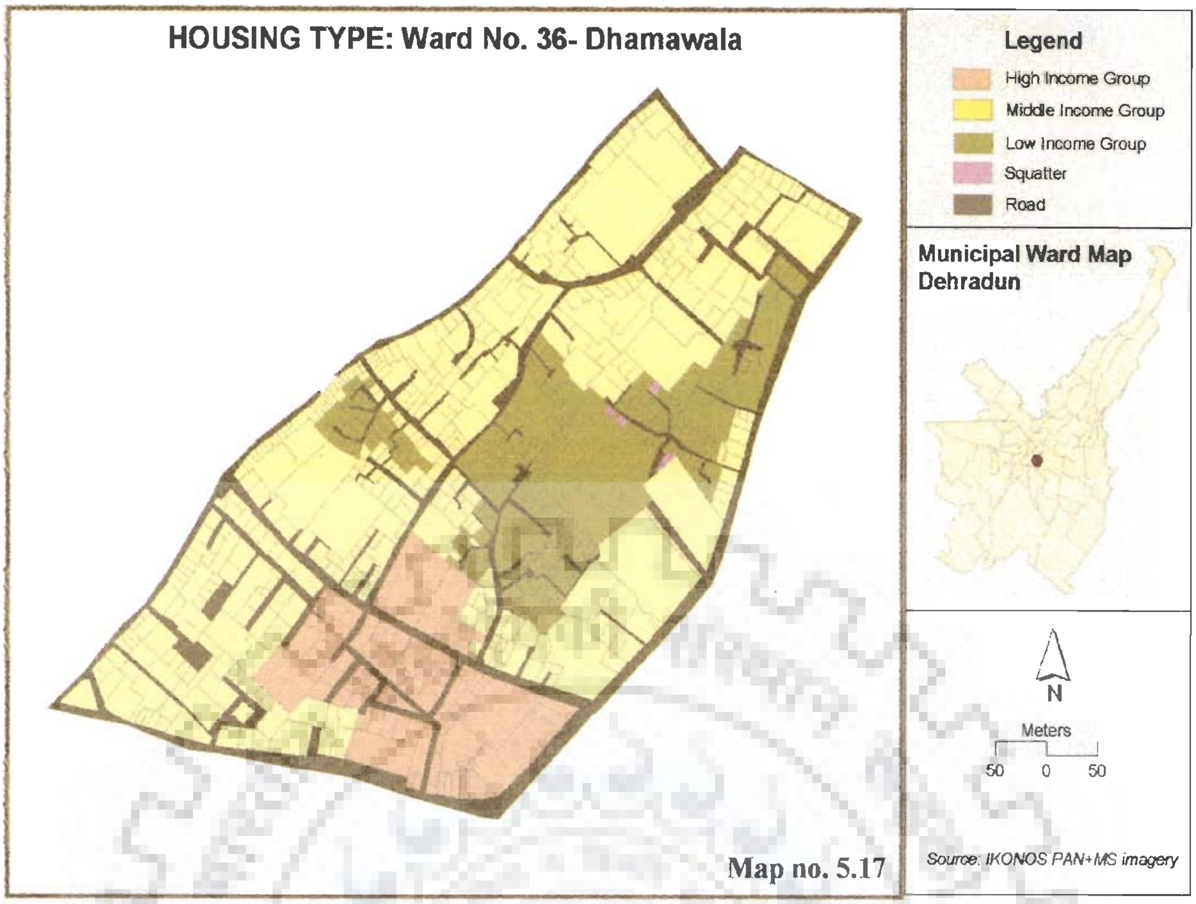
Map no. 5.14



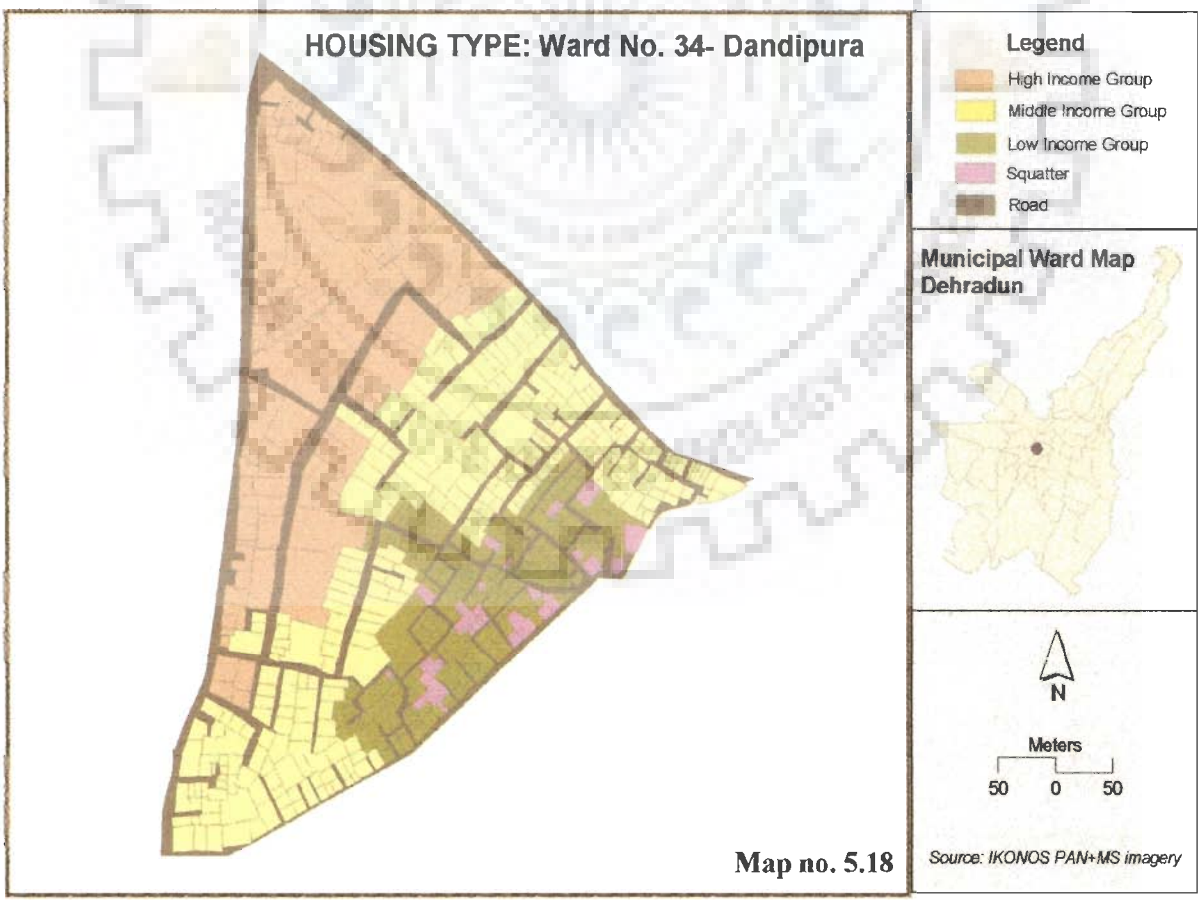
Map no. 5.15



Map no. 5.16



Map no. 5.17



Map no. 5.18

Similarly, small size dwelling units with accessibility from secondary or tertiary roads are grouped as LIG or squatters. The basic difference in the LIG and squatters is based on the physical condition of the house. During the field, it was observed that some houses of unplanned developments are in good conditions due to improved economic status or transfer of land rights are grouped as LIG. While, temporary structures with mud or exposed brick walls and plastic/ wood or tin roof cover are termed as squatters. Thus, in most of the wards, squatters are dispersed within the LIG housing types. In planned developments, LIG units also have accessibility from secondary roads, while in unplanned and old developments, most of the LIG units are having accessibility from tertiary roads.

5.5.3. Fiscal Scenario

The inadequacies in the rental value method of property taxation provide a base for change in the valuation system. Unit Area Method (UAM) is emerging as an alternative to the rental method as a base to property tax. The essential idea behind the approach is that the problem of assessment can be circumvented if tax is assessed in terms of some quantitative measures such as area, age and use of building etc. Under this system a building could be classified within few variables. It is also easy for the assessor to file self-assessment accordingly. Such a system, it was thought, would remove discretion and facilitate computerization, as well as, periodical revision (Singh, 2001a).

The location and the nature of human activities in an area provide an insight for the property taxation. Information on land use is a very valuable source to determine spatially located human activities and related taxation. The analytical components of tax calculation are taken directly from the Delhi Municipal Corporation (2003), which consists of five different steps:

1. Determining the human activities (land use)
2. Determining the areas
3. Combining various factors i.e. age, type, category.

4. Aggregating the tax and
5. Rebate (if applicable)

The main ingredients that have emerged as a pre-requisite to introduce UAM given by Delhi Municipal Corporation (2003) are as follows:

1. Development pattern,
2. Use,
3. Occupancy,
4. Type of construction,
5. Age of building.

In this section, an attempt has been made to access the potential of IKONOS satellite data for the extraction of information related to various factors of unit area method of property taxation. Under this system a building could be classified within few variables and basic tax is related to plinth area/carpet area. These factors of UAM include occupancy factor, situation of the holding, age factor, structure factor and use factor. Situation of the holding is related with the locality and accessibility with principal main roads or other secondary roads. Out of these five factors, situation of the holding has been traced out directly from IKONOS fused imagery, while age, structure and use factors have been extracted to some extent. Thus, information about occupancy factor as well as age, structure and use factors was collected during field verification.

Figure 5.13: Buildings classified under the factor weight "A"

Table 5.2-5.7 are related with the weight of different factors as given by Delhi Municipal Corporation. Land use maps and housing type maps prepared for physical and social scenario has been used to find out the average size of dwelling units under different income groups in different wards. Information on housing type is also used to determine the unit area value for different category of social scenario. Figure 5.13-5.15 shows different patterns of developments traced from satellite data, according to which, building are classified under different categories. In general, HIG dwelling units (figure 5.13) are classified under the factor weight "A", MIG dwelling units (figure 5.14) as "B", LIG dwelling units "C' and squatters as "H" category (figure 5.15).

Figure 5.14: Buildings classified under the factor weight "B".

Occupancy factor has been kept constant in all wards, as it is assumed that all buildings are self-occupied. Structure factor is also kept constant for different type of housing. For HIG, MIG and LIG dwelling units falls under the category of 'Pacca' while squatters are taken as 'Kachha' construction. Age factor vary among different wards but kept constant within the ward on the basis of information colleted through primary survey. Observation made during the field shows that some areas of ward no. 34, Dandipura and ward no. 36, Dhamawala are comprises old developments prior to 1960 while most of the areas of

Figure 5.15: Buildings classified under the factor weight "C" & "H".

ward no. 39 were developed after independence in 1952. Most of the areas in ward no. 12, Dharampur, ward no. 23, Devsuman and ward no. 4, D.L.Road were developed in late 1970s' and 1980s'. Tax calculations based on the following formula-

Covered Area x Unit Area Value x SF x OF x UF x AF = Annual Value

Table 5.2: Factors weights for different patterns of developments

A	B	C	D	E	F	G	H
For plotted colony, houses and shops	For flats, group housing, DDA flats, shops etc	For plotted colonies up to 100 sq.meter	For institution, hotels, business, towers, hoardings and industry	For farm house	For religious institut-ion	For Govt. property	Others

Table 5.3: Unit area value for different category of houses

CATEGORY	A	B	C	D	E	F	G	H
Unit Area Value (Rs/sq.meter)	630	500	400	320	270	230	200	100

Table 5.4: Use Factor (UF) value for different land use category

Public Purpose	Utility	Industry, Entertainment, Recreation & Clubs	Business	Star Hotels, Hoardings, Towers
1	2	3	4	10

Table 5.5: Occupancy Factor (OF) value for different occupancy

Self Occupied	Tenanted
1	2

Table 5.6: Structural Factor (SF) value for different types of construction

Pucca	Semi-pucca	Kutcha
1	1	0.5

Table 5.7: Age Factor (AF) value for developments of different time periods

Year of completion	Prior to 1960	1960 to 1969	1970 to 1979	1980 to 1989	1990 to 1999	2000 onwards
Factor (AF)	0.5	0.6	0.7	0.8	0.9	1

5.5.4. Environmental Scenario

Urban population is increasing to the extent that new approaches to urban environment and its assessment are needed. The inevitable spread of urbanisation in India poses the question as to what kind of ecosystem will be formed to meet the needs of sustainable developments. The design of sustainable ecosystem is a major challenge in present scenario of urbanization and it depends on vision, careful planning and management of urban areas.

To estimate the impact of urbanization on urban ecology, it is important to characterize the composition of urban surface as accurately as possible, particularly in terms of surface-type distribution and vegetation fraction. An accurate characterization of the surfaces will allow more accurate modeling of the urban ecology.

The spectral heterogeneity of urban land use categories is major limitation in the automated extraction of information from remote sensing data. Aplin (2003) compared the simulated IKONOS and SPOT HRV imagery for classifying urban areas. This study found that each of the classification based on 4-m spatial resolution imagery was more accurate than the corresponding classification based on 20-m spatial resolution imagery. The main reason for this was the greater proportion of mixed pixels in the 20-m spatial resolution per-pixel classified image than the 4-m spatial resolution per-pixel classified images.

As discussed above, pixel size plays an important role in the classification accuracy. Thus, in this research, classification is carried out of image fused through IHS to RGB transformation with 1 meter spatial resolution to investigate the environmental scenario. Pixel based supervised classification using maximum likelihood parametric rule is performed to classify the data set. On the basis of surface functional characteristics, land cover composition (table 5.8) is classified into following three categories –

Figure 5.16: Hard surfaces

Hard Surface: Building, roads, pavement including several man made features come under this category (figure 5.16). These hard surfaces are impervious in nature and reflect large amount of energy, which causes a comparative increase in temperature. Man made features appear in the tone of bright gray (near white) in panchromatic image while bluish-green tone in False Color Composite (FCC). These areas are generally regular in shape with medium to fine texture.

Figure 5.17: Soft surfaces

Soft Surface: This category comprises playgrounds (unpaved), barren lands, exposed soil and vacant plots generally with grass (figure 5.17). These are soft in nature and absorb more energy in comparison to hard surfaces, which causes normalization of temperature. Depending upon the type, minor changes in the brightness occur in bright gray tone in panchromatic image and pinkish tone in FCC. It shows fine texture with some regularity in shape.

Table 5.8: Land cover composition for supervised classification

Class	Characteristics	Colour		Texture	Shape
		PAN	FCC		
Hard Surface	Buildings, roads, pavement etc.	Whitish gray	Bluish green	Fine to medium	Regular
Soft Surface	Play grounds, barren land, vacant plots etc. generally with grass and shrubs	Medium gray	Pinkish	Fine	Regular
Green cover	Trees canopy	Dark gray	Red/ Dark red	Coarse	Irregular

Green cover: This class includes area under tree canopy (figure 5.18). It has different characteristics in comparison to above and play a major role in the improvement of air quality and temperature control at micro level. Vegetation appears in tones of dark gray (near black) in panchromatic image while in different tones of red in FCC. Dense vegetation reveals very dark tone of red while sparse vegetation (shrubs) appears in the tone of pure red. Densely vegetated areas are found in patches of varying spatial extent but under private ownership. In some parts boundaries are irregular while in other parts they are sharp with coarse texture.

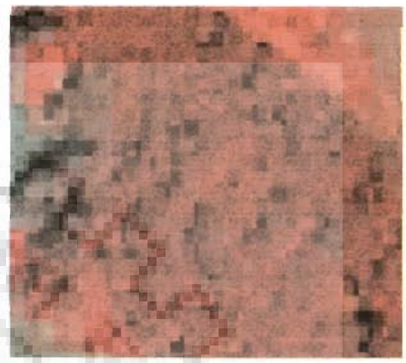
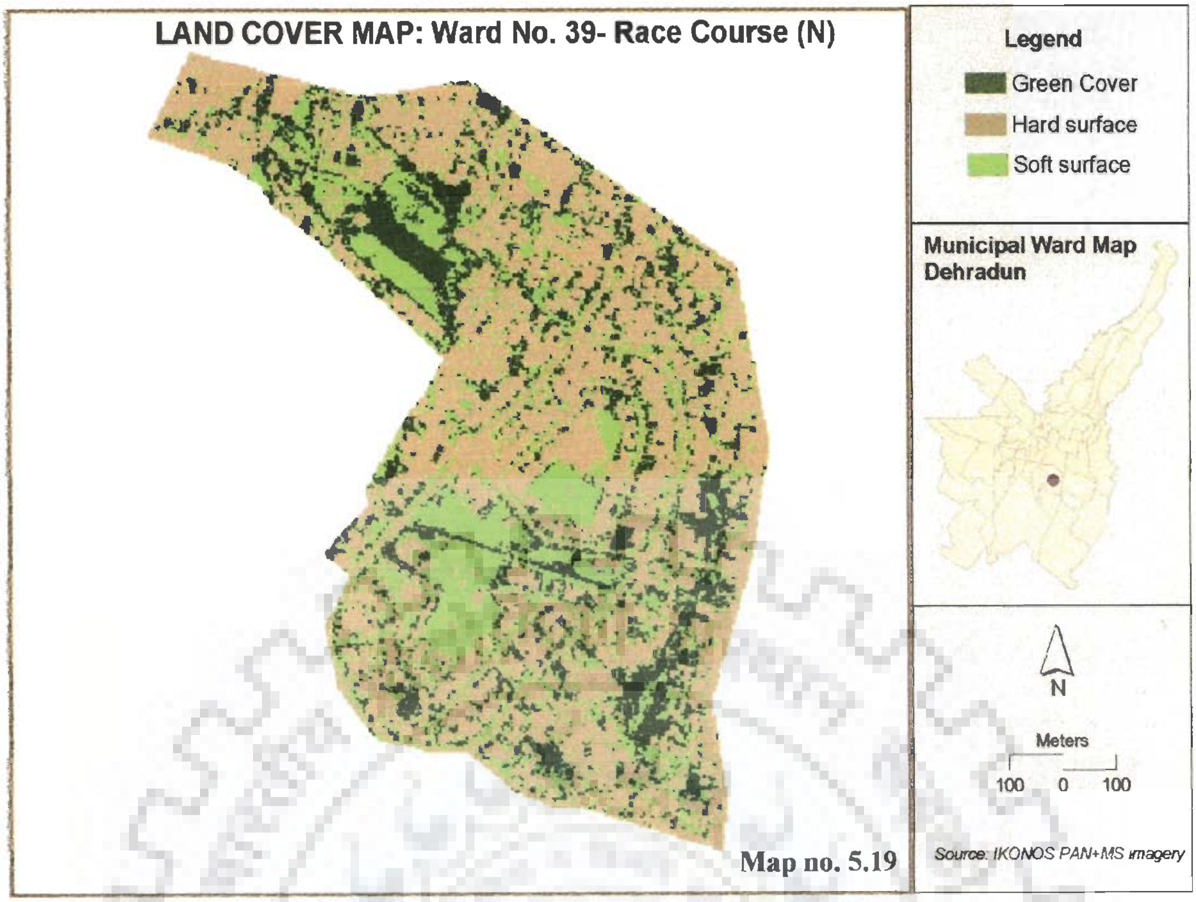


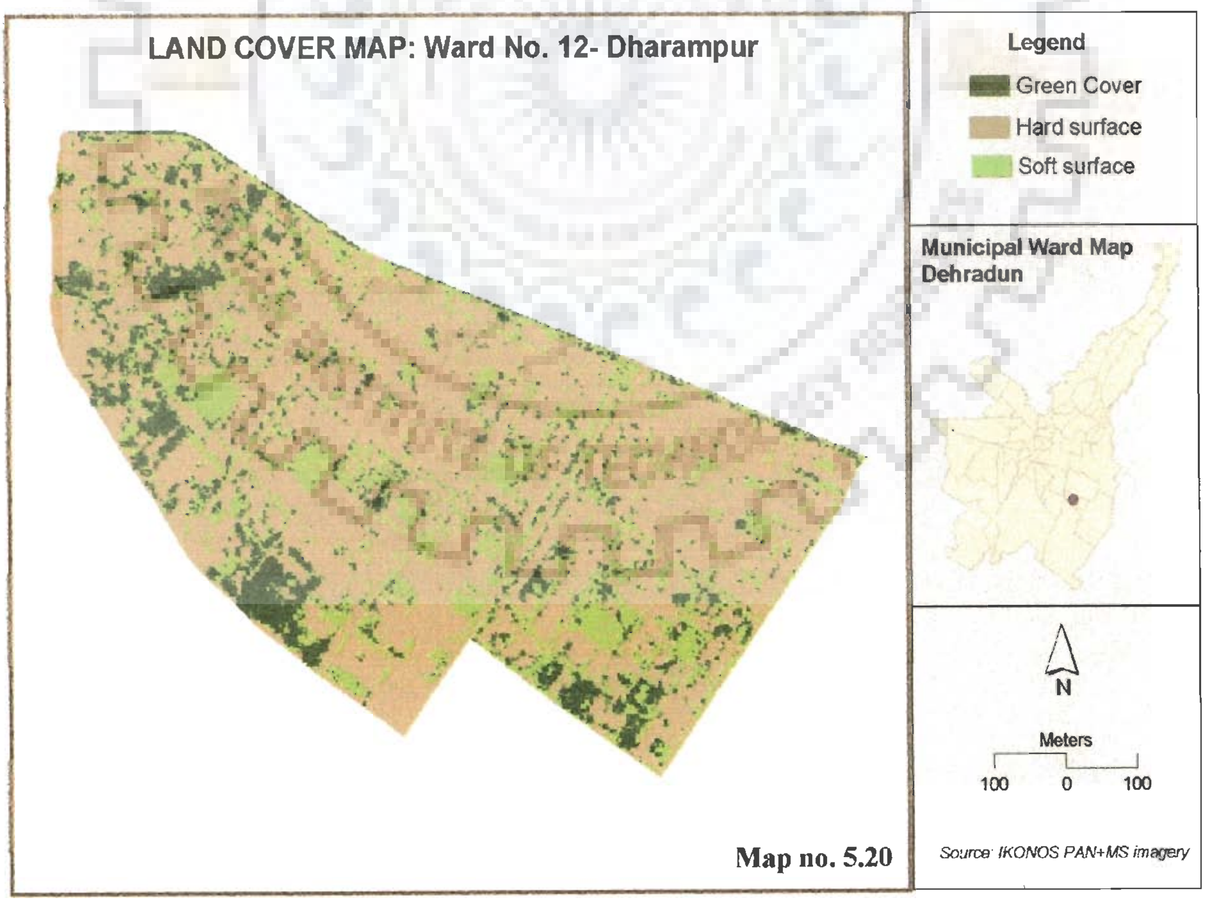
Figure 5.18: Green Cover.

The selection of training samples for supervised classification is made with reference to different types of surfaces classified under same category i.e. hard surfaces include training sets from buildings of different materials and age, road, sidewalk etc. Assemblage of various men made features into one-category results in large variation in spectral value. Soft surfaces include signatures between hard surface and green cover, which results in variation of spectral values. On one hand, grass surface reveals pinkish tone in FCC that is towards green cover, while on the other hand, exposed soil comes in bluish tone which mixes with hard surface. Different species of trees come under the category of green cover and attain least deviation in spectral value. Map no. 5.19-.24 shows the land cover compositions of different wards.

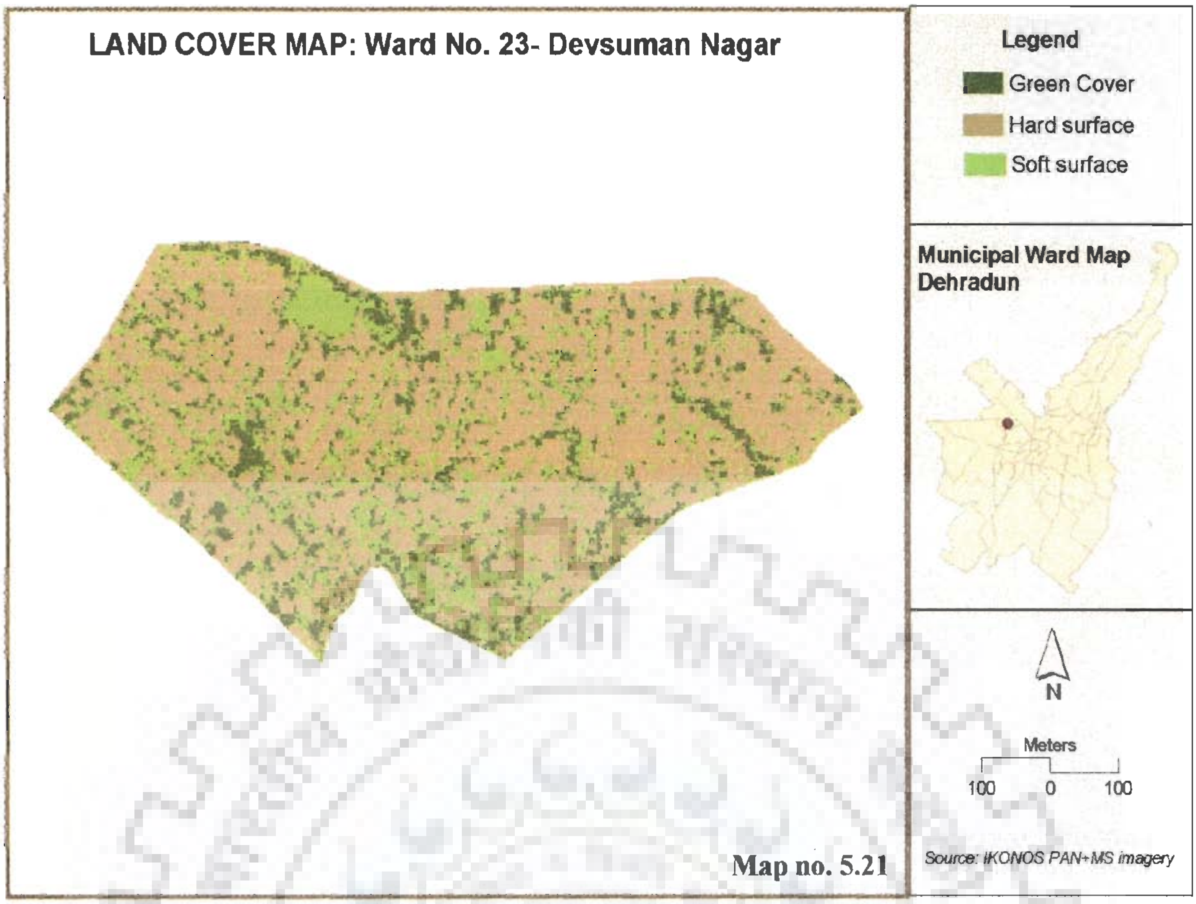
Accuracy of classification varies in different wards with the type of developments. Therefore, an individual accuracy assessment is carried out and evaluated for each ward. It also reflects the influence of pattern of developments and land uses on the classification accuracy as shown in table 5.9. Classification of hard surface and green cover within the city is more accurate than the classification of soft surface. Soft surface attain least accuracy and it is mixed with hard surface and green vegetation. It is assumed that complexity of urban areas and surfaces under green cover may induce about 5% error in the analysis. Also, as discussed earlier, Pan plus MS merged image



Map no. 5.19



Map no. 5.20



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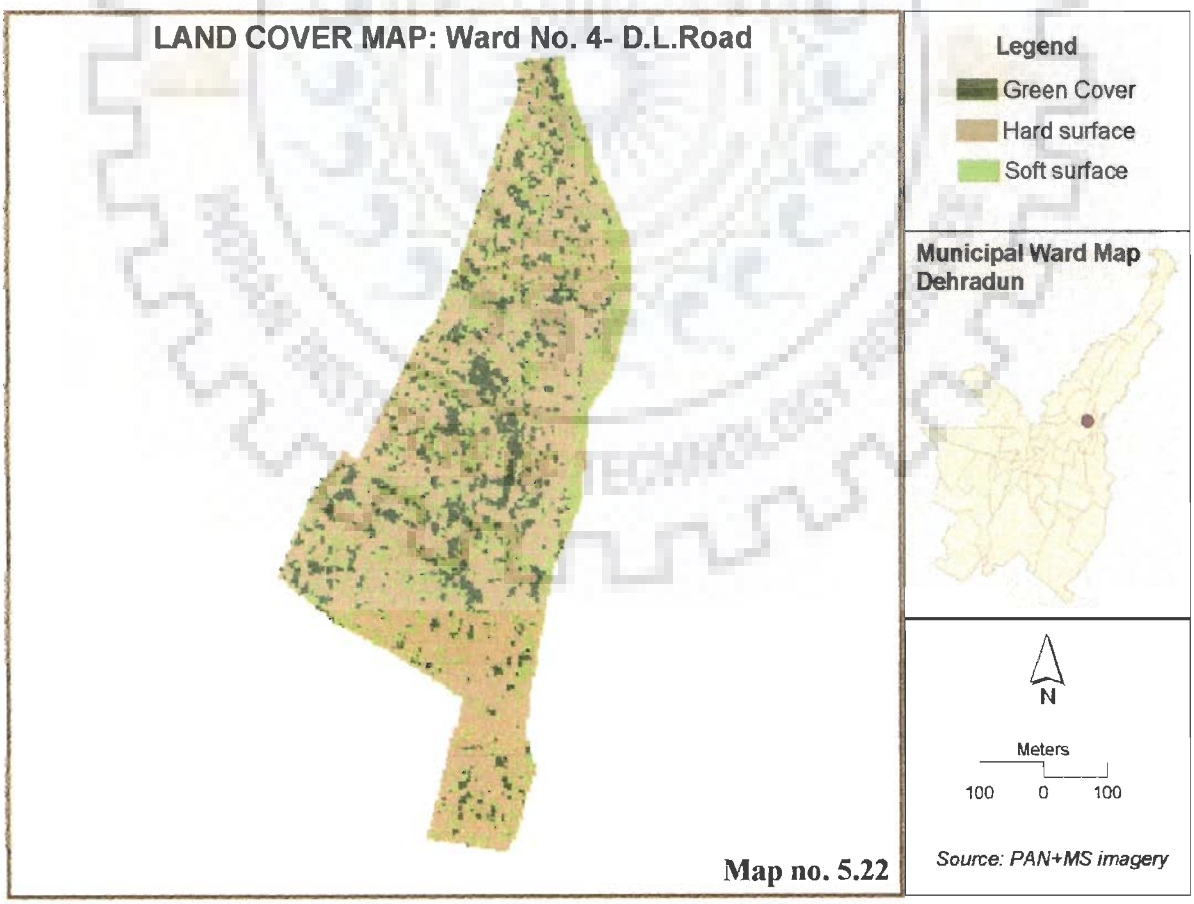

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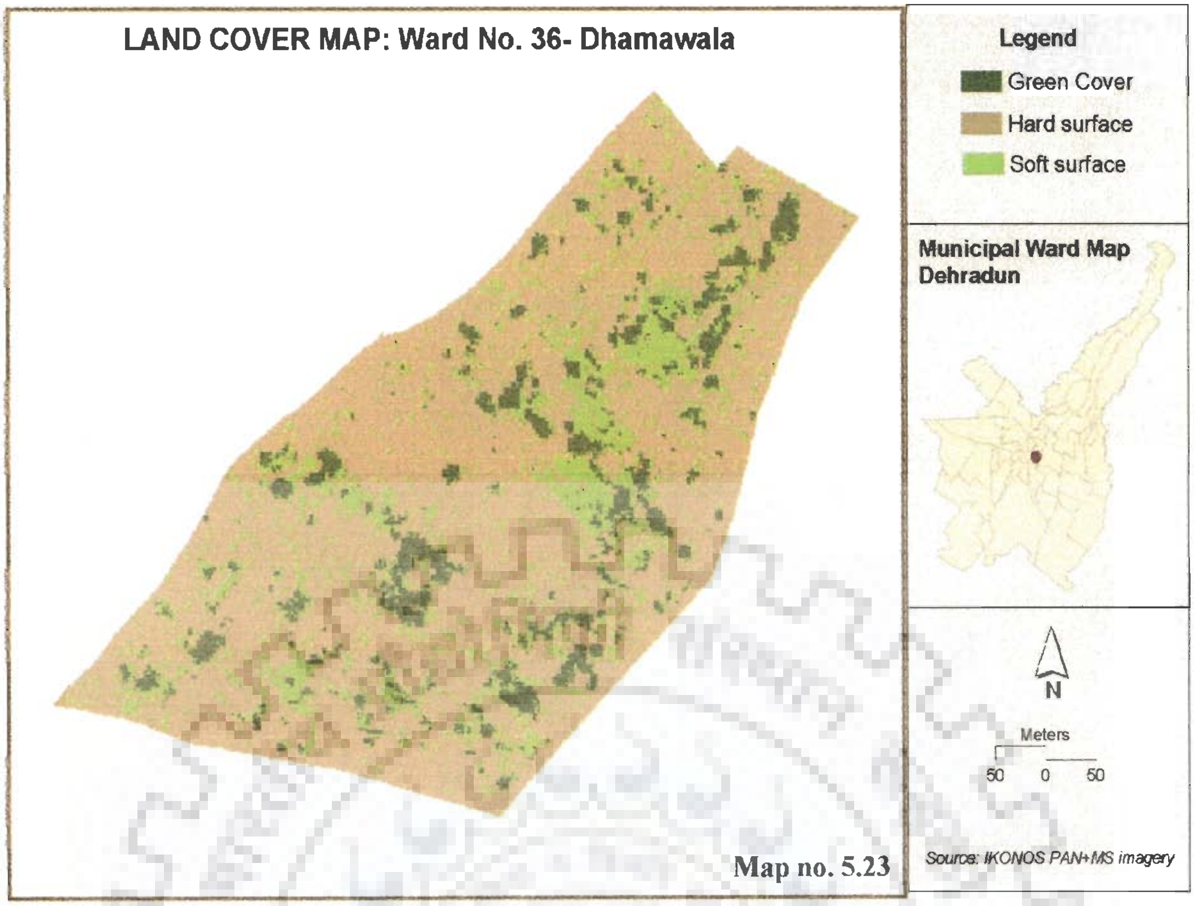
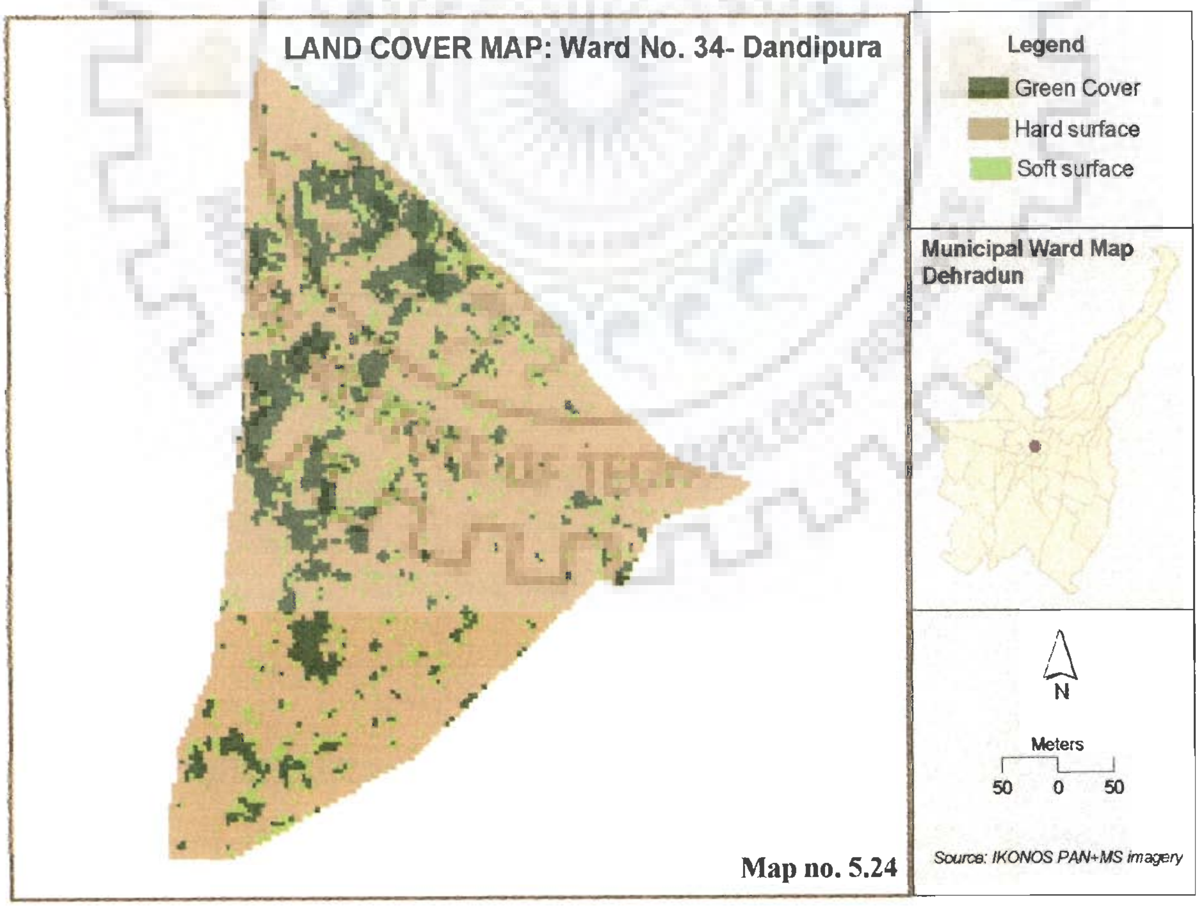


Map no. 5.23



Map no. 5.24

was resampled to 1-meter pixel size. Thus, smaller pixel size minimizes the error in terms of area caused due to mixed pixels.

Table 5.9: Confusion matrix for accuracy assessment of different wards

(a) Error matrix for ward no. 39- Race Course (N)

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	4399	8	144	4551
Green surface	2	3109	13	3124
Soft surface	154	92	3027	3273
Column Total	4555	3209	3184	10948

(b) Error matrix for ward no. 12- Dharampur

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	1261	0	19	1280
Green surface	2	1084	89	1175
Soft surface	13	33	1963	2009
Column Total	1276	1216	2071	4464

(c) Error matrix for ward no. 23- Devsuman Nagar

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	4124	4	23	4151
Green surface	2	1950	94	2046
Soft surface	37	161	2541	2739
Column Total	4163	2115	2658	8936

(c) Error matrix for ward no. 4- D.L.Road

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	2480	5	261	2746
Green surface	5	1714	115	1834
Soft surface	182	60	2151	2393
Column Total	2667	1779	2527	6973

(d) Error matrix for ward no. 36- Dhamawala

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	2418	9	915	4377
Green surface	16	1923	27	1966
Soft surface	39	83	2106	2228
Column Total	2473	2015	3048	7536

(e) Error matrix for ward no. 34- Dandipura

Reference Data

Classified Data	Hard surface	Green surface	Soft surface	Row Total
Hard surface	4316	2	59	4377
Green surface	0	1171	9	1180
Soft surface	61	43	623	727
Column Total	4377	1216	691	6284

5.5.5. Legal Scenario

Informal settlements are common phenomena in metro as well as in medium and small cities of developing countries. The absence of reliable and timely information about the locations, form and morphology of these areas creates difficulties in monitoring of these areas as well as facilitating proper decision making and planning. In India, population increase in urban centers is much faster than in rural areas because of rural to urban migration. Slums grow quickly in urban areas to accommodate this influx of immigrants. The rural population migrates to the city in search of employment and out of sheer necessity, they have no alternative but to settle in the existing slum areas or search new sites of least resistance for establishing their shelters, usually in the marginal areas like along the natural drainage, railway line, slope of the hills etc. In initial stage, these shelters are temporary in nature with mud or exposed brick walls and plastic, wood or tin as roof cover. But after some time, with the improvement of their economic status, they construct permanent shelter. In case of increase in land value of that area, property right is transferred to other person with better economic status. Thus, monitoring of temporary structures is a fundamental requirement for the planned development of the cities. The legal aspect in this research has been studied to find the potential of high-resolution satellite data to quantify the extent of temporary structures. This section discusses the various aspects related to temporary structures and their characteristics in satellite data.

Figure 5.19: Squatters associated with planned residential developments.

A general definition of informal settlement classifies it as an area in which the social and physical environment is so unhealthy as to constitute a menace to every aspect of well being, including physical, mental, social and psychological. It is an area consisting of dwelling units, which do not comply with urban standards of housing, usually high in density without proper structures or poorly maintained structures, which are deprived of basic infrastructure services. In other words, informal settlements are most often characterized by the physical appearance i.e. its aspects of housing and street patterns. Incidental open spaces due to undulating topography are a major cause of informal settlements even within planned residential development. Thus, these areas have irregular and narrow street pattern.

Fusion of panchromatic and multi spectral image plays an important role in the identification of temporary structures. Due to high spatial resolution of the panchromatic image, these structures are clearly visible but it is difficult to identify them due to variation in gray levels only. But, due to poor spatial resolution of MS image, these are not clearly identified. Thus, fusion of panchromatic and multi-spectral image increases the interpretation capabilities for the identification and mapping of temporary structures (squatters). The physical characteristics of these settlements as seen in IKONOS merged data are-

- Small sized structures with irregular pattern,
- Tone difference due to Kachha or semi-Kachha houses that are obvious in the slum areas,
- Location along the marginal areas.

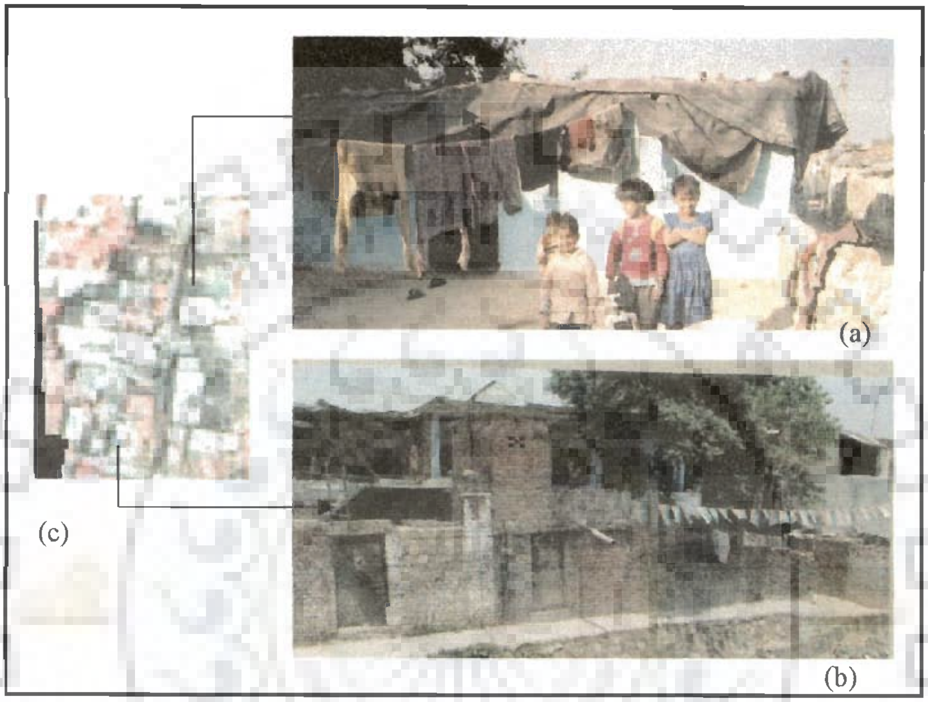


Figure 5.20: (a)Kachha (temporary) structure (b) Pacca (permanent) structure (c) different tones of these structures in IKONOS fused image.

IKONOS fused image gives valuable information regarding the pattern of development, type of structures through material used for the shade (roof) in slum areas. Various materials commonly used as roof cover in slums show different spectral response in the fused image. Temporary structures associated with the planned residential areas are also clearly identified using the IKONOS merged product (figure 5.19). Plastic roof covers give darker tone while RCC roofs give brighter tone in merged product (figure 5.20). Figure 5.20 (a) shows the Kachha (temporary) structure with plastic roof cover, figure 5.20 (b) shows Pacca (permanent) structure with RCC roof, and figure 5.20 (c) shows the corresponding buildings in the imagery. Areas of wastelands, such as on banks of rivers or canal, along railway line and road margin are most vulnerable areas, where such developments commonly take place.

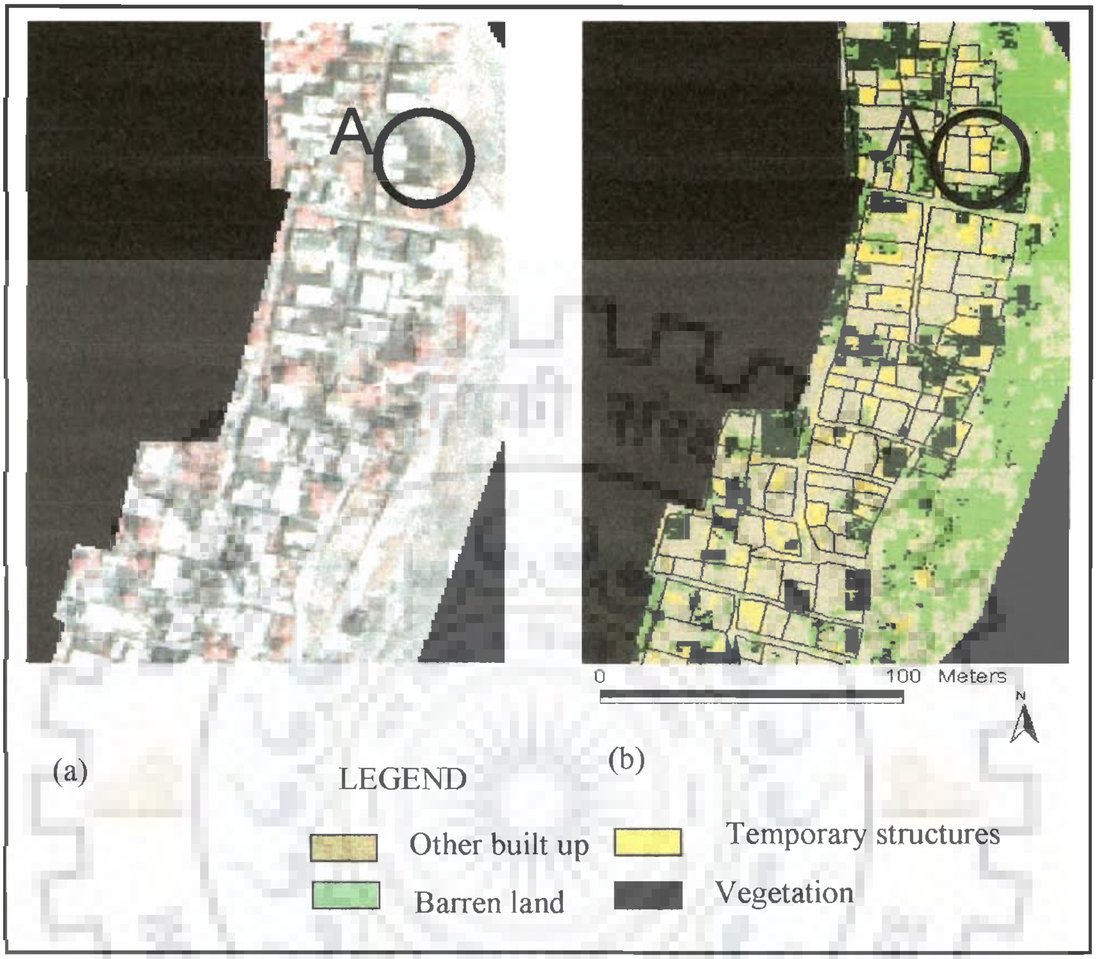


Figure 5.21: Comparison of classified image with merged product (a) IKONOS Merged product (b) Base map overlaid on the classified image.

Since, the spectral signature of temporary structures is different, pixel based digital classification is applied to find the extent of these structures. For this purpose, informal settlements in ward no. 4- D.L.Road are classified in four broad categories- temporary structures, other builtup, vegetation and barren land. Median filter of 3x3 window is applied on the classified image to remove the noise. For the validation of the outputs, base map prepared in previous section is overlaid on the classified image. Boundary of temporary structures in base map is overlaid exactly on the output-classified image. Figure 5.21 shows the comparison of classified image with merged image (Brovey transformation). Area obtained under the category of temporary structures in classified image is compared with the area under squatter category from social scenario. As per the classified image, area under temporary structure is about 1.33 hectare, while area obtained from base map is 1.19 hectare. It shows that area obtained from digital classification is slightly higher in comparison to vector map. It is basically due to mixing of shadow pixels in that category. Thus, high-resolution satellite data shows tremendous potential for monitoring of informal settlements and identifying the poverty areas within the city.

Visual interpretation seems to be a very accurate and cost effective method for identifying temporary structures within relatively small study areas. Parcel level map prepared in previous section provides more efficient and reliable information. Thus, statistics related to squatters derived from social scenario is used for qualitative assessment in next chapter (no. 6).

5.6 Inferences

The sun and elevation angle at the time of data acquisition results in relatively small shadow, which hide minimum information and helps in to delineate more details. Result of this chapter shows that interpretation of Pan plus MS fused image results in higher overall accuracy due to higher spatial and spectral resolution. Image fusion helps analyst to make more accurate interpretation from high-resolution satellite data. As discussed in section 5.4.1, building constructed of different materials over different time periods shows variation in color and tone in the FCC, which helps in the interpretation of data sets. Thus, fused satellite data with 1-meter spatial resolution is helpful to extract the details at parcel level and the preparation of base maps at the scale of 1:2000. Spatial resolution plays an important role in terms of area obtained from these data sets under different categories at micro level.

The preparation of large scale base map of urban areas using high resolution satellite data show about 90% accuracy in the planned residential areas and about 70% accuracy in unplanned and old areas observed during the field verification. Small size of the pixels results in an accurate estimation of area as well as reliable relationship among various parameters at micro level. For any GIS based analysis, it is important to create a digital database, which is accurate and update. This chapter therefore highlights the potential of high-resolution data for the creation of thematic layers required to carry out this study as discussed below-

(i) Physical scenario: Small pixel size (1-meter) with unique digital number shows the potential of high-resolution data for preparation of large scale land use map determining the use of every parcel at the scale of 1:2000. Building constructed over different time periods and different materials shows tremendous potential for the preparation land use map, as discussed in section 5.5.1.

(ii) Social scenario: Physical form of the development is an indicator towards the socio- economic conditions of its habitant. As discussed in section 5.5.2, satellite data with 1-meter spatial resolution has the potential to extract the social structure with in a small area.

(iii) Fiscal scenario: As discussed in section 5.5.3, 1-meter spatial resolution of satellite data is very useful to identify the development pattern of the area to determine the factor weight for calculating the property tax.

(iv) Environmental scenario: Small size of pixels in fused image with increased spectral resolution result in more accurate quantification of area under different land covers for the reliable relationship among these (section 5.5.4). As discussed earlier, fused image is resample to pixel size 1m x 1m., while MS imagery consist pixel of 4m x 4m size. Thus, misclassification of one mixed pixel of MS image result in 16 times error in area estimation in comparison to fused image.

(v) Legal Scenario: Tonal variation in the high spatial resolution data helps to identify the temporary structures in urban areas as discussed in section 5.5.5. Various materials commonly used as roof cover in slums show different spectral response in the fused image. Temporary structures with plastic roof covers give darker tone while RCC roofs give brighter tone in merged product.

CHAPTER VI

INVESTIGATING THE EXISTING SCENARIO

6.1 An Overview

Analysis of database created in previous chapter breaks down complex phenomenon into simple elements for better understanding. It organizes, illuminates, correlates, classifies, displays and resolves complexity related with physical social and environmental aspects into simplified vision. These are helpful to planners for the study of settlements, society and their physical and socio-economic status, impact of technology, environmental conditions and the changes that occur over a period of time. Based on the understanding of the existing condition, the planners carve out short term and long- term scenario of the future and then design schedules of interconnected interventions to steer development towards a desire future state from micro to macro level.

In this chapter, statistics derived from the database developed in chapter 5 is used to analyze the existing scenario and find the relationship between different factors. In the first part of the chapter, analysis is carried out to explore the existing scenario related to physical, social, fiscal, environmental and legal parameters in each ward. In second part of the chapter, inter-relationship between different parameters is developed. For this purpose, different scenarios are compared with each other and coefficient of correlation is derived, which leads to the development of the correlation matrix. Pearson's coefficient of correlation is a measure of the relationship between any two phenomena. Higher value of the coefficient shows a stronger relationship between those two phenomena. The derived correlation matrix is an indicator towards the existing scenario at ward level.

6.2 Physical Scenario

Urban centers are seen as a combination of at least 3 elements- locations, use and accessibility. Accessibility is the dominant factor influencing the location, use and growth of urban centers. Impact of accessibility can be experienced from macro to micro level. It has direct impact on –

- urban structure and land use pattern,
- distribution of population densities.

Physical scenario in different wards has been studied through two parameters- land use pattern and road network. Database developed for land use pattern and road network in section 5.4.1 is analyzed to investigate the exiting scenarios at ward level.

The spatial patterns of various land uses at ward level (map 5.1-5.6), assessed and visualized by means of visual interpretation, provides valuable source of information to analyze the functional characteristics at micro level. Statistics derived from these land use map for different wards is discussed in this section.

Land use map at parcel level of ward no. 39, Race Course (N), is shown in map 5.1. Statistics derived from this map is given in table 6.1. About 12 categories are taken into consideration including health and education.

Table 6.1: Land use composition in ward no. 39- Race Course (N)

Land use	Area (in hectare)	%
Residential	33.42	36.36%
Commercial	3.53	3.84%
Commercial + Residential	5.41	5.89%
Health + Residential	0.26	0.28%
Health	0.94	1.02%
Educational	2.48	2.70%
Institutional	3.81	4.15%
Public Services	2.38	2.59%
Religious	1.17	1.27%
Open spaces	4.36	4.74%
Road	20.78	22.61%
Vacant	11.48	12.49%
Others	1.89	2.06%
Total	91.91	100.00%

Almost 36% area comprises under residential land use, about 4% area is under commercial use. Around 6% of ward area is consisting commercial activities associated with the residential dwelling units. This ward is situated towards the south-east side of the city center, Clock Tower, and very close proximity to central business district of the city. Thus, it is in the phase of transition from residential to commercial land use due to pressure of market. Large percentage of mixed land use is result of land use transformation from residential to commercial due to the demand of market over the period of time, which is taking place mainly in the central part of the ward. It comprises private institutions and offices of companies/individuals distributed mainly along the main access road. Detailed land use at parcel level provides the status of social infrastructure i.e. health, education etc. About 3 hectare area is under educational activities and almost 1 hectare area comprises health facilities, which is about 3% and 1% of ward area respectively. This ward comprises different levels of educational and medical facilities at city level. Educational facilities comprise from primary to higher secondary education in the central part and medical facilities includes individual clinic to big specialized hospitals towards the north-east direction of the ward. Diagram 6.1 shows the percentage distribution of different land uses in ward no. 39-Race Course (N).

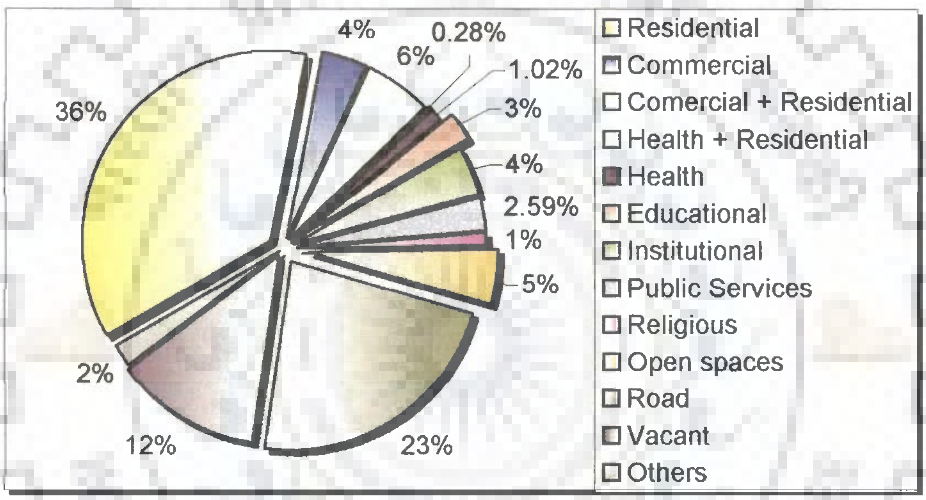


Diagram 6.1: Percentage distribution of different land uses in ward no. 39-Race Course (N).

One major reason for the low density of this ward is because of many institutions and public services at city level like jail campus, workshop of Uttranchal Road & Transport Corporation as well as schools, religious buildings associated with large track of open spaces. In this ward, area under public services is about 2 hectare, which is about 3% of ward area. Area under roads is also considerable high about 23% due to undulating topography. Public open spaces are just about 5% of ward area while 13% of ward area falls under vacant category. Large amount of vacant land adjacent to jail campus shows the possibility of increase in population density in the future.

As it is clear from the above discussion that accessibility has an important role in the land use pattern in this ward. Most of the land use transformation is taking place along the Haridwar road and roads providing main access to the ward towards north and east direction. The statistics related to the length of the primary, secondary and tertiary roads mapped in this ward are given in table 6.2. The percentage of primary, secondary and tertiary roads shows the pattern of development as well as its extent within the ward.

Table 6.2: Road network in ward no. 39- Race Course (N)

Type	Width	Road length (km)	%
Primary roads	>8 m	8.49	49.42%
Secondary roads	2-8 m	8.14	47.38%
Tertiary roads	< 2 m	0.55	3.20%
Total		17.18	100%

Road network in ward no. 39, Race Course (N), (map no. 5.7) represents a planned development of the area. In this ward, road length under primary, secondary and tertiary categories are about 50%, 47% and 3% respectively (table 6.2). Roads providing the access to the ward from Haridwar road are mainly Primary roads in the Race Course area, along which land use transformation is taking place. Roads providing access from these roads around the central part are mostly secondary roads. Most of the secondary roads are in Chandan Nagear colony. Tertiary roads area around 3% towards the south-east part of the ward. Road network provides the overall image that about 97% of ward area consists of planned development. In this ward, the planned central area as preordained street layouts become overwhelmed by the many and multifaceted forces operating in the urban land market, resulting in land use transformation from residential to commercial.

Ward no. 12, Dharampur (map no. 5.2) is another planned development with regular street network comprises mostly dwelling units of the middle and lower income group. About 80% area is planned while unplanned developments are observed towards north-west part of the ward, which occupies almost 20% of ward area. Statistics derived from land use map is given in table 6.3. Residential is the biggest land use category occupy almost 26-hectare land, which is about 50% of the ward area (diagram 6.2). Most of the dwelling units are in the form of the row houses occupied by the low and middle income group people. Apartments for the employees of the different government institutions are another feature of the residential area.

Table 6.3: Land use composition of ward no. 12- Dharampur

Land use	Area (in hectare)	%
Residential	26.08	50.04%
Commercial	2.46	4.72%
Comercial + Residential	2.54	4.87%
Health + Residential	0.17	0.33%
Health	0.03	0.06%
Educational	0.94	1.80%
Institutional	1.14	2.19%
Public services	0.24	0.46%
Religious	0.54	1.04%
Open spaces	4.58	8.79%
Road	11.32	21.72%
Vacant	2.08	3.99%
Total	52.1	100.00%

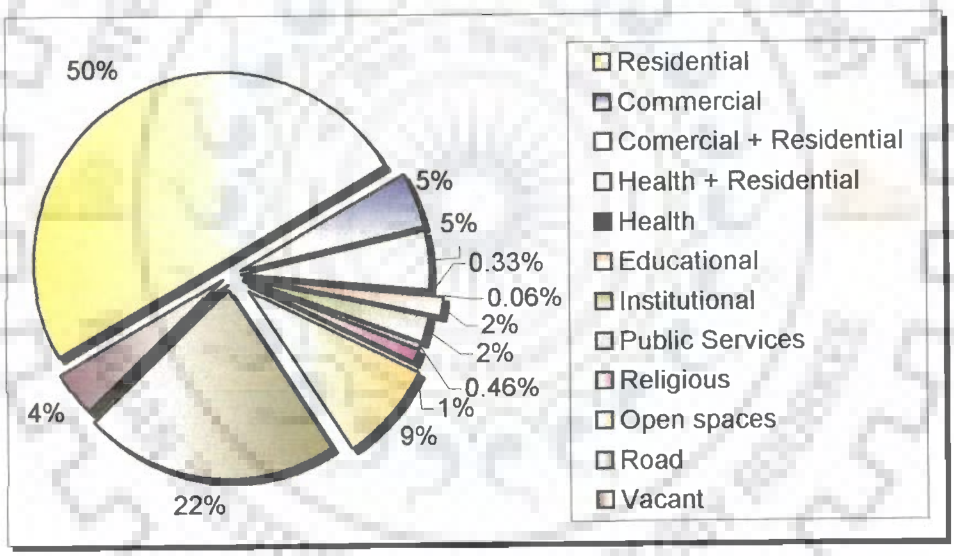


Diagram 6.2: Percentage distribution of different land uses in ward no. 12-Dharampur.

Commercial activities are observed within 100 meters along the main Haridwar road towards the south-western part of the ward. About 2.5 hectare land is under commercial use, which is about 5% of the ward area. The striking feature of the commercial use is the concentration of the community halls within very close proximity to each other. It shows, that this ward fulfills the need of the other parts of the city also. While, almost equal area is coming under the commercial use observed in the inner parts of the ward associated with residential dwelling units, which is also about 5% of the ward area.

Almost 1 hectare area comprises educational and health facilities, which is about 2% of the ward area. Thus, it shows the lack the basic social infrastructure facilities. While 1.14 hectare land is occupied by different government institutions including central government Excise office, state government offices of Jal Nigam and Jal Sansthan, regional office of the Life Insurance Corporation etc.

Since, it is a planned development, large amount of open spaces enhances the aesthetic and environmental quality of the residential area distributed almost in the whole ward uniformly within planned development. Though most of these spaces are not properly maintained. About 5 hectare land is under this category, which is about 9% of the ward area. Area under religious use is just 1% of the ward area. Road network is almost 22% of the ward area while 4% of the ward area is still vacant.

Table 6.4: Road network in ward no. 12- Dharampur

Type	Width	Road length (km)	%
Primary roads	>8 m	7.6	38.78%
Secondary roads	2-8 m	10.16	51.84%
Tertiary roads	< 2 m	1.84	9.39%
Total		19.6	100%

This ward comprises regular streets network except in the north-west part of the ward (map no. 5.8). The statistics related with the road length under different categories is given in table 6.4. Thus, about 39% roads are more than 8 meters wide, which comes in the category of primary roads. These are mainly in the central part dividing the ward into three equal parts. While others area the secondary roads providing the access to the dwelling units of low and middle income groups. Secondary roads are about 52% of the total road length mainly in the Nehru colony while tertiary roads are just 9% towards the north-west direction in the Dharmapur area.

Pattern of land use distribution in ward no. 23, Devsuman nagar is shown in map no. 5.3. Aggregation of different social and occupational group leads to existing land use pattern.

Distribution pattern of different types of land uses within the ward shows that changing requirements. It comprises residential units mainly of middle income group. Major land use activities (table 6.5) i.e. residential and commercial are comprises about 61% and 4% of ward area respectively. In this ward also, about half of the commercial activities are associated with the residential dwelling units mainly along the Chakarata road and some are dispersed inside the ward. Most of the commercial activities are also along the Chakarata road towards the north direction, which provides main access to the ward. It comprises mainly commercial activities within residential area i.e. beauty parlors, computer center, Internet café etc. Areas of Saiyyad Mohalla, Deep Lok, Akash Deep colonies towards the northern [part of the ward facing Chakarata road comprises more commercial activities in comparison to the Mittra Lok, Mahendra Vihar colonies towards the southern part of the ward.

Table 6.5: Land use composition of ward no. 23- Devsuman Nagar

Land use	Area (in hectare)	%
Residential	25.59	60.86%
Commercial	0.92	2.19%
Commercial + Residential	0.89	2.11%
Health+Residential	0.26	0.63%
Educational	0.11	0.27%
Institutional	0.06	0.13%
Open spaces	0.05	0.12%
Religious	0.24	0.58%
Drainage	1.13	2.68%
Road	9.3	22.12%
Vacant	1.96	4.66%
Others	1.53	3.65%
Total	42.04	100.00%

Almost 0.4 hectare area is under educational and medical facilities, which is about 1% of ward area. Most of the medical facilities in this ward are associated with the residential dwelling units, which includes private clinic of the Ayurvedic and Heomopathy. While, two private hospitals are located towards the north-east and north-west part of the ward, having accessibility from the main Chakarata road. The total of 0.26 hectare area comprises medical activities in this ward. While, status of educational facilities is not good and comprises only primary schools. Total 0.11 hectare area is under educational

use, which shows that this ward is lacking basic middle and higher education facilities and depends on the surrounding areas for the same. About 1 hectare area is under drainage network, which comprises almost 3% of ward area and indicate towards the undulating topography. Though, about 80% of ward area is planned but it lacks parks/ playgrounds. Just 0.05 hectare area falls under playground, which is 0.12% of ward area. While, about 2 hectare area falls in the others category in the form of incidental open spaces due to topographical undulations along the drainage channel. It is about 4% of total ward area. Percentage distribution of different land uses is shown in diagram 6.3.

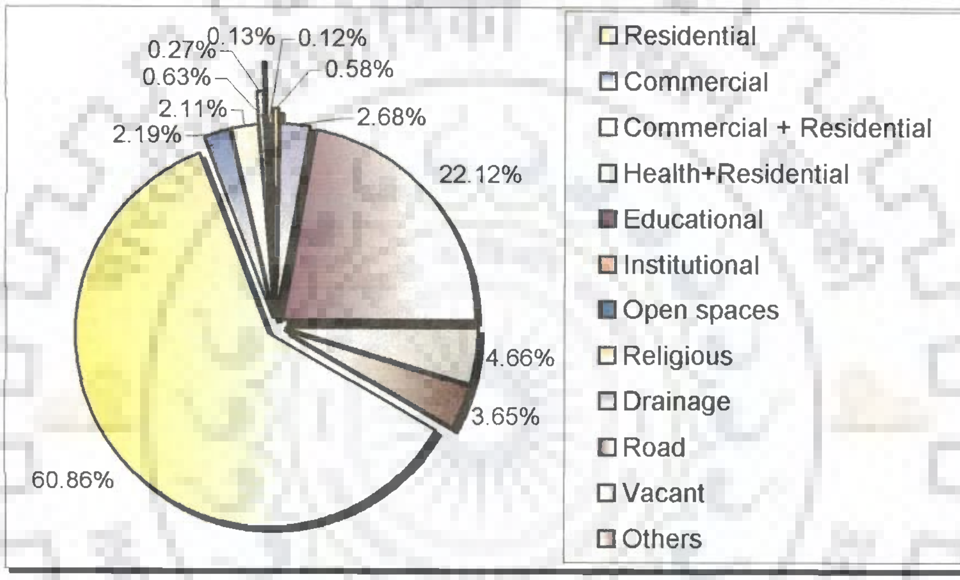


Diagram 6.3: Percentage distribution of different land uses in ward no. 23- Devsuman Nagar.

The road length under primary, secondary and tertiary categories in ward no.23, Devsumar Nagar is 32%, 48% and 20% respectively (table 6.6). It shows that about 80% of ward area has planned while 20% of ward area has haphazard developments as shown in map no. 5.9.

Table 6.6: Road network in ward no. 23- Devsuman Nagar

Type	Width	Road length (km)	%
Primary roads	>8 m	4.15	32.05%
Secondary roads	2-8 m	6.20	47.88%
Tertiary roads	< 2 m	2.60	20.07%
Total		12.95	100.00%

In this ward, primary roads are distributed in the north of the ward approaching to the main access in Aakash Deep, Deep Lok colonies , while secondary roads are in the south, east and west side of the ward having regular pattern in Saiyyad Mohhla, Mittar Lok, Mahendra Vihar, a part of Vasant Vihar colonies. Pattern of tertiary road in this ward is governed by the topography of the area. Tertiary roads are distributed along the drainage network and provide one side access to the dwellings.

Ward no. 4, D.L. Road, is situated towards the left side of the river Rispana Rao, which is one of the main seasonal drains of the city. Organically, a seasonal river allows un-built spaces, along which slum/ squatter development has taken place. A comparison of map prepared from IKONOS imagery with the toposheet of Dehradun, surveyed in 1972, shows that most of these settlements have been developed on the riverbed itself. The impact of development pattern is clear on the land use pattern (map 5.4) in this ward.

Table 6.7: Land use composition of ward no. 4- D.L. Road

Land use	Area (in hectare)	%
Residential	18.59	63.06%
Commercial	0.19	0.64%
Commercial+Residential	1.08	3.66%
Health+ Residential	0.11	0.37%
Educational	0.2	0.68%
Health	0.06	0.20%
Public services	0.09	0.31%
Religious	0.02	0.07%
Drainage	3.12	10.58%
Vacant	0.99	3.36%
Others	0.22	0.75%
Road	4.81	16.32%
Total	29.48	100.00%

Land use distribution of this ward is given in table 6.7. This ward has dominance of residential activities and about 63% of ward area is under residential use. Informal settlements namely Arya Nagar, Chiriyamandi and Nalapani Nai Basti are highly congested with very small size of dwelling units is the major cause for the same. While commercial land use is just 0.64% of total ward area. But area under mixed land use, commercial activities associated with the residential dwellings occupies almost 4% of ward area. Most of the commercial land use is along the D.L.Road, which provides main access to the ward from old survey road. Inside residential areas, mixed land use is in the form of informal activities i.e. carpentry, milk dairy etc.

Due to organic growth of informal settlements, planned open spaces/ play grounds are lacking in the ward. Almost 11% of ward area falls under drainage network, which fulfills the requirements of the playground in the dry seasons. Diagram 6.4 shows the percentage wise distribution of different land covers in this ward.

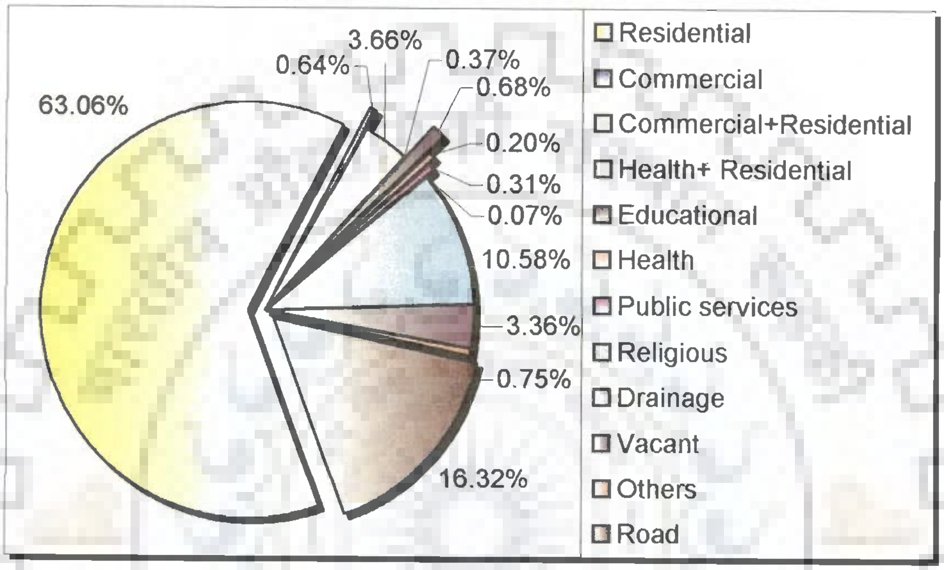


Diagram 6.4: Percentage distribution of different land uses in ward no. 4- D.L.Road

Educational activities in the ward are about 0.2 hectare, while medical facilities occupy 0.17 hectare area, which is about 1% of ward area. Road network is another major category comprises 16% of the ward area. Considerable amount of land in the ward is vacant, which is about 3% of the ward area indicates towards the further increase in population density with the developments of the vacant plots in future.

Table 6.8: Road network in ward no. 4- D.L.Road

Type	Width	Road length (km)	%
Primary roads	>8 m	0	0.00
Secondary roads	2-8 m	5.01	52 %
Tertiary roads	< 2 m	4.54	48%
Total		9.55	100.00%

Road length under the different categories in this ward also indicates towards the haphazard growth. Percentage of secondary and tertiary roads in this ward is respectively 52% and 48% (table 6.8). Since, this ward is located along seasonal drain, Rispana Rao, tertiary roads are distributed along this. The length of tertiary roads in this ward is due to the informal settlements mainly towards the eastern part of the ward comprises the area of Arya Nagar, Chiriyamandi and Nalapani Nai Basti areas, while secondary roads are towards western part of the ward. Secondary roads occupy 2/3 of the ward area towards western side and tertiary road occupies about 1/3 towards the eastern part of the ward, which indicates towards the population concentration within the ward.

Ward no. 36, Dhamawala is located in the central part of the city. It comprises a part of main commercial area, Paltan Bazar. Which is also clear from the land use pattern of this ward. Detailed land use map prepared of this ward is shown in map no. 5.5. Statistics derived for land use pattern in this ward, is given in table 6.9, which also indicates toward the dominance of commercial activities.

Table 6.9: Land use composition of ward no. 36- Dhamawala

Land use	Area (in hectare)	%
Residential	6.09	23.83%
Commercial	5.11	19.99%
Comercial + Residential	4.55	17.80%
Educational	1.12	4.38%
Health	0.3	1.17%
Institutional	0.59	2.31%
Public Services	1.05	4.11%
Religious	1.2	4.69%
Open spaces	0.57	2.23%
Road	4.23	16.55%
Vacant	0.75	2.93%
Total	25.56	100%

About 5 hectare area, which is about 20% of the ward area, falls under commercial activities. While, commercial activities on about 18% of the ward area are associated with the residential land use. Big commercial complexes are located along the main access roads towards east and south directions. Due to its strategic location, large numbers of hotels are also present along these main access roads.

Mixed land use is observed along the major roads inside the ward. In this part, ground floor is having commercial activities while above floors have residential use. Old Imamualh building on the main road towards the east side, one major landmark of the ward, is also having mixed land use. It is a linear building comprises shops on the ground floor and dwelling units on the above two floors. Due to mixed land use, central part of the city remain alive even after working hours and checking thereby anti social activities. Percentage distribution of different land uses is given in diagram 6.5.

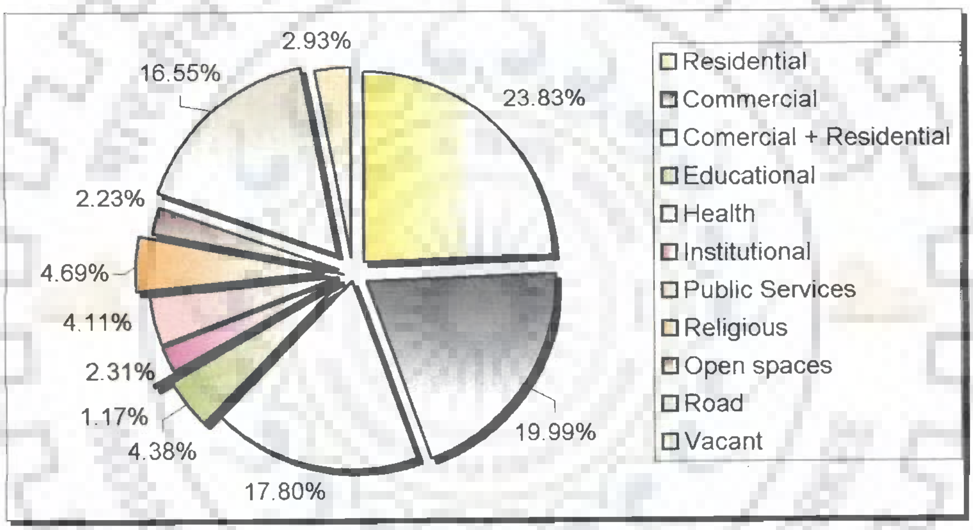


Diagram 6.5: Percentage distribution of different land uses in ward no. 36-Dhamawala.

Residential land use occupy about 6.09 hectare area, which is about 24% of the ward area, mainly in the central part of the ward comprises old development namely Dhamawala area. It comprises very old dwelling units of small sizes, where occupancy rate is very high. Some of them are in dilapidating conditions. Most of these dwelling has access from very narrow lanes. While, towards the south of the ward, Laxmi Park residential colony is very well planned having large double story dwelling units. During the field, it was observed that about 80% buildings are multistoried in this ward.

About 1 hectare area of the ward falls in the category of open spaces, which is almost 2% of the ward area. Most of the open spaces are in the form of urban plaza, around which small shops are designed. Thus, this ward lack any planned green open space. Public services comprise about an area of 1 hectare. Most of which is occupied by the old bus stand, local city bus stand and taxi stand towards the eastern side of the ward as well as office of the Uttranchal Road and Transportation Corporation in the south western part of the ward on the main road leading to railway station. About 1.2 hectare area is under religious use mainly concentrated towards the north-east direction. It comprises temples and mosque. About 17% area of the ward is under circulation while almost 1 hectare area is still vacant.

Table 6.10: Road network in ward no. 36- Dhamawala

Type	Width	Road length (km)	%
Primary roads	>8 m	1.1	14%
Secondary roads	2-8 m	4.9	64%
Tertiary roads	< 2 m	1.6	21%
Total		7.6	100%

Map no. 5.11 shows the road network of ward no. 36, Dhamawala. This ward comprises 14% primary, 64% secondary and 21% tertiary roads (table 6.10). Gandhi road towards the east and south direction providing the main access to the ward is primary road. A segment of Dispensary road in the back of Rama market is also wide more than 8 meters. Secondary roads are distributed in the whole ward. While tertiary roads are concentrated in the old developments at the central and eastern part of the ward.

In ward no. 34, Dandipura, also land use pattern is similar to any other ward (map no. 5.6). Despite its location adjacent to the center business district, this ward also has dominance of residential land use (table 6.11). It is almost 55% of ward area. Mixed land use is higher in comparison to commercial activities, which is on different floors along the Tilak road towards the western side of the ward. About 7% area is under commercial activities. Out of which, two third of commercial activities are associated with the residential use. Although this ward is located in the central part of the city, commercial land use is 2.5% of total ward area. Just 0.57 hectare land in under educational activities, which is about 4% of ward area. It comprises schools of different categories- primary to higher secondary level, which shows that it also fulfills the demand of surrounding areas but it lacks any big playgrounds. While 0.06 hectare area is under medical facilities associated with the residential use, which is about 0.5% of the ward area.

Table 6.11: Land use composition of ward no. 34- Dandipura

Land use	Area (in hectare)	%
Residential	8.95	55.38%
Commercial	0.41	2.54%
Commercial+Residential	0.74	4.58%
Health+ Residential	0.06	0.37%
Educational	0.57	3.53%
Institutional	1.81	11.20%
Religious	0.13	0.80%
Public services	0.02	0.12%
Road	2.9	17.95%
Vacant	0.57	3.53%
Total	16.16	100%

Almost 11% of the ward area comprises institutions, mainly office of forest department. It provides considerable amount of greenery in the ward. Because of very high land value and old developments, this ward lacks planned open spaces/ playgrounds. Almost 0.6 hectare area is under the category of vacant, some of them are in the form of incidental open spaces due to undulating topography. Percentage wise distribution of various land uses in this ward is given in diagram 6.6.

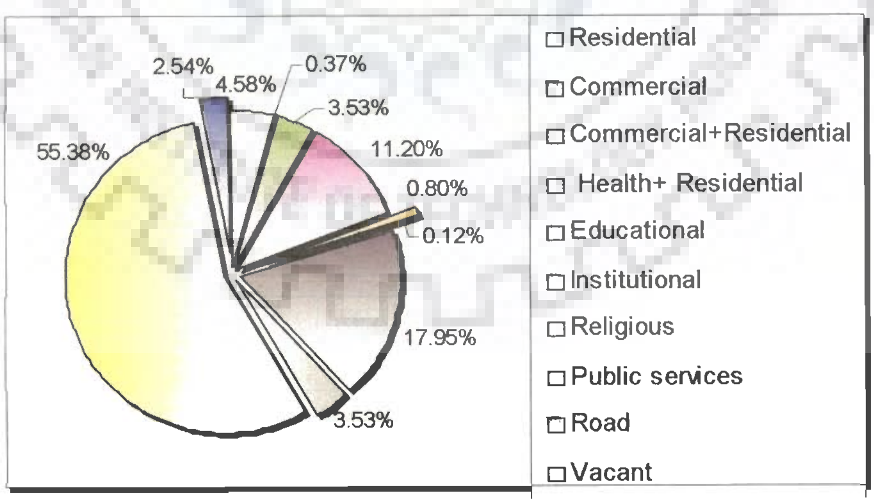


Diagram 6.6: Percentage distribution of different land uses in ward no. 34- Dandipura.

Percentage of road length (map 5.12) under primary, secondary and tertiary roads in ward no. 34, Dandipura is 22%, 24% and 54% respectively (table 6.12). About 54% road length is under tertiary category is due to old developments and high land value towards the eastern side of the ward.

Table 6.12: Road length under various categories in ward no. 34- Dandipura

Type	Width	Road length (km)	%
Primary roads	>8 m	1.23	22%
Secondary roads	2-8 m	1.39	24%
Tertiary roads	< 2 m	3.10	54%
Total		5.72	100.00%

Towards the north side of the ward, some big dwelling units have access through tertiary roads, which is related to old part of the city with the historical developments. Due to undulating topography, tertiary roads are distributed in the east and north side of the ward while primary roads leads to the main access road towards the west side of the ward. About 54% of ward area classified under tertiary roads, which is distributed over ¼ of the ward area towards eastern side. It indicates towards the very high density in this part of the ward.

6.2.1 Inferences: Physical Scenario

The large scale land use map shows the deviations in the land uses along the natural drainage with reference to the Master Plan for Dehradun 1982-2001 (section 20, page no. 77) in ward no. 4, D.L. Road; ward no. 23, Devsuman Nagar and ward no. 34, Dandipura. Above discussion reveals that road network has very high influence on the land use pattern. As in all wards, it has been observed that land use along major roads is changing from residential to commercial or some other uses. Overall, considerable amount of activities i.e. commercial, medical, offices etc. are associated with the residential use resulting in mixed land use. Higher percentage of mixed land use is a common scene almost in all wards especially in the central part of the city and adjoining areas. The mixing is taking place on the same floor as well as on different floors of the buildings. The phenomenon of mixing of land use is growing in different wards, which also reveals the change in attitude of people and requirements of the area over the period of time. Even in planned areas mixing of land uses, irrespective of the zoning regulations have occurred. Almost 6% area of ward no. 39, Race Course (N) and 5% area of ward no. 12, Dharampur and ward no. 23, Dandipura falls under the mixed land use. The area occupied by mixed land use in ward no. 4, D.L.Road, and ward no. 23, Devsuman Nagar is 3% and 4% respectively. While about 18% area of the ward no. 36, Dhamawala is under mixed land use because of its strategic location.

The level of primary roads in ward no. 39, Race Course (N), shows that about 50% of the ward area is very well planned inverse to ward no. 4, D.L. Road where tertiary roads indicates that about 50% of ward area has haphazard developments. Higher percentages of tertiary roads about 54% in ward no. 34, Dandipura and 48% in ward no. 4, D.L. Road are due to different reasons. In ward no.4, higher percentage of tertiary roads is because of unplanned developments especially of low-income group people, while in ward no. 34, Dandipura, old developments are also a reason for the same. The percentage of tertiary roads varies from 54% in ward no. 34, Dandipura to 3% in ward no. 39, Race Course (N).

6.3 Social Scenario

The social structuring at ward level is result of demand arises due to changing requirements and developments. The diverse life style are associated closely with each other due to interdependence especially among high and low income groups. Large tracts of urban land with similar development patterns and spectral signatures in satellite imagery helped in the mapping of different housing types (map no. 5.13-5.18) belonging to diverse social classes. The statistics derived from these maps for different wards is given in table 6.13-6.18.

In ward no. 39, Race Course (N), (map no. 5.13) about 54% area is under HIG units followed by MIG unit with 40% (table 6.13) of ward area.

Table 6.13: Housing type composition of ward no. 39- Race Course (N)

Type	Area (in hectare)	%
HIG	37.94	54.10%
MIG	28.09	40.06%
LIG	3.96	5.64%
Squatter	0.14	0.20%
Total	**70.13**	**100.00%**
Drainage	00.00	
Road	20.78	
Total ward area	**90.91**	

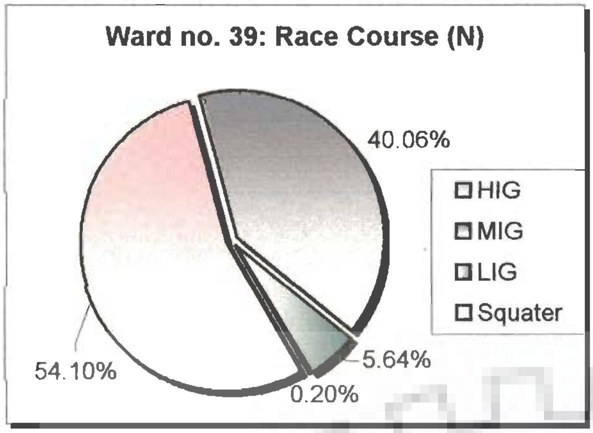


Diagram 6.7: Percentage distribution of housing types in ward no. 39-Race Course (N)

Area of the Race Course colony in the central part of the ward is occupied by high income group units while area of Chandan Nagar colony adjacent to Central jail is occupied by the middle income group dwelling units. LIG and squatters are just 6% and 0.2% of the ward area respectively (diagram 6.7). LIG dwelling units are also planned development thus have accessibility from secondary roads in this ward and concentrated towards south-east and western part of the ward. Mostly, low-income group units are double storied. The distribution pattern of housing units of different income groups follows the hierarchy of the development. HIG units occupy more than 50% of ward area, which is also one reason for the low population density at ward level.

In ward no. 12, Dharampur (map no. 5.14), about 17% area comes in the HIG type dwellings, mainly towards the southern part of the ward (table 6.14). These units are observed along the roads providing the access to the ward from the main road Haridwar road towards the south-west direction in Nehru colony. While, about 63% area is occupied by the MIG housing type (diagram 6.8). Maximum variation is observed in the size of the MIG dwelling units. Towards the eastern side, most of the dwelling units of MIG are small in size but double storied and in good condition.

Table 6.14: Housing type composition in ward no. 12- Dharampur

TYPE	AREA (in hectare)	%
HIG	6.86	16.83%
MIG	25.56	62.66%
LIG	8.26	20.22%
Squatter	0.12	0.29%
Total	**40.80**	**100.00%**
Drainage	0	
Road	11.32	
Total ward area	**52.12**	

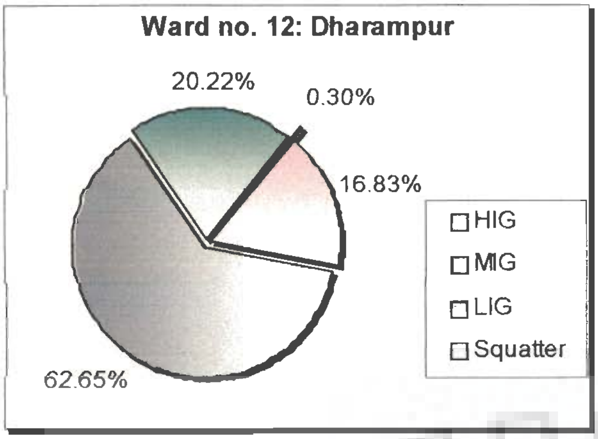


Diagram 6.8: Percentage distribution of housing types in ward no. 12- Dharampur

LIG dwelling units are dispersed within the ward towards the north, central and north west direction with single storied building. It occupies about 20% of the ward area. Most of the LIG dwelling units are in the form of row houses of small sizes. MIG and LIG dwelling units are distributed in Nehru colony and Dharampur area while squatters are dispersed within Dharampur area.

Topography is the guiding factor in the distribution of houses of different income groups in ward no. 23, Devsuman Nagar (map no. 5.15).

Table 6.15: Housing type composition in ward no. 23- Devsuman Nagar

TYPE	AREA (in hectare)	%
HIG	11.02	34.92%
MIG	14.99	47.49%
LIG	4.99	15.81%
Squatter	0.56	1.78%
Total	**31.56**	**100.00%**
Drainage	1.13	
Road	9.35	
Total ward area	**42.04**	

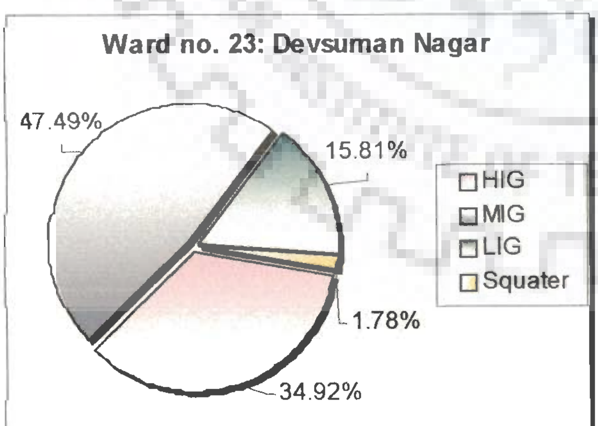


Diagram 6.9: Percentage distribution of housing types in ward no. 23- Devsuman Nagar

In this ward, haphazard changes are observed in the distribution pattern of different income groups. Within a small area, housing units of all categories shows the persuasive aspect of everyday life. HIG and MIG units are concentrated in different parts while LIG and squatters are distributed in the whole ward follows the pattern of undulating topography. Middle income group units contain larger portion of the wards followed by HIG units, which occupies about 48% and 35% of ward area respectively (table 6.15). Areas of Deep Lok and Aakash Deep colonies comprise the dwelling units of middle and higher income group. About 16% area falls under LIG and 2% area under squatter units in the area of Sayyaid Mullah and adjoining areas along the drainage. In this ward, squatter are dispersed within LIG units because most of the LIG units are emerged with the improvement of the family income of the habitants of squatter areas or due to transformation of land rights. Diagram 6.9 shows the percentage distribution of the housing types in ward no. 23- Devsuman Nagar.

Location ward no. 4, D.L.Road along seasonal river is a major cause of higher percentage of LIG and squatters units (map no. 5.16).

Table 6.16: Housing type composition in ward no. 23- D.L.Road

Housing Type	Area (in hectare)	%
HIG	1.83	8.49%
MIG	11.20	51.97%
LIG	6.96	32.30%
Squater	1.56	7.24%
Total	**21.55**	**100%**
Drainage	3.12	
Road	4.81	
Total ward area	**29.48**	

About 52% of ward area is under MIG while LIG and squatters occupies 32% and 7% of ward area respectively (table 6.16). MIG dwelling units are towards the left side comprises areas of Arvind Marg, while LIG and squatter dwelling units are towards the right side of the D.L.Raod comprises areas of Arya Nagar, Chiriyamandi and Nalapani Nai Basti. In other words, the eastern part of the ward consists of LIG and squatter units while western part of the ward has units of

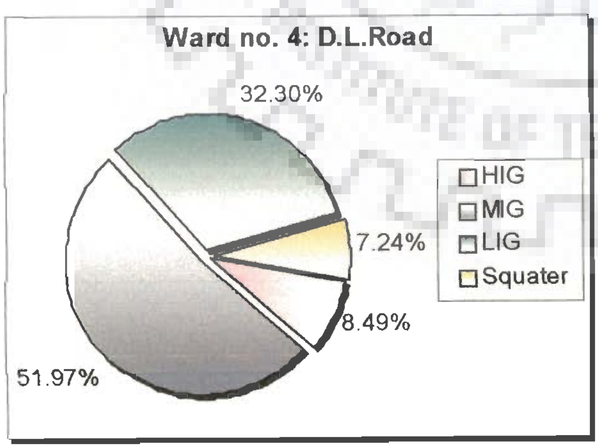


Diagram 6.10: Percentage distribution of housing types in ward no. 4- D.L. Road

middle-income groups. Just 9% of the ward area in under HIG dwelling units at the south- west direction of the ward. Percentage distribution of different housing types in ward no. 4 D.L.Road is given in diagram 6.10.

Housing pattern of ward no. 36, Dhamawala is shown in map no. 5.17. Statistics derived from this is given in table 6.17. About 16% of ward area consists of HIG dwelling units in Laxmi Park colony and surrounding areas.

Table 6.17: Housing type composition in ward no. 36- Dhamawala

TYPE	AREA (in hectare)	%
HIG	3.36	15.84%
MIG	13.39	63.24%
LIG	4.39	20.73%
Squatter	0.04	0.18%
Total	**21.18**	**100.00%**
Drainage	0	
Road	4.23	
Total ward area	**25.41**	

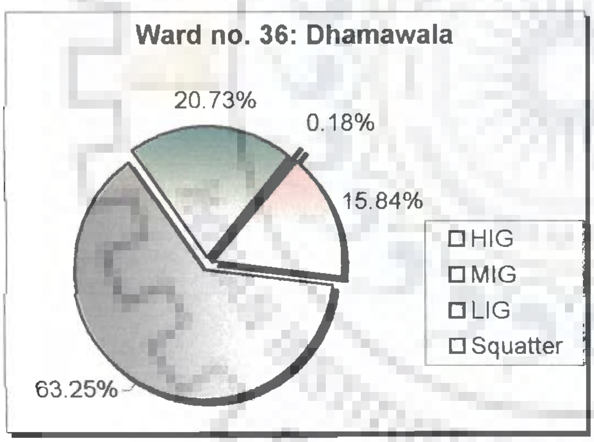


Diagram 6.11: Percentage distribution of housing types in ward no. 36- Dhamawala

While 21% of the ward area is having LIG dwelling units mainly towards the backside of the Immamulah building. It comprises mainly areas of Dhamawala Mohhla. About 63% area is belonging to the MIG dwelling units. It comprises maily areas of Dispensary road, Raja raod, Pipal Mandi and surrounding areas. Diagram 6.11 shows the percentage distribution of housing types in ward no. 36, Dhamawala.

Social characteristics of ward no. 39, Dandipura has influence of old/historical developments. About 39% of ward area is occupied by HIG units along the Tilak road, which provides main access to the ward (map no. 5.18). While, MIG dwelling units are located in the central, north and south directions of the ward occupies 44% of ward area.

One of the major causes of high density in this ward is multistoried LIG units towards the eastern side comprises the area of Dandipura Basti, which is about 15% of ward area (table 6.18).

Table 6.18: Housing type composition in ward no. 34- Dandipura

TYPE	AREA (in hectare)	%
HIG	5.15	38.84%
MIG	5.79	43.67%
LIG	1.94	14.63%
Squatter	0.38	2.87%
Total	**13.26**	**100.00%**
Drainage	0.00	
Road	2.90	
Total ward area	**16.16**	

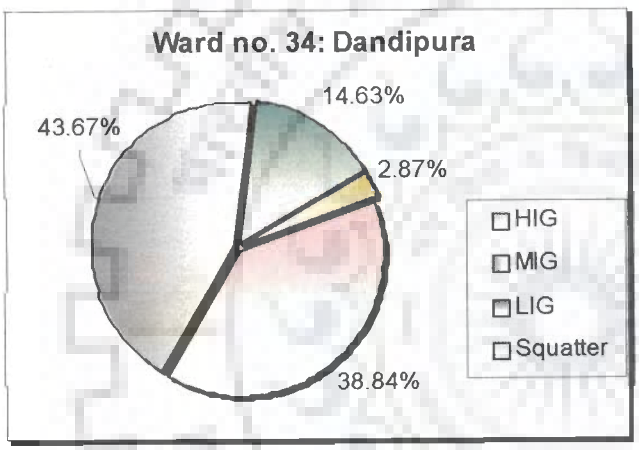


Diagram 6.12: Percentage distribution of housing types in ward no. 34- Dandipura

Since, this ward consists the central part of old city, it is having very high land value. Thus, LIG units constitute out of single room sets within a multistoried building. Low-income and squatters units constitute about 15% and 3% of ward area respectively (diagram 6.12). People living in these areas are engaged in commercial activity in the neighboring central business district (CBD).

6.3.1 Inferences: Social Scenario

The form of social structure at ward level is the result of a mixture of elements, most importantly from its unique topography. Comparison of distribution of housing types in different wards reveals that higher income group seeks out zones of superior residential amenity including large house size, accessibility, and desirable physical feature of landscape. Ward no. 39, Race Course (N), consists maximum area, which is about 54% of ward area, under HIG while ward no. 4, D.L.Road comprises about 9% of ward area under HIG class. In contrast to these, ward no. 34, Dandipura have about 39% area under HIG, which are very old bungalow with very large campus.

The most notable changes in terms of their income occurred in the people living in informal settlements. Many houses in these areas are good to very good physical conditions. In ward no. 4, D.L.Road, one double storied building with marble façade along the drainage channel represents the economic condition of its habitant. It is because people have improved their economic base and constructed permanent structures or due to transformation of land ownership. Thus, in all wards, LIG and squatter units are closely associated with each other.

The maps and related statistics derived form high resolution satellite data reveals the facts about the social structure and spatial distribution of population at ward level. Family income is an indicator of social class and closely related with the affordability of the basic infrastructure. It also affects the demand and supply as well as distribution pattern of infrastructure facilities. Housing type maps derived from remotely sensed data permit a far more efficient method of analysis to calculate the demand of basic infrastructure facilities.

The above discussion demonstrates that the high degree of socio-economic heterogeneity within small areas very much affects the conventional urban analysis. Thus, aggregation of built-up units into smaller zones has been shown to obscure much of the diversity of social conditions at the small-area level. Applied to remotely sensed images of urban areas, zoning of imagery on the basis of these criteria enhances the prospects for meaningful spatial analysis.

6.4 Fiscal Scenario

Being the single largest source of municipal revenue, the share of property tax varies in the range of 40 to 80% of municipal income (Singh, 2001). A healthy situation of municipal finances is a primary requisite for maintaining the quality of urban environment.

To visualize the fiscal scenario in different wards, database developed for social scenario has been used to calculate the property tax for an average dwelling unit of different income groups at ward level. Tax contribution only of residential dwelling units is calculated using proposed unit area method of property taxation. For this purpose, average residential plot size under different category i.e. HIG, MIG, LIG and squatters is calculated in following manner-

$$\text{Average plot size} = \frac{\text{Total area under each housing type}}{\text{Total no. of houses under each housing type}}$$

Average plot size under the different housing types in different ward is calculated from the statistics derived in social scenario. Average built-up area is assumed to 50% of plot area, which is used to calculate the property tax at ward level.

Various factors related to UAM are kept constant according to type of development in each ward. Rental value varies according to the category of HIG, MIG, LIG and squatters, which are kept uniform in all wards under A, B, C and H category respectively (refer section 5.4.3). The defined rental value of each category is Rs. 630, 500, 400 and 100 respectively (table 5.3). It is assumed that residential units are self-occupied with Pacca construction in HIG, MIG and LIG category while Kachha construction in squatters. Age factor is also kept constant within each ward but vary among different wards according to the phases of development. During the field visit, it was observed that ward no. 34, Dandipura, ward no. 39, Dhamawala and ward no. 39, Race Course (N), were developed before 1960. Thus, age factor for these three wards is kept constant to 0.6. While AF of other two wards, ward no.4, D.L.Road and ward no. 23, Devsuman Nagar, is kept constant 0.7 and for ward no. 12, Dharampur, value for it is 0.8 depending upon the phases of development. Finally, tax calculated for individual dwelling units of different income groups is shown in table 6.19-6.24 for different wards.

Average property tax calculated for an average dwelling unit of different income groups in ward no. 39, Race Course (N), using Unit Area Method (UAM) is given in table 6.19. An average built up area under HIG, MIG, LIG and squatter dwelling units in this ward is

188 sq. m., 129 sq. m., 74 sq. m. and 38 sq. m. respectively. Property tax for an average HIG unit is about Rs. 71,000/-, for MIG unit Rs. 39,000/-, for LIG unit Rs. 18,000/- and squatter, it is about Rs.1100/-.

Table 6.19: Property tax of an average dwelling in ward no. 39- Race Course (N)

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	188.09	630	1.00	1	0.60	1	71098.02	55.21%
MIG	128.85	500	1.00	1	0.60	1	38655	30.02%
LIG	74.44	400	1.00	1	0.60	1	17865.6	13.87%
Squatter	38.44	100	1.00	0.5	0.60	1	1153.2	0.90%
Total							128771.8	100.00%

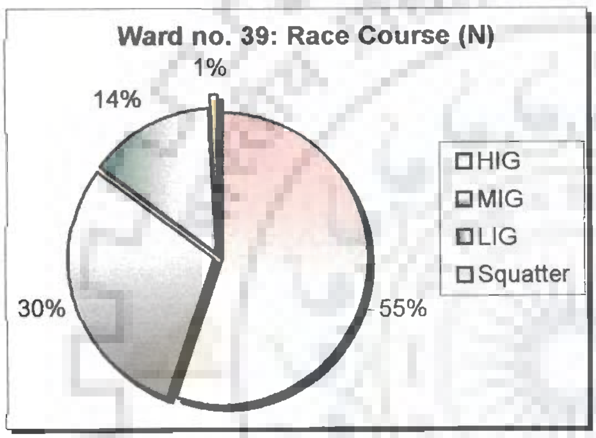


Diagram 6.13: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 39- Race Course (N)

It is respectively 55%, 30%, 14% and 1% of total contribution by an average dwelling unit of HIG, MIG, LIG and squatter respectively (diagram 6.13).

An average dwelling unit of the different income groups and property tax calculated for the same in ward no. 12, Dharampur is given in table 6.20. An average size of HIG dwelling unit is about 123 sq. m., MIG dwelling unit is about 93 sq. m., LIG dwelling unit is about 41 sq. m. and squatter is about 30 sq. m. The property tax contribution by an average HIG unit is around Rs. 78,000/-, MIG unit is around Rs. 46,000/-, LIG unit is around Rs. 16,000/- and squatter is around Rs. 1,500/-. It is around 54%, 33%, 12% and 1% of the total tax contribution by an average dwelling unit of HIG, MIG, LIG and

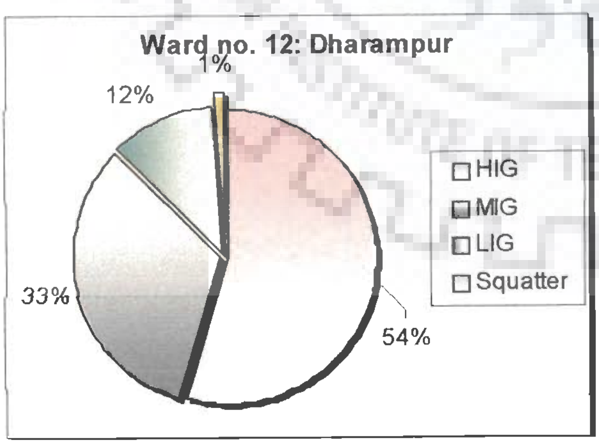


Diagram 6.14: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 12- Dharampur

squatter respectively. Diagram 6.14 shows the percentage distribution of tax contribution by an average dwelling unit of HIG, MIG, LIG and squatter in ward no. 12, Dharampur.

Table 6.20: Property tax of an average dwelling in ward no. 12- Dharampur

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	123.26	630	1.00	1	0.80	1	77653.8	54.72%
MIG	92.93	500	1.00	1	0.80	1	46465	32.74%
LIG	40.81	400	1.00	1	0.80	1	16324	11.50%
Squatter	29.61	100	1.00	0.5	0.80	1	1480.5	1.04%
Total							141923.3	100.00%

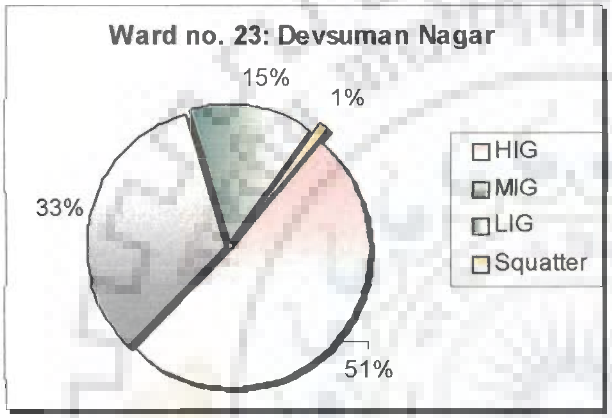


Diagram 6.15: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 23- Devsuman Nagar

Average built up area in ward no. 23, Devsuman Nagar (table 6.21), vary from 129 sq. m. to 37 sq. m. from HIG to squatters units. It is about 129 sq. m. in HIG units, 105 sq. m. in MIG, 59 sq. m. in LIG and 37 sq. m. in squatters. Tax calculated for an average unit varies about Rs. 1000/- to Rs. 57,000/- from squatters to HIG units. Tax calculated for an average HIG unit is Rs. 57,000/-, MIG unit is around Rs. 37,000/-, LIG unit is around Rs. 16,000/- and squatter is around Rs. 1300, which is about 51%, 33%, 15% and 1% of total tax contributed by an average dwelling unit of HIG, MIG, LIG and squatter respectively. Diagram 6.15 shows the percentage of tax contributed of an average dwelling unit of HIG, MIG, LIG and squatter.

Table 6.21: Property tax of an average dwelling in ward no. 23- Devsuman Nagar

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	129.39	630	1.00	1	0.70	1	57060.99	51.20%
MIG	104.79	500	1.00	1	0.70	1	36676.5	32.91%
LIG	58.67	400	1.00	1	0.70	1	16427.6	14.74%
Squatter	36.53	100	1.00	0.5	0.70	1	1278.55	1.15%
Total							111445	100%

In ward no. 4, D.L. Road, contribution of property tax (table 6.22) by HIG, MIG, LIG and squatter is almost same as observed in other wards.

Table 6.22: Property tax of an average dwelling in ward no. 4- D.L.Road

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	122.38	630	1.00	1	0.70	1	53969.58	49.71%
MIG	105.65	500	1.00	1	0.70	1	36977.5	34.06%
LIG	58.95	400	1.00	1	0.70	1	16506	15.20%
Squatter	31.82	100	1.00	0.5	0.70	1	1113.7	1.03%
Total							108566.8	100.00%

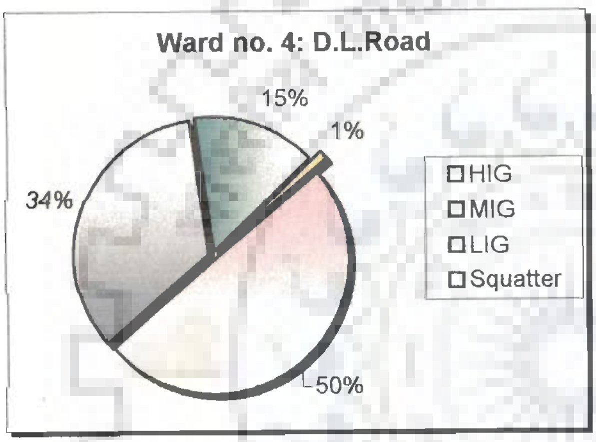


Diagram 6.16: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 4- D.L.Road

In this ward, average built up area varies from 122 sq. m. in HIG unit to 32 sq. m. in squatter. The property tax calculated for HIG dwelling unit around Rs. 54,000/-, MIG dwelling unit is around Rs. 37,000/-, for LIG dwelling unit around Rs. 17,000/- and for squatter dwelling unit around Rs. 1,000/-. It is respectively 50%, 34%, 15% and 1% of total tax contributed by an average dwelling unit of HIG, MIG, LIG and squatter respectively (diagram 6.16).

In ward no. 36, Dhamawala also, average size of HIG units is relatively large in comparison to the wards having new developments (table 6.23).

Table 6.23: Property tax of an average dwelling in ward no. 36- Dhamawala

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	175.54	630	1.00	1	0.60	1	66354.12	59.02%
MIG	105.37	500	1.00	1	0.60	1	31611	28.12%
LIG	57.28	400	1.00	1	0.60	1	13747.2	12.23%
Squatter	23.99	100	1.00	0.5	0.60	1	719.7	0.64%
Total							112432	100.00%

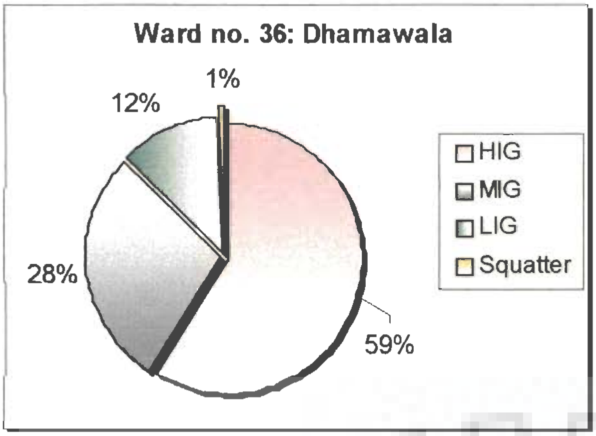


Diagram 6.17: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 36- Dhamawala

The average size of HIG dwelling unit is about 176 sq. m., MIG dwelling unit is about 105 sq. m., LIG dwelling unit is about 57 sq. m. and squatter is about 24 sq. m.. Property tax contribution calculated for an average HIG dwelling unit is around Rs. 66,000/-, MIG dwelling unit is Rs. 32,000/-, LIG dwelling unit is Rs. 14,000/- and squatter dwelling is around Rs. 700/-. It is about 59%, 28%, 12% and 1% of total tax contributed by an average dwelling unit of HIG, MIG, LIG and squatter respectively (diagram 6.17).

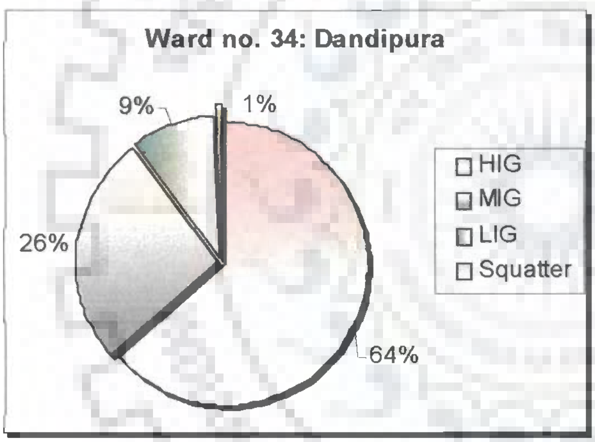


Diagram 6.18: Percentage distribution of tax contribution by an average dwelling unit of different income group in ward no. 34- Dandipura

Due to the location of the ward no. 34, Dandipura in the central part of the city, size of an average dwelling unit of an average MIG, LIG and squatter are relatively less in comparison to other areas. It shows that a person of middle or low-income group can afford relatively small area in the central part of the city, where land prices are very high, in comparison to other parts of the city.

Table 6.24: Property tax of an average dwelling in ward no. 34- Dandipura

Type	Average house size (sq.m.)	Unit area value	UF	SF	AF	OF	Tax	Tax contribution %
HIG	170.11	630	1.00	1	0.60	1	64301.58	63.65%
MIG	87.92	500	1.00	1	0.60	1	26376	26.11%
LIG	39.54	400	1.00	1	0.60	1	9489.6	9.39%
Squatter	28.73	100	1.00	0.5	0.60	1	861.9	0.85%
Total							101029.1	100.00%

The average built up area (table 6.24) of HIG is 170 sq. m., in MIG is 88 sq. m., in LIG about 40 sq. m. and squatter it is about 29 sq. m. The tax calculated for HIG, MIG, LIG and squatter is Rs. 64,000/-, Rs. 26,000/-, Rs. 9,000/- and Rs. 900/- respectively. Percentage distribution of the tax contributed by HIG, MIG, LIG and squatter is shown in diagram 6.18. The ratio of the total tax contributed by dwelling units of different income groups shows more deviation in comparison to other wards.

6.4.1 Inferences: Fiscal Scenario

Table 6.25 is derived from table 6.18-.24, which shows the property tax contribution by an average dwelling unit of different income groups in wards selected for detailed study.

Table 6.25: Tax contribution by an average dwelling unit of different income groups

Ward Name	Tax contribution by HIG (%)	Tax contribution by MIG (%)	Tax contribution by LIG (%)	Tax contribution by Squatter (%)
Race Course (N)	55	30	14	1
Dharampur	55	33	12	1
Devsuman Nagar	51	33	15	1
D.L.Road	50	34	15	1
Dhamawala	59	28	12	1
Dandipura	64	26	9	1

Overall, an average dwelling unit of HIG, MIG, LIG and squatters provides a general picture about the property tax contribution by different income groups in different wards. It shows that HIG gives highest contribution for the property tax in comparison to other types.

The contribution of higher income group unit is more than 55% while squatters contribute about 1% of total tax contributed by an average unit of other income groups. Table 6.25 also shows some common trends in tax contribution by an average dwelling unit of different income groups. It shows that the tax contribution by HIG, MIG and LIG units is about 55, 32 and 12 times higher in comparison to the tax contribution by an average dwelling unit of squatter. Pearson Coefficient of Correlation is derived to find the

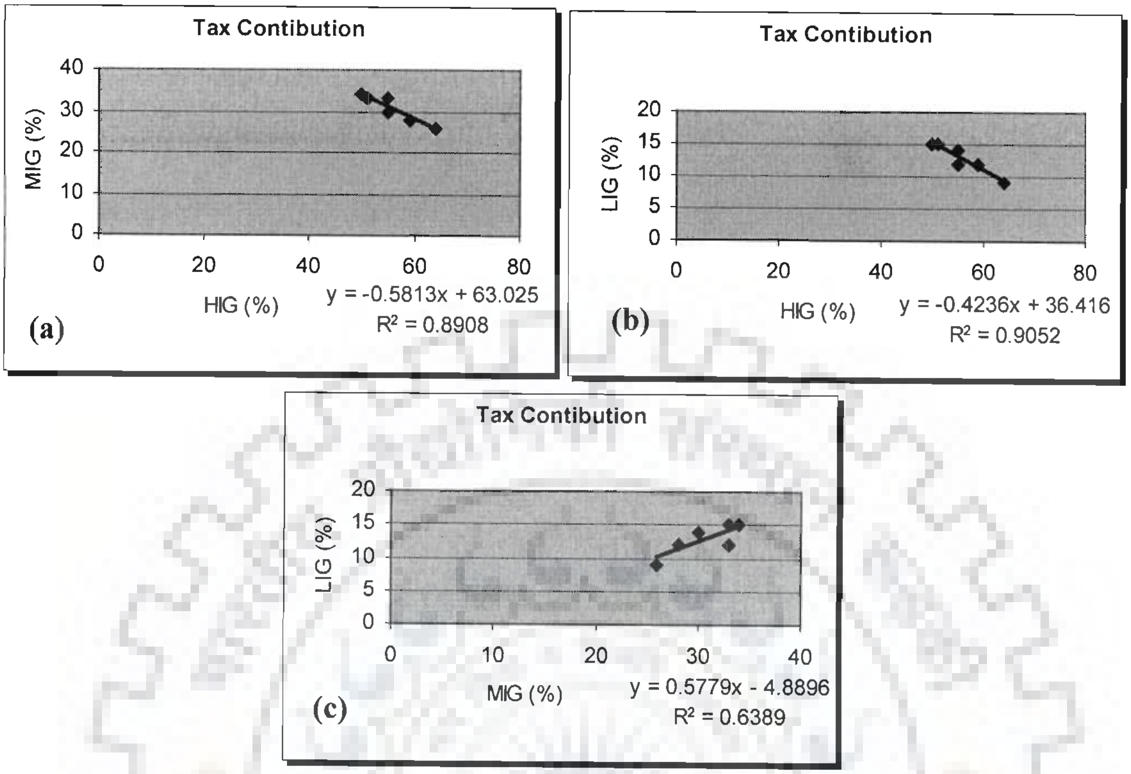


Diagram 6.19: Relationship between tax contribution by an average dwelling unit of different income groups

strength of relationship between the tax contributions by an average dwelling unit of different income groups. The high value of coefficient of correlation, between HIG, MIG and LIG also confirm the same. The derived value of the correlation coefficient between HIG and MIG dwelling unit is 0.944. Diagram 6.19(a) shows strong but negative relationship between the tax contribution by an average dwelling of HIG and MIG. Tax contribution by HIG and LIG dwelling units also are shows strong negative relationship as shown in diagram 6.19(b), as value of correlation coefficient is 0.951. The derived value of the correlation coefficient between MIG and LIG dwelling unit is 0.799. But, as shown in diagram 6.19(c), tax contribution by MIG and LIG units are positively correlated. It provides qualification of the revenue generated with different income groups and helpful to plan the expenditure for the infrastructure accordingly. Since, variation in tax contribution by an average dwelling unit of squatter is almost constant in different wards, it does not show any relation with other income groups. Table 6.26 is derived from table 6.19-.24, which shows the total of tax of an average dwelling unit of different income groups in different wards.

Table 6.26: Tax contribution by an average dwelling unit in different wards

Ward name	Total tax of an average dwelling	Tax contribution %
Race Course (N)	128772	18.29
Dharampur	141923	20.15
Devsuman Nagar	111445	15.83
D.L.Road	108567	15.42
Dhamawala	112432	15.97
Dandipura	101029	14.35
Total	704168	100

In Dehradun, rental value is the base for the property taxation. Thus, parameters for unit area method as given by Delhi Municipal Corporation adopted for the metro city have been used for the same. Such types of quantification are also helpful to determine the property tax and its revision over the period of time.

6.5 Environmental Scenario

Urban population is increasing to the extent that new approaches to urban environment and its assessment are needed. Statistics related to land cover composition derived from classified map no. 5.19-5.24 in different wards is shown in table 6.27-6.32.

In ward no.39, Race Course (N), about 57% of the ward area is covered with man-made hard surfaces as shown in map no. 5.19.

Table 6.27: Land cover composition in ward no. 39- Race Course (N)

Types	Area (in hectare)	%
Green cover	13.38	14.72%
Hard Surfaces	51.75	56.92%
Soft Surfaces	25.78	28.36%
Total	90.91	100.00%

Total 13.64 hectare area comprises green cover, which is about 15% of the ward area (table 6.27). Out of these, about 50% of green cover is in the form of domestic gardens and 10% is in the form of roadside trees occurring across the ward. These spaces vary

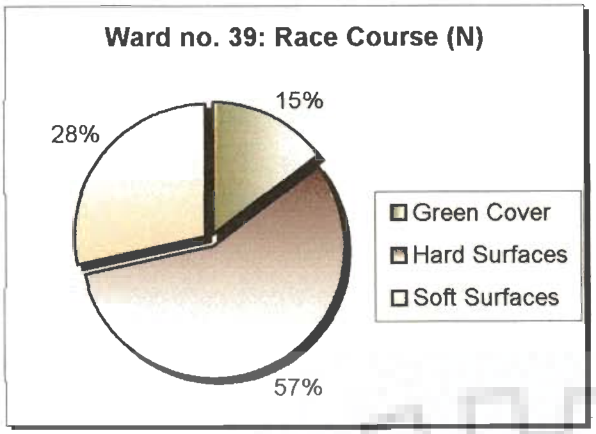


Diagram 6.20: Percentage distribution of land cover composition in ward no. 39- Race Course (N)

and 10% is in the form of roadside trees occurring across the ward. These spaces vary from a few square meters in size to major segments. Planned woodland adjacent to jail campus towards north-west direction comprises rest of the 40% trees, which is under private ownership and surrounded with large portion of vacant/ agriculture land. About 26 hectare area is classified as soft surface, which is 28% of ward area. Distribution of soft surfaces follows the development patterns as about 25% such spaces are along the road. Linear spaces throughout the ward follow the road corridors and provide considerable amount of soft surface. Two public schools and one Gurudwara provide large extends of soft surface under the play fields within the ward. Diagram 6.20 shows the percentage distribution of land cover composition in ward no. 39, Race Course (N).

Area classified under hard surfaces, soft surfaces and green cover in ward no. 12, Dharampur (map no. 5.20), is respectively 60%, 28% and 12% (table 6.28).

Table 6.28: Land cover composition in ward no. 12- Dharampur

Type	Area (in hectare)	%
Green cover	6.45	12.38%
Hard surfaces	31.22	59.90%
Soft Surfaces	14.45	27.72%
Total	52.12	100

This is a planned area with population density 152 persons/ hectare. Impact of planning regulation is clear from the pattern of distribution of soft and green surfaces. Soft and green areas are well distributed in the whole ward mainly in the form of playgrounds and right of way along the road. About 50% of the green cover is in the form of individual trees dispersed within ward mainly along the road while rest of the 50% of green cover is

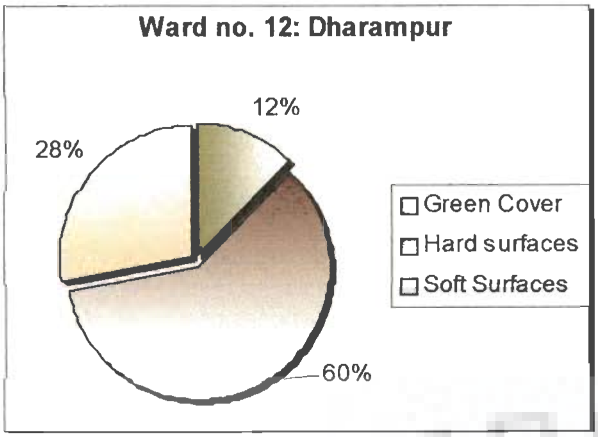


Diagram 6.21: Percentage distribution of land cover composition in ward no. 12- Dharampur

concentrated with in few pockets. Green areas are concentrated among few private premises and government institutions. Most of the green areas are along the Haridwar road towards the south west direction. About 40% of the green cover is concentrated within the premises of Shiv Ashram and residential building with big orchard in the front on Haridwar road towards the southern part. Rest of the 60% of the green cover is dispersed on the vacant plots, individual buildings premises and along the roads. About 90% of the soft surfaces are in the form of open spaces while rest of the 10% is in the form of vacant plots and area out of the carriage way. Diagram 6.21 shows the percentage distribution of hard surface, soft surfaces and green covers in ward no. 12- Dharampur.

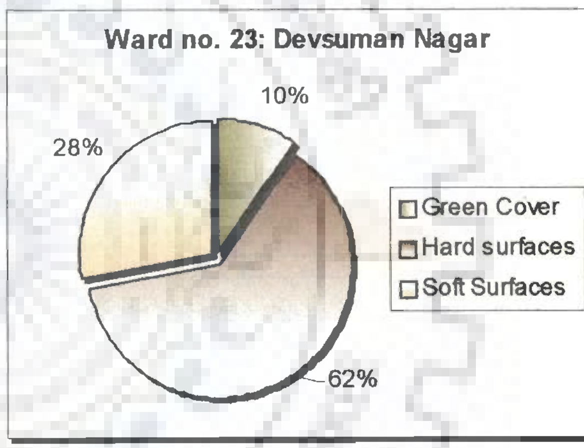


Diagram 6.22: Percentage distribution of land cover composition in ward no. 23- Devsuman Nagar

Land covers composition in ward no. 23, Devsuman Nagar, (map no. 5.21) comprises hard surface around 26.21 hectare, green surface around 4.21 hectare and soft surface around 11.89 hectare (table 6.29). This is respectively about 62%, 10% and 28% of ward area (diagram 6.22).

Table 6.29: Land cover composition in ward no. 23- Devsuman Nagar

Type	Area (in hectare)	%
Green cover	4.12	9.80%
Hard surfaces	26.12	62.13%
Soft Surfaces	11.8	28.07%
Total	42.04	100.00%

Green cover is not concentrated within few bungalows, but it is spread over the whole area almost in a uniform way.

Most of these areas are located within private premises especially in Aakash Deep and Vasant Vihar colonies. Soft surfaces reveal the pattern of development because most of the areas are along the road. About 35-40% of soft surfaces are in the form of set backs or play fields and rest of the 60-65% are under vacant plot/ undeveloped land.

While ward no 4, D.L. Road, (map no. 5.22) comprises 17.61 hectare hard surface, 2.74 hectare green surface as well as 9.13 hectare soft surface, which is about 60%, 9% and 31% of total ward area respectively (table 6.30).

Table 6.30: Land cover composition in ward no. 4- D.L.Road

Type	Area (in hectare)	%
Green cover	2.74	9.29%
Hard surfaces	17.61	59.74%
Soft Surfaces	9.13	30.97%
Total	29.48	100.00%

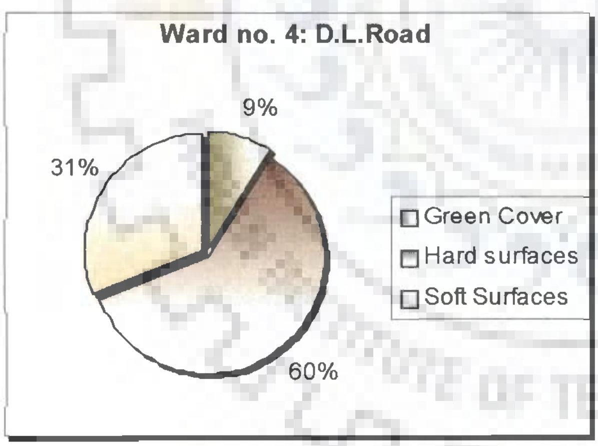


Diagram 6.23: Percentage distribution of land cover composition in ward no. 4- D.L. Road

Impact of slum/ squatter developments is clear on the availability of green spaces. Most of the green covers are concentrated within individual premises and just 5-10% of these are in public areas mainly in the form of roadside trees and incidental open spaces due to undulating topography. North, west and central pert of the ward comprises most of the green cover while western side of the ward is lacking green lungs. The presence of seasonal riverbed results in considerable increase of soft areas within the ward. Diagram 6.23 shows the percentage distribution of hard surface, soft surface and green cover in ward no. 4, D.L.Road.

Out of the total 25.56 hectare area in ward no. 36, Dhamawala (map no. 5.23), 17.82 hectare area falls under hard surface, 5.28 hectare area falls under soft surfaces and 2.46 hectare area falls under green cover, which is about 70%, 21% and 10% of ward area respectively (table 6.31).

Table 6.31: Land cover composition in ward no. 36- Dhamawala

Type	Area (in hectare)	%
Green cover	2.46	9.62
Hard surfaces	17.82	69.72
Soft Surfaces	5.28	20.66
Total	25.56	100

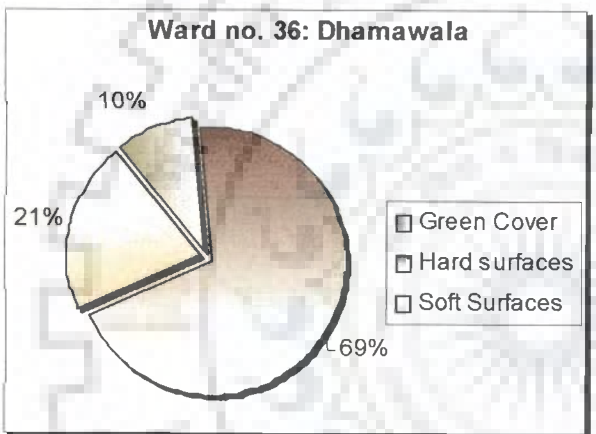


Diagram 6.24: Percentage distribution of land cover composition in ward no. 36- Dhamawala

Soft surfaces are not distributed in the whole ward but concentrated with in few pocket of irregular shape backside of the Immamulah building associated with the mosque and north-eastern part of the ward under the private ownership. While 80% of the area under green cover is also within the individual premises and rest of the 20% of green cover is dispersed in the whole ward. Most of the green cover is concentrated towards the south-west direction in few big houses along the Raja road. In this ward also domestic garden plays an important role in the contribution of the green covers. Diagram 6.24 shows the graphical presentation of the land cover distribution in ward no. 36, Dhamawala.

Land cover composition in ward no. 34, Dandipura, (map no. 5.24) is different from other three wards as soft surface consist of a less area in comparison to green cover. In this ward, about 69% area is hard in nature as well as 17% area comes under green surface and 14% area under soft surfaces (table 6.32). It proves that in high-density areas, vertical expansion takes place to accommodate more and more people. Most of the green cover falls within the campus of forest department. About 80% of the green cover is concentrated within 10-15 individual premises of old developments.

Table 6.32: Land cover composition in ward no. 34- Dandipura

Type	Area (in hectare)	%
Green Cover	2.79	17.26%
Hard surfaces	11.18	69.18%
Soft Surfaces	2.19	13.55%
Total	16.16	100.00%

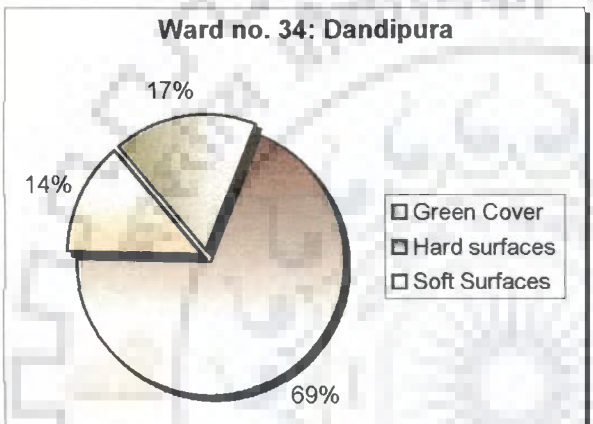


Diagram 6.25: Percentage distribution of land cover composition in ward no. 34- Dandipura

Soft surface is just 2.19 hectare or 14% of ward area. It has less soft surface because squares and parking lots with hard surfaces form the outdoor areas. These spaces are spread irregularly as result of changes in attitude and planning. Percentage distribution among hard surfaces, soft surfaces and green covers in ward no. 34, Dandipura is shown in diagram 6.25.

6.5.1 Inferences: Environmental Scenario

In Dehra Dun, domestic gardens, which are considerable large in size play an important role to provide natural environment within city. Domestic gardens are generally ignored as open space and difficult to identify. But such types of studies allow to monitor the supply of urban green spaces through time and space against quantitative and qualitative targets and to assess the effects of future policy scenarios. Over all, about 10-15% variation is recorded among hard surface, soft surface and green cover in wards having different population densities.

Table 6.33: Amount of various land covers available per 1000 person

Ward Name	Hard Surface Area (X) (hectare/ 1000 persons)	Soft Surface Area (Y) (hectare/ 1000 persons	Green cover (Z) (hectare/ 1000 persons
Race course (N)	6.31	3.16	1.65
Dharampur	3.94	1.82	0.81
Devsuman Nagar	3.78	1.71	0.61
D.L. Road	2.49	1.3	0.40
Dhamawala	2.33	0.69	0.32
Dandipura	1.45	0.29	0.37

Land cover composition of different wards is used to visualize the relationship between different land covers. To establish the relationship, it is necessary to convert all data into same unit. Thus, area under different land cover is divided by ward population to find the availability of different types of land cover. Table 6.33 is derived from table 4.7 and table 6.27-6.32, which shows the area of various land covers in hectares available per 1000 person. Table 6.33 shows that proportion of various land covers almost remain same in urban areas of different densities. In low-density areas, about 6.31 hectare hard surface, 3.16 hectare soft surface and 1.65 hectare green cover are available per 1000 person. While, in the case of high density, 1.45 hectare hard surface, 0.291 hectare soft surface and 0.366 hectare green cover are available per 1000 capita. Ratio of area under soft surfaces is about ½ and green cover is about ¼ of the hard surfaces.

Coefficient of correlation shows very high relationship between hard and soft surfaces, as computed value of the same is 0.97. It means that 97% of the total variation in soft areas is accounted for by its co-variation with hard surface area. Relationship between hard surface area and green surface is also highly correlated, as computed coefficient of correlation is 0.91. Or 91% of the total variation in green cover is accounted for by its co-variation with hard surface area.

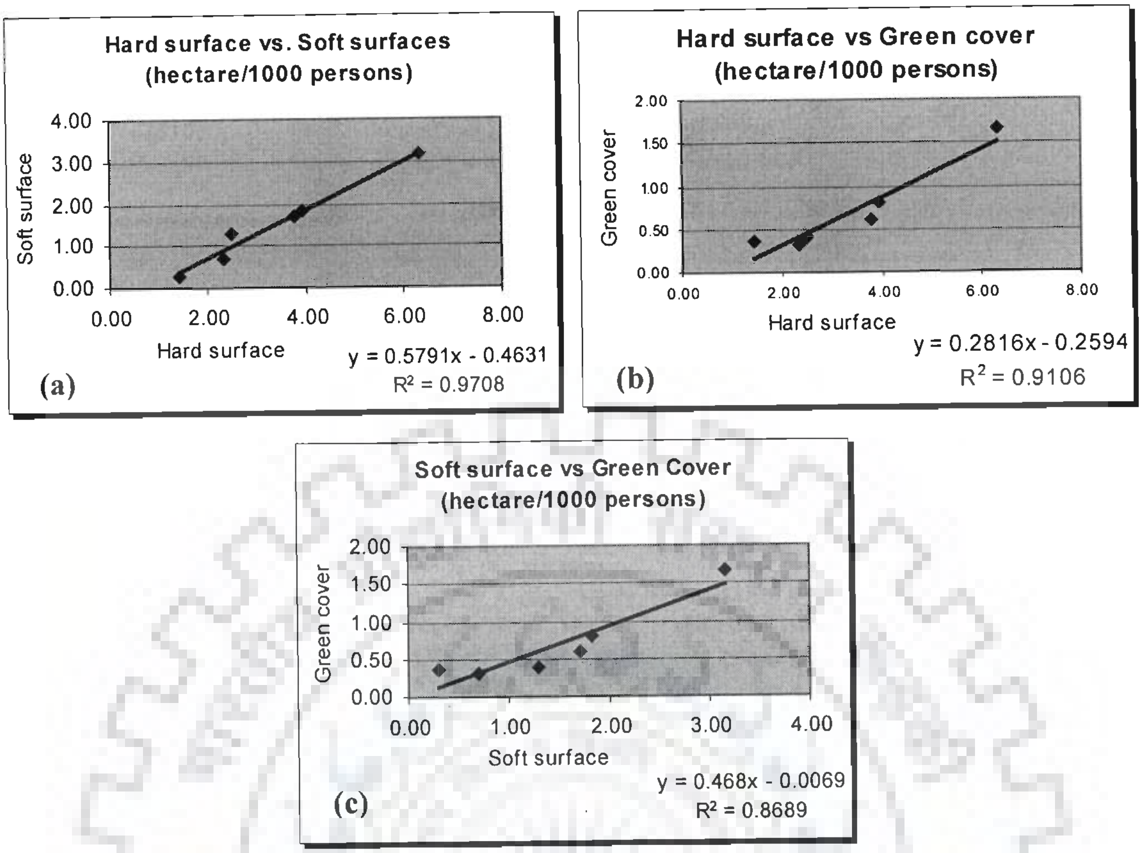


Diagram 6.26: Relationship between different types of land covers

Soft surface and green cover, both of these areas fall under the category of open spaces. But functions are different and cause different impact on micro level environment. Computed coefficient of correlation is 0.87. It means that about 87% of the total variation in green cover is accounted for by its co-variation with soft surface area.

The results shows that proportion of various surfaces almost remain same in different wards of varied densities. This provides a scientific support and visualization for the sustainable development of the city. A major reason for the high correlation among various land cavers is land use control and planning regulations. Presence of public institutions such as jail, religious buildings and government offices with large open spaces is another cause of derived relationships. Undulating hilly topography also plays a major role and result in considerable amount of incidental spaces in the form of soft and green cover.

6.6 Legal Scenario

Many urban areas in developing countries are poorly planned and often characterized by the presence of large informal settlements that have little form of regularity (Malcolm et al., 2001). Squatter settlements (settlements on public land) are inherently unauthorized and, to the extent, have no legal authority to exist. A squatter is a physical unit who has taken possession of lands and occupied it without lawful authority to do so (I.T.P.I. reading material on Planning Legislation & Professional Practice). Unbiased, accurate and timely information from high-resolution satellite data is an important source to identify temporary structures and monitor the growth of informal sector in the city. Status of slums/squatters in different wards as derived from the social scenario under study area is given in table 6.34.

Table 6.34: Area under squatters in different wards

Ward Name	Area under squatters (in hectare)	% of ward area
Race Course (N)	0.14	0.20%
Dharampur	0.12	0.29%
Devsuman Nagar	0.56	1.78%
D.L.Road	1.56	7.24%
Dhamawala	0.04	0.18%
Dandipura	0.38	2.87%

Pattern of development of slum/squatters in all wards is linear mainly along the natural drains. The population density of these areas is relatively high. Maximum area about 2 hectare under the squatters is in ward no. 4, D.L.Road, which is about 7.2% of the ward area. In ward no. 23, Devsuman Nagar, about 1 hectare area while in ward no. 34, Dandipura, about 1 hectare area is occupied by the squatters.

6.6.1 Causes

Squatters are resultant of social, economic and physical factors. Some important factors that contribute for creation of these settlements can be attributed to low income of the people, preference to be near work place, shooting up of urban land prices, building materials and last but not least, the political and vested interests of self centered people. The problem of squatters has very important economic aspects. This sounds elementary, but non-realization of the importance of this aspect has led in the past due to absence of timely and accurate information about these.

As being the largest urban center in the region, migration from the other parts of state to the city is considerably higher. Demand of land for housing has raised land prices beyond the affordability of the common urban populace. Migrants from the surrounding rural areas starts to stay near work place by encroaching marginal spaces along the natural drainage, railway line and major roads. As a result, squatters are growing by day and by night. Most of the people living in these areas are employed in the informal sector including labors for construction industry and household jobs in the surrounding planned residential areas.

Transportation network and accessibility plays a major role in the pattern of development of squatters. Development of squatter's in ward no. 4, D.L.Road shows that accessibility and physiographic conditions are the major influence factor for linear pattern of development of squatters.

The growth of slums/squatters has led to the growth of unstable living environments. These settlements are often located on steep slopes, along riverbed or adjacent to transport facilities. These are the areas where the urban poor live in very poor conditions with inadequate infrastructure and social amenities. The difficulty here lies in the fact that the land is always too expensive in the safe and developed areas and building costs too high to keep the formal housing supply within the reach of the second and third income groups. Another difficulty lies due to absence of timely database to monitor the growth of such developments. Development needs to be regulated in terms of its impact on overall environment.

6.6.2 Consequences

Poorly developed areas threaten our environment, health and quality of life in numerous ways. Impact of slums and squatters on its environment have been studied under three parameters-

- Physical environment (*includes ecological aspects*),
- Aesthetical environment (*includes qualitative aspects*),
- Social environment (*includes psychological aspects*),

6.6.2.1 Physical environment

In Dehradun, most of the slums and squatters are developed along the drainage network and seasonal riverbed. These developments have considerable impacts on ecosystems and other environmental resources, which provide societal and environmental benefits simply by existing and functioning. The ecological impact of these settlements spans not only locally but also at city and regional scale. Effects of these settlements are very clear on the quality of ground and surface water. These settlements are the major reasons for the reduction in the width of the seasonal rivers. It pollutes the storm water runoff originating from upper hills and reaching to the rivers as well as responsible for under ground water contamination. These settlements are responsible for the deterioration of air and water quality. Further it causes to alter the natural landscape and soil erosion.

6.6.2.2 Aesthetical environment

The aesthetical quality of city is lost by such spontaneous slum and squatter settlements. This category mainly includes qualitative aspects related with natural/ manmade environment. It is directly linked with the economic condition of the inhabitants. Due to poor economic condition, aesthetics of man made environment is governed by ruined/ poor quality construction of houses. Care should be taken to develop ecological sensitive areas and other incidental spaces simultaneously at the time of development of residential areas. Proper provision can be made to integrate planning for economic weaker section. In this way, aesthetical quality as well as ecology of the city can be maintained and the birth of future slum can be prevented. Natural dimension in these areas seems to be lost because of unplanned and haphazard development. Aesthetical environment in some parts of the slum resembles with the rural environment. With the help of government aid under slum improvement programme, a part of slum is less dilapidated than others.

6.6.2.3 *Social environment*

Social environment of the area is directly associated with the human behaviors. Squatter increases unemployment and concentrate poverty in urban centers. Most of the people living in these areas are working in the surrounding planned residential areas. The social integration within community is of average level as they belong to one particular category of the society. Discussion with slum dwellers reveals that they came to cities in the search of employment. The man-folk came first and after building or obtaining huts on rent they brought their families. Sometimes, expectations/ frustrations associated with the people of squatters' leads to non-social activities within planned colonies.

It generates pressure on existing infrastructure and increased traffic congestion. These are the areas where the urban poor live in very poor conditions with inadequate infrastructure and social amenities. They do not pay any tax for infrastructure facilities thus bring disparity in the supply of basic facilities. Most of the women of these areas are employed in the surrounding planned residential area of high and middle-income group.

6.7 Relationship between Different Factors

The above discussions illustrate that physical, social, fiscal and environmental aspects are related to each other in different wards selected for detailed study. Thus, coefficient of correlation is derived to measure the strength of relationship between these parameters in different wards. Since, qualitative assessment is carried out to study legal aspects, it is not used for the mathematical modeling. The value of derived coefficient of correlation shows the strength of relationship between two parameters. This leads to the development of correlation matrix. It is helpful in measuring the impact and acceptance of specific changes in urban environment and can be a basis for planning policies towards changing requirements and human behaviors.

6.7.1 Physical vs. Social

Accessibility is an important factors and it has impact on the distribution pattern of population density as clear from above discussions. The relationship between physical and social aspects is established to visualize the impact of road network on the population density. For this purpose, road density derived from land use pattern in section 6.2, physical scenario is compared with the population density of different wards, as given in table 6.35.

Table 6.35: Physical vs. Social

Ward name	Road density (%)	Population density (persons/hectare)
Race Course (N)	22. 61	90
Dharampur	21.72	152
Devsuman Nagar	22.12	164
D.L.Road	16.32	239
Dhamawala	16.55	300
Dandipura	17.95	474

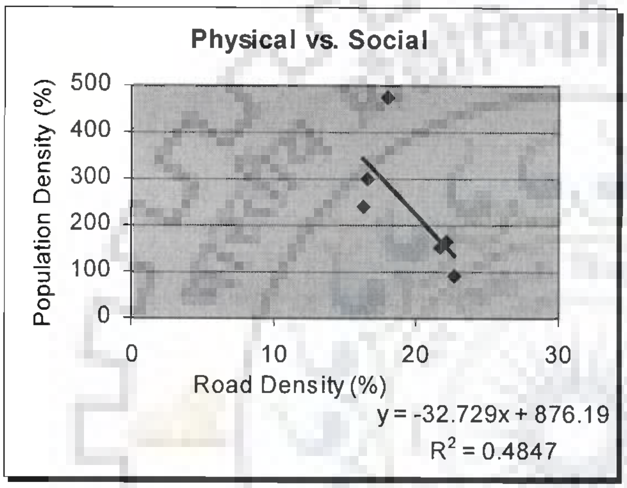


Diagram 6.27: Relationship between road density and population density

The value of derived coefficient of correlation is 0.696, which shows the moderate relationship between these two parameters. It means that about 70% variations in population density are due to road network *or* narrow streets are responsible for the increase in population density in 70% cases. In other word, vertical expansion of the development is also responsible for the high population density. Diagram 6.27 shows that these two phenomena are negatively correlated and increase in road density results in the decrease of population density. It is clear from the table 6.34 also, which shows that higher percentage under road network in Race Course (N), Dharampur and Devsuman Nagar are having low population density.

6.7.2 Physical vs. Environmental

Impact of road density on the environment is used to visualize the relationship between physical and environmental parameters. Table 6.36 is derived from section 6.2, physical scenario and table 6.20-.25 of environmental scenario, which shows the composition of urban environment within each ward.

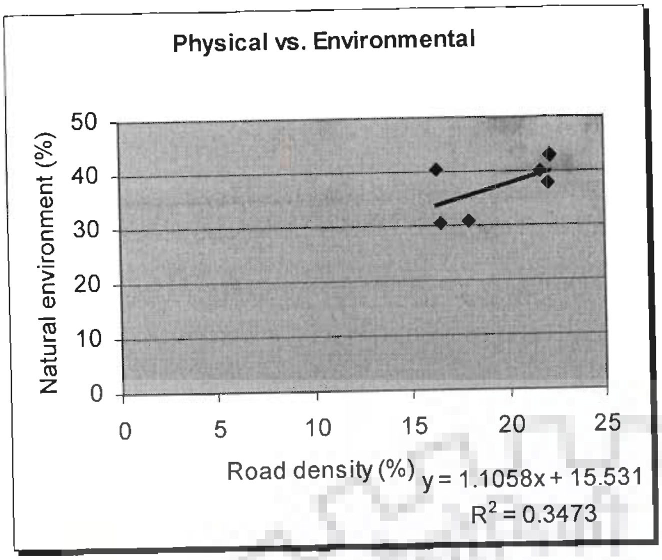


Diagram 6.28: Relationship between road density and natural environment

Natural environment is the total of area classified under soft surfaces and green cover in each ward. The computed value of coefficient of correlation between road density and natural environment is 0.589. It shows poor relationship between built and natural environment. Or, road density has negligible impact on the natural environment. These two phenomena are positively related as increase in one result in increase of another (diagram 6.28).

Table 6.36: Physical vs. Environmental

Ward name	Road Density (%)	Natural environment (%)
Race Course (N)	22.16	43.06
Dharampur	21.72	40.09
Devsuman Nagar	22.12	37.87
D.L.Road	16.32	40.26
Dhamawala	16.55	30.28
Dandipura	17.95	30.81

6.7.3 Physical vs. Fiscal

Road network and its effect on the property taxation in different wards have been taken to visualize the relationship between physical and fiscal aspects. Table 6.37 is derived from the statistics of land use pattern in section 6.2, physical scenario and total tax contribution by an average dwelling unit of different income groups (table 6.26) in section 6.4. The derived value of

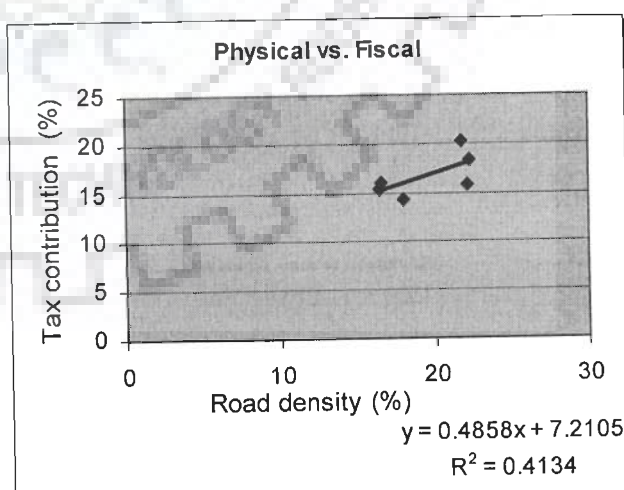


Diagram 6.29: Relationship between road network and property tax contribution

correlation coefficient is 0.642, which shows moderate relationship between physical and fiscal aspects. It means that about 65% variations in the property tax are due to variation in road density. Diagram 6.29 shows the positive relationship between these two aspects. It means increase in road density will result in increase in property taxation.

Table 6.37: Physical vs. Fiscal

Ward name	Road density %	Tax contribution %
Race Course (N)	22.16	18.29
Dharampur	21.72	20.15
Devsuman Nagar	22.12	15.83
D.L.Road	16.32	15.42
Dhamawala	16.55	15.97
Dandipura	17.95	14.35

In other words, total tax contribution by an average dwelling unit of different income groups is higher in planned developments, where more area is under road network. An average dwelling unit in Race Course (N), Dharampur and Devsuman Nagar contribute higher tax in comparison to D.L.Road, Dhamawala and Dandipura.

6.7.4 Social vs. Environmental

Relationship between social and environmental aspects is derived to visualize the impact of population density on the natural environment. Table 6.38 is derived from table 4.7 and the land cover composition of different wards discussed in section 6.5, environmental scenario. Area classified under green cover and soft surfaces is combined under the natural environment in different wards. The derived value of the coefficient of correlation is 0.844, which shows the strong relationship between these two aspects.

Table 6.38: Social vs. Environmental

Ward name	Population density	Natural environment (%)
Race Course (N)	90	43.06
Dharampur	152	40.09
Devsuman Nagar	164	37.87
D.L.Road	239	40.26
Dhamawala	300	30.28
Dandipura	474	31.81

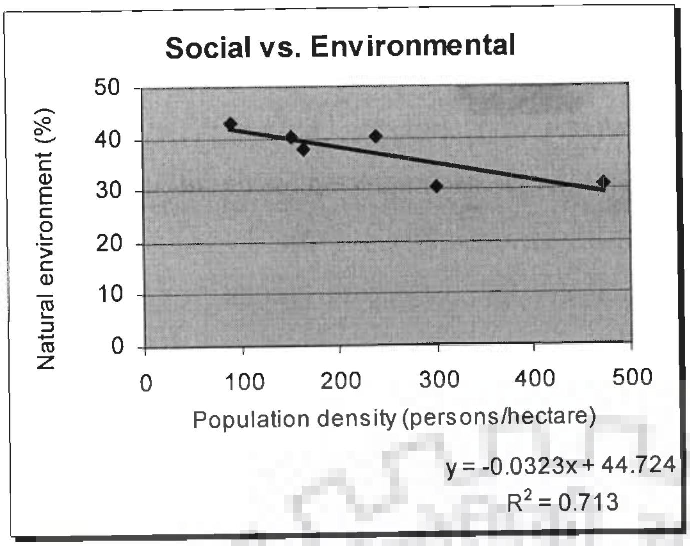


Diagram 6.30: Relationship between population density and natural environment

It means that about 80% variation in natural environment is due to the population density. Diagram 6.30 shows the negative relationship between population density and area under natural environment. It shows that increase in population density results in decrease in natural environment. The amount of open spaces is varying according to population density and type of development. With the increase of population density, area under natural environment is decreasing.

6.7.5 Social vs. Fiscal

Impact of population density on the property taxation is anticipated to study the relationship between social and fiscal aspect. Housing type is an important factor in the property tax calculation. For this purpose, total tax of an average dwelling unit of different income groups in different wards, is used to quantify the percentage of property tax contribution by different wards. Table 6.39 is derived from the table 6.26 and table 4.7.

Table 6.39: Social vs. Fiscal

Ward name	Population density (persons/hectare)	Tax contribution %
Race Course (N)	90	18.28
Dharampur	152	20.15
Devsuman Nagar	164	15.83
D.L.Road	239	15.42
Dhamawala	300	15.97
Dandipura	474	14.35

The value of derived correlation coefficient is 0.727, which shows moderate relationship between population density and percentage contribution of property tax by an average dwelling in different wards. Diagram 6.31 shows the negative relationship between these two aspects. It means that increase in population density results in decrease in house size and property tax contribution by an average dwelling unit accordingly. It means that about 70% variation in property tax of an average dwelling unit is accounted for variation in population density.

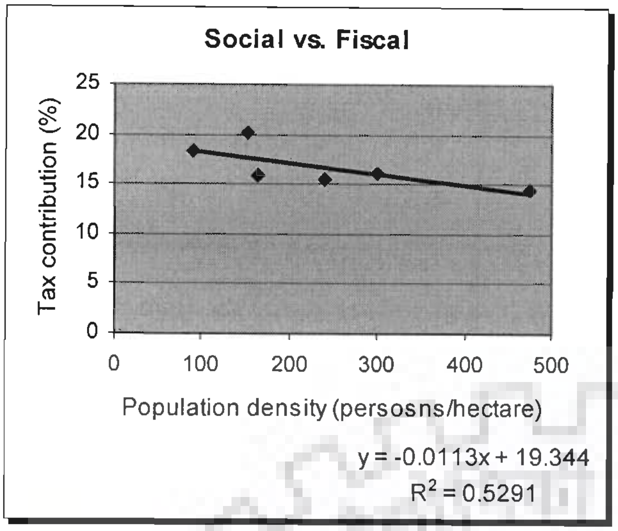


Diagram 6.31: Relationship between population density and tax contribution

6.7.6 Fiscal vs. Environmental

Percentage contribution of property tax at ward level is compared with the percentage of availability of natural environment in different ward to find relationship between the environmental and fiscal scenario. Table 6.40 is derived from the table 6.26 and 6.27-6.32. In wards with very low and high population density, higher percentage of area under green cover in comparison to percentage of tax contribution.

Table 6.40: Fiscal vs. Environmental

Ward name	Tax contribution %	Natural environment %
Race Course (N)	18.28	43.06
Dharampur	20.15	40.09
Devsuman Nagar	15.83	37.87
D.L.Road	15.42	40.26
Dhamawala	15.97	30.28
Dandipura	14.35	30.81

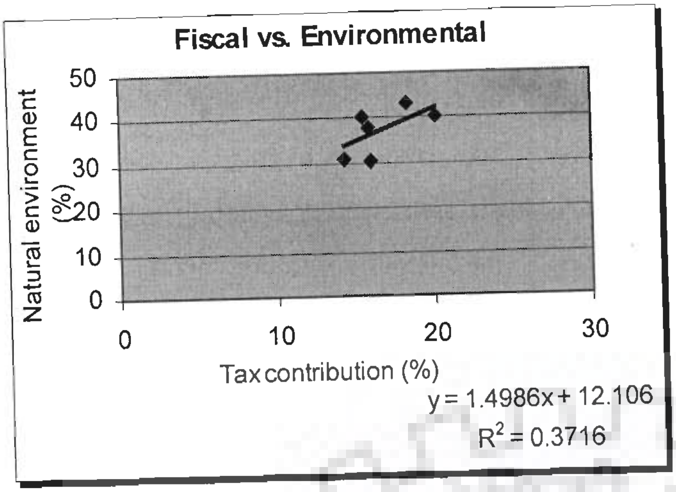


Diagram 6.32: Relationship between tax contribution and natural environment

Overall, coefficient of correlation shows the moderate relationship between these two aspects, as derived value is 0.609. Diagram 6.32 shows the positive relationship between these two aspects. It means that wards with high tax contribution have more area under natural environment. This confirms our understanding that in low-density developments, higher income group people can afford more green area within individual premises. While, in high-density developments, vertical expansion preserves more green cover. Wards comprises middle-income group units have less green cover in comparison to tax contribution.

6.7.7 Correlation matrix

Correlation is a technique for investigating the relationship between two quantitative, continuous variables. It is calculated through correlation coefficient, which is a numeric measure of the strength of linear relationship between two random variables. A number of different coefficients are used for different situations. The best known is the Pearson coefficient of correlation, which is derived between different parameters. If values are derived for more than one parameters, then it can be arranged in the matrix form, known as correlation matrix. The value of coefficient ranges from –1 to 1. Value near to 1 shows the strong relationship between the two variables while value near to 0 means two variable are not correlated. A value of 1 shows that a linear equation describes the relationship perfectly and positively, with all data point lying on the same line and Y is increasing as X is increasing. A score of –1 shows that all data points lying on a single line but that Y increases as X decreases.

Table 6.38: Correlation matrix between different parameters

	Physical	Social	Fiscal	Environmental
Physical	1			
Social	-0.696	1		
Fiscal	0.642	-0.727	1	
Environmental	0.589	-0.844	0.609	1

Table 6.38 shows the value of coefficient of correlation between physical, social, fiscal and environmental parameters derived in section 6.7.1-.7. Social and environmental parameters are strongly correlated, as the value of correlation coefficient is –0.844. It means that increase in population density results in decrease in natural environment. While physical and environmental parameters are poorly correlated, as the value of derived coefficient of correlation is 0.105. It means that road density has negligible effect on the natural environment.

Correlation matrix shows positive relationship between physical vs. fiscal parameters, fiscal vs. environmental parameters, physical vs. environmental parameters. While physical vs. social, social vs. environmental and fiscal vs. social parameters are negatively related.

CHAPTER VII

FRAMEWORK FOR SYSTEM DEVELOPMENT

7.1 An Overview

Database created in chapter V and its analysis in chapter VI shows the potential of high resolution to investigate the existing scenario related to physical, social, fiscal, environmental and legal aspects. Database created for physical scenario in section 5.5.1 and its analysis in section 6.2.1 shows the deviations in the land uses along the natural drainage with reference to the Master Plan for Dehradun 1982-2001 (section 20, page no. 77) in ward no. 4, D.L. Road; ward no. 23, Devsuman Nagar and ward no. 34, Dandipura. As per the provision of Master Plans, 5-10 meter area along the natural drainage is reserved for the green spaces. Though, it is difficult to find out the deviation in the land use pattern of planned areas due to absence of zonal plan determining the use of every parcel.

Deviation in the land use pattern from the Master Plan due to poor mechanism for the implementation and monitoring affects the social (discussed in section 5.5.2 and section 6.3), fiscal (discussed in 5.5.3 and analysis carried out in section 6.4), environmental (discussed in section 5.5.4 and its analysis in section 6.5) and legal (discussed in section 5.5.5 and section 6.6) scenarios. Thus, the physical scenario influences social, fiscal, environmental and legal aspects in urban areas. Analysis carried out in previous chapter shows that various aspects of urban phenomena are directly or indirectly related with each other. Thus, information structure for the implementation and monitoring is comprises of the physical, social, fiscal, environmental and legal parameters.

Various activities under urban regimes need intensive information handling and decision making that can be enhanced through adoption of integrated information system. This chapter describes the conceptual model of information system from the perspective of planning agencies, municipality and other organizations under the umbrella of urban regimes. First part of the chapter is focused on the fundamental datasets for the system. Spatial database developed and analyzed in previous chapters are adopted and integrated within the system. Ultimately, of course, the challenge of linking different data sets related to different scenario to mainstream urban analysis is one of the pragmatic tasks.

Second part of the chapter describes different interface designs with the purpose of integration of spatial database as online tools for various activities. It aims to provide an effective, efficient and economic land administration and management system in our cities. It is concerned with the integration and sharing of land-related information viz. physical, social, fiscal, legal and environmental information, which are important in urban regimes. To build the theoretical foundation of system development that is neglected during decades of practice-oriented work, it provides a set of circumstances under which urban local bodies can share data and collaborate on analysis. The goal of the system is to offer a carefully designed web based service for planning, development and management process.

Third part of the chapter is concerned with the organizational restructuring. The use of a parcel-based GIS for effective system operationalisation requires organizational readjustment for the effective sharing of databases, hardware, software or personnel. System development emphasizes the structural changes in organizations to improve data gathering process for improved urban management. A systematic RS/GIS strategy is suggested to coordinate the database development and coupling of various organizations within system. Organizational change involves restructuring to create new organizational forms, processes, procedures, information flows and responsibilities, which correspond to new technology and are enabled by web development. The purpose of such change is to integrate technology and organization by mutual adjustment as well as to institutionalize the activities needed to use the technology effectively in pursuing organizational missions and functions. An implication of this is that GIS based urban analysis will develop upon the foundations of data available through system. System is proposed to serve three categories: public, administrator and planners.

The problems of cities are related to physical, social, economic and environmental factors, thus management of these cannot be neglected if sustainable development is to be achieved. City planning and management spell out the need for integration and sharing of information and the way to implement them. System adopts different data as an inter-disciplinary meeting place, where it can be assessed to increase our understanding of the spatial distributions of urban phenomena, and how these, in turn, may inform practical planning issues.

7.2 Fundamental datasets forming Information Structure

Before getting into detail about the system, it is necessary to describe the fundamental datasets forming the information structure for the implementation and monitoring of the plans. The fundamental datasets are defined as those components sufficient for involved parties to integrate and share the land related information with each other. At the city level, policy makers often favor the small-scale abstract information to study the general pattern and development trends. Development agencies need the medium to large-scale information for zoning and monitoring spatial development in their jurisdiction. Enterprises and developers are interested in site maps to assess the activities along with utilities, location, and accessibility to their parcel. Thus, fundamental datasets should be able to cater the need at different levels within the city.

Spatial database developed for detailed studies related of various scenarios i.e. physical, social, fiscal, environmental and legal parameters are forming the information structure. It will provide geo-spatial data for integrated planning, development and other decision-making procedure. Together these dataset presents a strategic vision from the point of view of planners and decision makers. An important element of any information structure is the fundamental datasets that are used for a large number of different applications. Because of their overall strategic importance, these datasets constitute the final key elements of any information strategy. Coordination and the establishment of core databases takes most efforts associated with the development of information system. Its primary responsibilities are with respect to the coordination of land information management activities related to physical, social, economic, environmental and legal aspects at city level.

Furthermore, the establishment of standards has been hailed as a central element necessary for successful integration of GIS resources. A set of standards which is adopted by all the participating agencies in the city such as land parcel, parcel identifiers, land ownerships, buildings, building identifier, building ownership, facility identifiers, name of roads, demographic profile, taxation and similar items needs to be identified as fundamental datasets. Several efforts at national level have been under way to develop and foster the adoption of GIS standards. The National Urban Information System committee has drafted standards for both spatial and attributes data from cadastral level to city and regional level. Registration, abstract scaling and coding are often viewed as first steps of integrating and sharing of information. Registration holds a primary role in establishing integrated geodetic reference between map components of the information system. The registration ties maps into large location scheme such as state plane coordinate latitude, longitude and Universal Transverse Mercator (UTM). It benefits accurate map overlay, regardless of information type, scale, and handling tool from manual tracing to computerized systems. Therefore, a common city registration system is proposed to be compatible with or effectively convertible from the information system at national level i.e. NUIS.

The task of combining the various data sets is achieved using a set of common identifier to join the large number of potential combinations of information related with individual land parcel. The parcel level base map is a common data source for many information systems. It is obvious that forming and sustaining of systems in an effective structure depends on construction of the up-to-date and accurate base map in digital environment. Therefore, the large-scale base map in digital format is the fundamental requisite for the system.

7.2.1 Base Map as Common Element

The most important component needed in the development of system is a large-scale base map at the scale of 1:2000 or larger as discussed in previous chapters. It defines size, shape, location, value of the real estate and other land related information. It plays an important role to develop and supply new data such as spatial based information in urban areas.

Land parcel is basic spatial unit upon which records of land use is compiled. For many purposes of area wise analysis, the parcel is an inappropriate unit. In urban areas this is subdivided into parts of buildings-a shop on the ground floor, which is separated from the residential accommodation above it. But parcel data can be aggregated to meaningful larger analytical units. It fulfills the gap existing between growth related monitoring approaches that relates to the parcel as a unit of data analysis and collection and its management.

The forming and sustaining of systems in an effective structure depends on construction of the up-to-date and accurate large-scale base map in digital environment. It helps in standardization of the way in which the specific geographical features are to be shared between different departments, levels of governments and private institutions. Through this, all parcels are identified by same name and the same terminology, which reduces the cost of administrative operations as well as planning process. A common base map is used to link different land-related data. Consequently, large-scale base map derived from high resolution satellite data is further integrated with secondary /attribute data related with various parameters in the system. As this is achieved, the transformed data is used for a much wider range of applications.

7.2.2 Physical aspects

To plan rapid urbanization, local planners urgently need reliable data on locations and features of urban activities. Planning regulations are concerned with the quality as well as type of land use. Building a parcel-based database is a matter of coordinating the work of different departments to obtain requisite data in a workable format and at an adequate level of accuracy and timeliness for planning purposes. Standardized base mapping enables better delivery of public services, especially through the ability to combine data for such uses as planning, land tax, valuation, facility management etc. The fundamental datasets related to physical aspect includes number of dwelling units, stories or the height of the building, floor area, type of construction, and general physical conditions of the building. This enables better analysis of data as well as consequent planning for public services.

7.2.3 Social Aspects

Social aspect concerns with the location and the nature of housing type in an area and adopted to generate distribution pattern of population. Land is also related with the social dimension in society. The social impact of information is through the decision making process related to basic infrastructure as level of consumption varies according to the income group. The derived local database of housing type is useful for assessing the infrastructure level with respect to spatial distribution of population.

In other words, census data is one of the good examples as fundamental dataset. Many organizations want to utilize this information as well as wishing to analyze it in very different ways and at widely differing scales.

7.2.4 Fiscal aspect

The development of a system is essentially a tool that can grow and be adopted in the light of economic pressures and local needs. As such, it is a basis for planning and development of land. Land records and assessment function also focuses on the juridical and fiscal components of land apart from its physical land use characteristics. By merging the results i.e. the land use map and homogeneous housing areas, however, it is possible to combine their respective strengths. Analyses of economic and housing conditions have typically been unconcerned with detailed considerations of the spatial aspects of land developments. The parcel based urban land information systems are helpful in assessment and taxation records that are linked to tax-lot maps.

The relationship between monitoring and the assessment function are fundamental dataset because tax assessors' files are a primary source of parcel level data. Tax assessment has a direct interest in estimates of the future develop ability of land as a factor for appraising land and improvements values. As the assessment function becomes increasingly dependent on the system and reliant on GIS as an analytical tool, accurate and detailed data on the existing and future development capacity of land help to make the process both reliable and transparent. For these reasons, the importance of building and maintaining databases at parcel level are useful to the assessment function will likely grow.

7.2.5 Environmental aspect

UDPFI guidelines recommends various standards for the developments of open spaces at different scales. The remote sensing application has the potential to provide a useful monitoring tool by visualizing the various factors of city fabric and their changes in relation to policy scenario.

Evaluation of planning, on the other hand, based not only on the facts about the impact of plan implementation on population density, quality of life implied by various built environments, the importance of protecting agricultural land and conserving natural resources, the tolerance for environmental pollution and traffic congestion, and other issues that are difficult to automated within an information or decision support system. Addressing the relationship between land use and environmental planning, and linking land and environmental monitoring require sharing data across a broad range of agencies, each with different tasks and needs.

7.2.6 Legal Aspect

The legal right of the land is one of the fundamental datasets to secure and uphold the social and productive functions of land. Administrative boundaries defining political subdivisions, town boundaries, planning zones, census districts, and other units, which affect each land parcel needs to be uniform. In a computerized system, they need to be stored in such a form that, when enquiries are made about an individual parcel and the administrative region within which it lies can be readily determined. The records of land ownership should be complete in terms of both owners and occupants, up-to-date and accessible to the planning organization. The legal uncertainties about ownership could be easily to remedy through the system. Legal aspect is also related with the unauthorized construction in environmental sensitive areas.

7.3 Information Structure for Plan Implementation and Monitoring

The zonal plans are the prerequisite for the implementation and monitoring of the master plans in urban areas. In India, absence of large scale base map for the preparation of zonal plans is the major cause for the poor implementation of the master plans not only in Dehradun but also in large metro cities i.e. Bhopal, ~~Calcutta~~ Kolkata including

Delhi, capital of India. Thus, the information structure to support the different stages of the planning process determining the flow of the information is shown in figure 7.1. Large-scale land use map is an input for the planning considering the social structure and economic base of the city, while environmental and legal aspect supports the decision making in the planning process. Large-scale land use map is also required for the implementation of the provisions made in plans. Changes in the land use are observed through the large-scale land use maps and impacts of these changes on the social, fiscal, environmental and legal scenarios in the monitoring process. Changes observed during the monitoring of implementation process are the input for planning process. Thus, there is a need for the system for the continuous monitoring and feed back for planning and sustainable management of urban areas.

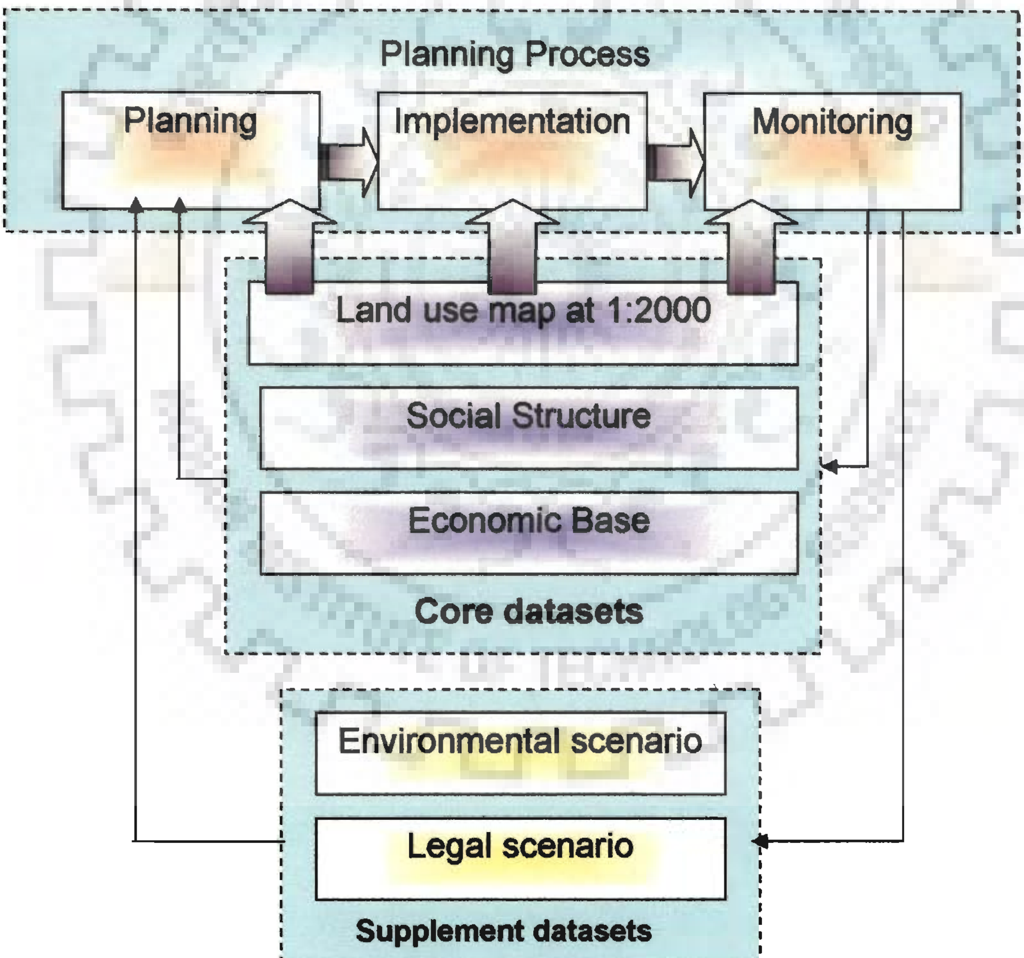


Figure 7.1: Information structure to support the plan implementation and monitoring

7.4 Conceptual model of system

After the analysis of fundamental datasets, an open multi-stage system is proposed, whose components favor city management and the participation of city agencies. The design strategy is to secure the technical and institutional factors that serve various integration interests of involved parties. This requires identifying-

- a set of common elements in order to maximize their integration consensus
- sharing methods relevant to agency participatory capacity and means
- an implementing mechanism pertinent to monitor the communication and/or coordination

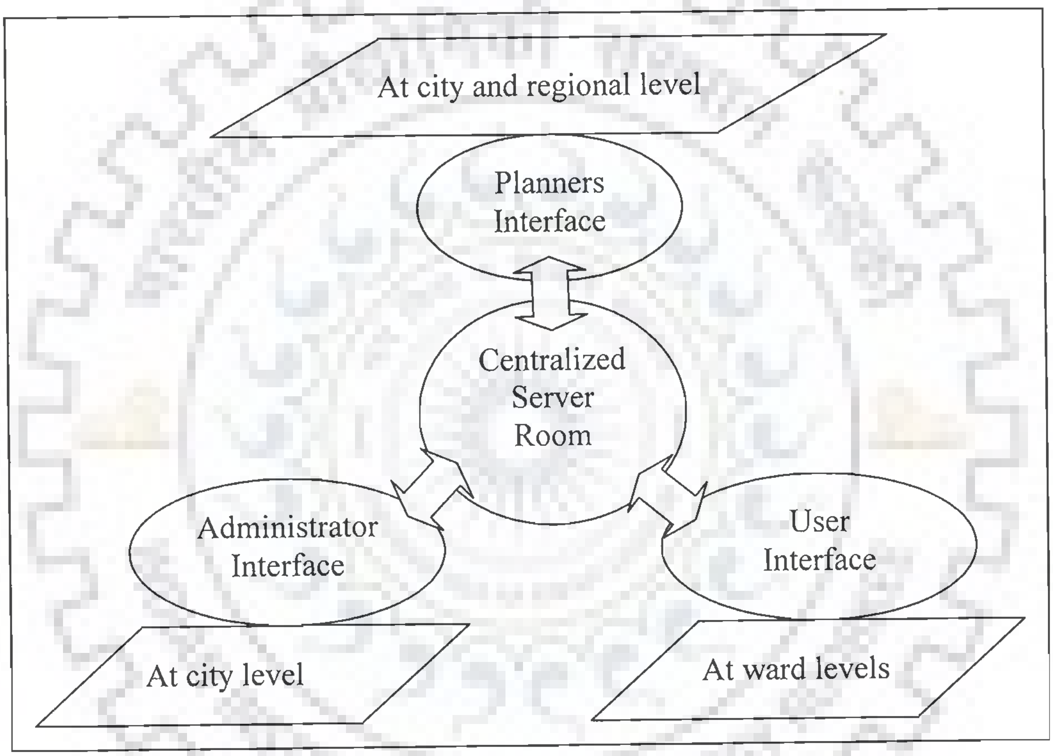


Figure 7.2: Conceptual model of the proposed system

The conceptual model of the system is developed as an open multi-level system in the following section. It focuses on integration of fundamental datasets at parcel level and database organization within the system at 3 levels –

- Planner interface
- Administrator interface
- User interface

Different interfaces containing sub-system is proposed for the integration of various spatial databases linked within the system. Figure 7.2 presents conceptual model to build an integrated information system for urban regimes. The three-level interface framework of core common elements and handling methods is open for the integrated database to be built by different agency capacity while ensuring the sharing and regular updation.

Emphasis is given on the development of integrated information system at ward level. The integration issues we have addressed are those relating to information exchange, data integrity and most importantly, uniform base map. Spatially distributed data in the form of various thematic maps and land use map have been incorporated into the system to share the data among various interfaces. That database will be capable of resolving queries pertaining to different scenario.

7.4.1 User Interface

In real estate, the most important characteristics of a property are location, shape, size, use and ownership as well as demographic profile associated with it. First step is the integration of land related information structure within day-to-day operations, called the user interface. This interface uses to build a database at ward level, which is a difficult task in actual planning and management practice. Careful design of user interface and links with other interfaces allows information gathering at micro level to diffuse extensively through out the system. It allows coordination and sharing of the databases with different agencies related with infrastructure development and its maintenances i.e. roads, sewer and water etc. Within the system, this is the module that is responsible for policy formulation and for day-to-day operations.

However, thorough understanding of professional data needs and application definitions in order to reach consensus, these elements are more crucial to start information integration and sharing. The web based tools, which have been developed in this interface, have the potential to be used by a variety of agencies for multiple purposes.

7.4.1.1 Components

The user interface consists of components to capture, store, manage different types of databases to record physical, social and fiscal issues, to visualize and evaluate various activities such as planning, implementation, monitoring etc. These components are grouped to handle day-to-day activities as well as for coordinating the development activities at ward level. It will help to analyze the different scenario at micro level and helps in identifying the driving forces behind land use developments. The database integration process at ward level in the user interface system of city as shown in figure 7.3.

Household data related with physical, social and fiscal aspects are basic components of the user interface. These are related with unique identifier of the large-scale base map i.e. physical aspect is related with land use, construction type, no. of stories and basic infrastructure facilities related with individual parcel. Basic spatial unit for data collection is the parcel. To make the system more generic, an expected number of objects in a sub-class are provided and stored as an attribute of the sub-class.

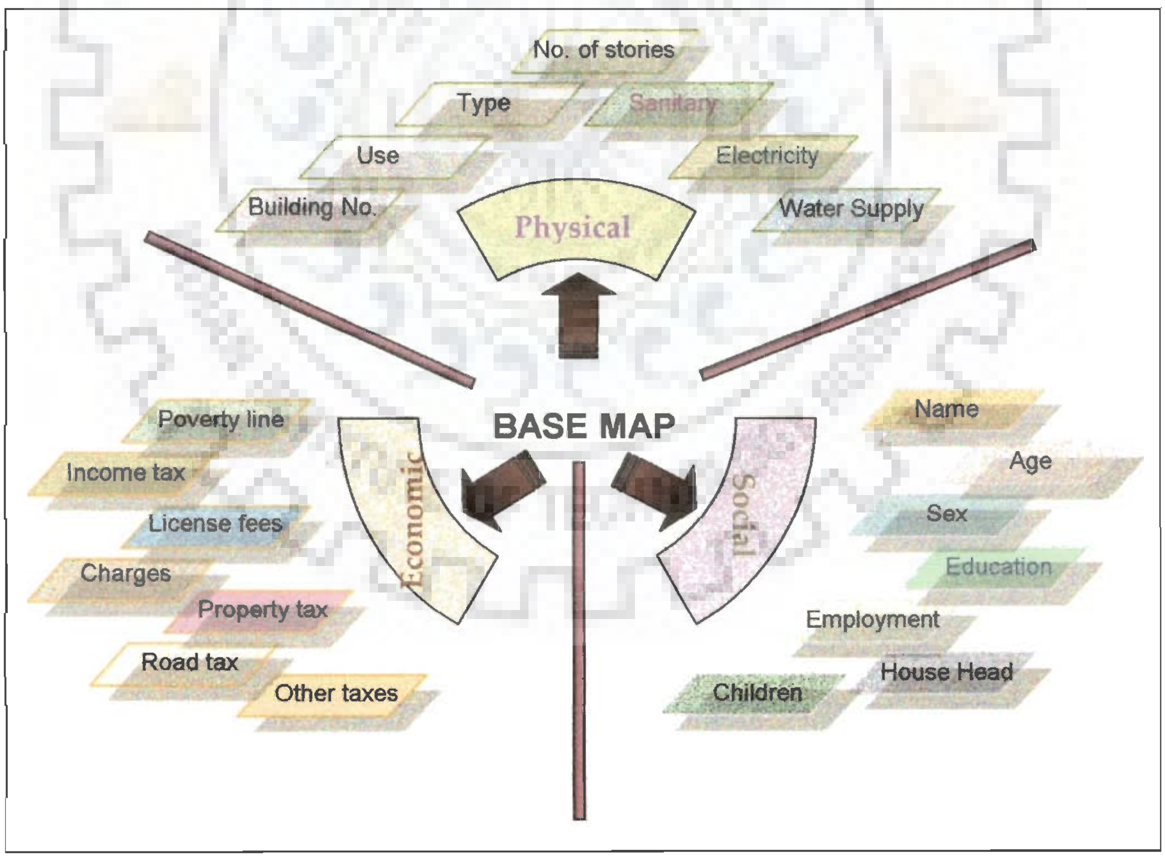


Figure 7.3: Conceptual design of user interface

Physical Aspect- It is related with number of dwelling units, ownership, its use, year of constructions, number of stories or the height of the building, floor area, type of construction, and general physical conditions of the building etc. The base map is in part concerned with the physical attributes associated with each land parcel, including networks of basic infrastructure services. It will fulfill the need of local authorities for reliable data on locations and features of urban activities at local level to plan rapid urbanization.

Social Aspect- Virtually all-human activities take place within a land parcel, which thus form the basic spatial unit for recording census data. To provide better picture of the city, spatial distribution and changes in population is proposed to record at ward level. Population demographic data is linked with unique identifier at parcel level base map. Many countries carried out census every decade. But population growth rate varies during the decade depending upon various natural as well as man-made factors. The user interface component offers an opportunity to visualize different scenarios, based on new spatial arrangements of population distribution. It contains description of best practice from real planning and descriptions of how to forecast area populations. It is helpful in demand-and-supply analysis of basic utilities and services. Thus, social aspect focuses on geo-demographic visualization of demographic data.

Fiscal Aspect- Land value and tax records are the most important economic factors in justifying the system development. It is linked with a number of taxes including property tax imposed by Municipality at local level. The appraisal of property for taxation purposes and the collection of taxes on real estate are performed by the municipality. Under these circumstances, it is necessary to coordinate these activities coupled with the financial assistance to local government agencies. Tax assessors normally include land use classification as part of data collected on individual parcels for the purposes of assigning value, tax rates or determining exemption status with the variations of spatial layout. The maintenance of adequate land records for tax assessment will bring significant revenues to government. Management of land record is an ongoing activity, with property description updates and ownership transfer occurring on a continuous, often daily, basis. The maintenance of property records overlaps considerably with the assessment of property taxation. The assessor's land records contain data for tax lots on existing land use, physical descriptions of land and improvements, valuation (for land and improvements), ownership, right in property, tax status (including delinquent lands), and other data relevant to the assessment process. It provides monitoring for property tax assessment.

Environmental and legal aspects are indirect outcome of from physical, social and fiscal aspects within the system.

7.4.1.2 Functions

Basic function of user interface is database generation at local level and its regular updation. In this, information at the local level is used for day-to-day functions i.e. billing, connections, complaints etc. functions carried out in various organizations through single window service. It is to support utility mapping and management that are important components for integrated planning. Sharing common registration and area coding and scale hierarchy enables coordinating the utilities with each other and with socio-economic data for demand-and-supply analysis. In addition, the utilities network-based system also maintains a more specialized node-link object definition and representation for separate mapping and modeling purposes. The integrated system provides a significant basis for the plan implementation and coordination of development activities at ward level. User interface interactively allocate land uses to parcel of land and report back statistics on the type and amount of land converted, the population changes that would be associated with the land conversion, and its social, environmental, fiscal and legal impacts.

7.4.2 Administrator Interface

An integrated approach to system development cannot ignore the different organizations as component. The relationships and exchange of information between those responsible for infrastructure development and its maintenance is linked through administrator interface (figure 7.4). The administration of land is a multidisciplinary affair thus a number of organizations are involved.

To coordinate different activities, organizations interaction is proposed at different levels and for various purposes. Frequent and open communication, discussion, persistent negotiation, commitment and teamwork are possible through administrator interface. Better knowledge and information tend to bring about a better understanding for direction of urban development and hence create the possibility for better management.

A large number of agencies are involved in the collection and dissemination of geographic information mainly the agencies with responsibilities for land titles registration, surveying & mapping agencies and organizations concerned with socio-economic data provision. Variations between the various agencies in the city with respect to their range of responsibilities, their size, the extent to which they have created digital databases and the products are major challenges in the integration of various organizations. System proposes more decentralized structure with land titles registration and large-scale surveying and mapping responsibilities at ward level.

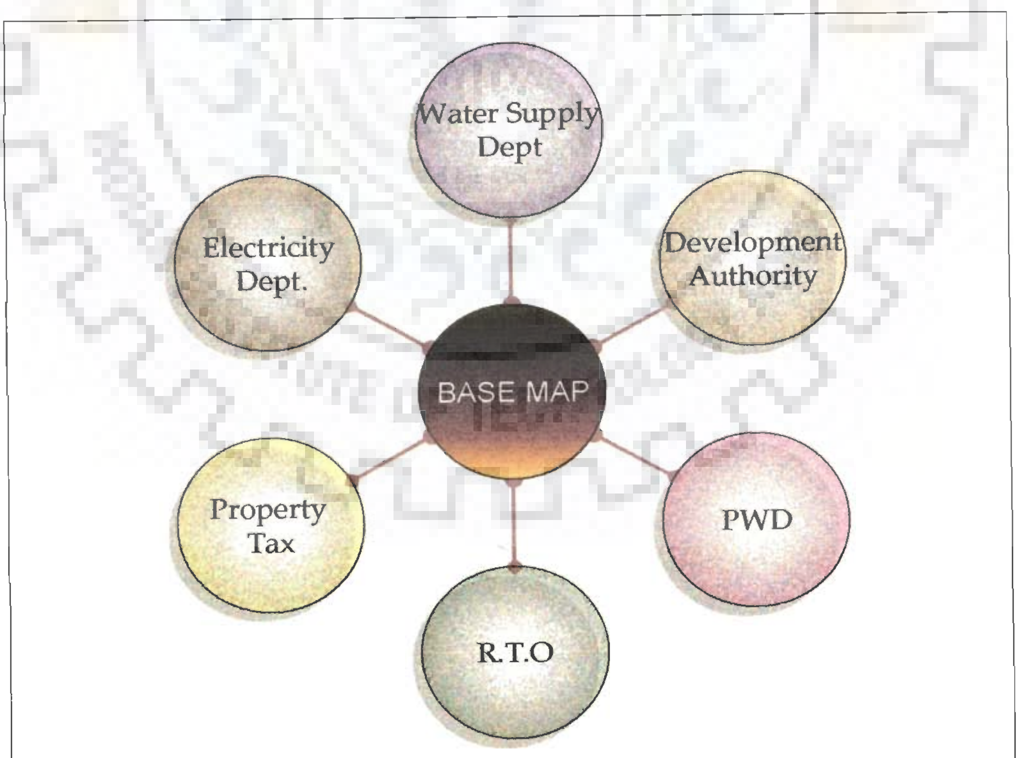


Figure 7.4: Conceptual design of administrator interface.

The development of administrative interface follows an adaptive approach, which is having more regard to the departmental organization of an authority. Adaptive approaches seek to effect improvements in such a way as to minimize alterations to the structure of the authority and political balance between departments. It avoids radical changes in procedures.

However, system design propose new ways in which different departments collect and maintain their data-especially preferred spatial units and approaches to data updating- and adjust data management and analysis methods accordingly.

7.4.2.1 Components

Various organizations at city level i.e. electricity department, water supply department, development authority, public works department, road and transportation office (RTO) development/ regulatory authority, property tax department etc would be the components of the administrator interface. The administrators' role in adopting and administrating the system within its actual institutional organization and professional agency participation is very relevant to the system's implementation. Since the functions of departments are different, so too are their data requirements, and hence to conclude that the separate departments require their own sub-systems. The sub-systems mainly consists spatial network of infrastructure related with each department on a common base map at ward level.

Database provided by user interface is proposed to aggregate at city level for decision-making related with development and management of basic infrastructure to various departments i.e. water supply, electricity, development authority, road and transport office etc. The system is made more specific by providing heuristic knowledge about the spatial location of object related with different utilities and services. The interest of all stakeholders, even corporate agencies and functional units of the same organization is ensured as well. Their application needs, system choice, and data development are major driving forces to make integration and sharing really happen.

Database may be classified into different functional categories depending on the organization involved within system, such as cadastral (parcel, records), environmental resources (land cover, water bodies, slope), structure (building, floors), space uses (socio-economic activities, residential units) and infrastructure (facility, utility). In terms of information type they are classified as maps (topography, land use), planning documents (zoning, setbacks) and census.

7.4.2.2 Functions

The functions of administrative interface identify as related to policy, management, operations, and so on. For example, retrieving and summarizing information on development permitting activities and the amount of land affected within a certain time period (e.g., monthly or weekly) is a routine application that can be handled with standardized database procedures, query interfaces and reports through administrator interface. The prime importance, however, is that it offers functionality which ease the communication between various organizations in substantial ways: proposals in the form of spatial scenarios become much clearer when they are drawn on a familiar background map on the smart board; implications of proposals can be evaluated immediately; rebuilding of proposal in the form of revised spatial scenarios can be designed during the interactive sessions; information can be captured, exchanged, combined and stored for later sessions; and by providing a meta information service, the instrument facilitates the accessibility of available data and information.

The administrative interface provides a basic, consistent set of digital spatial data and supporting services for the organizations-

- o To add detail and attach attribute information,
- o To register and compile other themes of data such as electricity network, water supply work etc.,
- o Orient and link the results of different elements.

The challenge in fitting parcel based data within system across several organizations has to do with the nature of the tasks involved, which include both structured and unstructured decisions, which are required for routine and specific applications. GIS based methods are important tools for assisting the different organizations in their works. It also helps to have good communication between various organizations. It creates a basis for communication between different organizations related with the development and maintenance of basic services and environmental disciplines. In this, different application domains are linked with the uniform base map. These methods virtually implement the integration structure, which is open for gradual participation for various other departments in the future.

Various public utilities are proposed to link in the system as different layers on the common base map. For example, many cities need to renew their underground sewers and storm water drains, but has no adequate records of their location. A land information system has a major role to play in support of such refurbishment, provided that the data are structured in a readily accessible form to a common base map. The public utility companies are a major driving force behind the development of land information systems.

7.4.3 Planners Interface

Urban planning involves processes of making and implementing decisions about land uses and space dependent social and economic policies, i.e. policies of housing, recreation, and services. Because of the comprehensive nature of their responsibility, planners tend to have wide-ranging interests in information and they depend upon many other sources to provide it. Urban planners are also interested in combining different types of information in order to analyze relationships. A variety of local departments and private sector groups use the same planning information. Establishing relations and interacting between spatial data users and producers is major approach in the development of information systems for urban planning practice.

To urban planners, the term 'land use' incorporates information on the function i.e. economic, social, administrative status, and ownership of a land parcel. Thus system has been supported by socio-economic and cadastral data within an integrated remote sensing/GIS framework. Urban planners and managers can derive information from user interface as well as remotely sensed data to assist planning process as well as their day-to-day activities.

The planners interface is designed around four criteria of planning process: exploration, analysis, allocation and evaluation. More precisely, planners interface forms a framework in which three sets of components are combined: the specific planning task and problems at hand, the system models that inform the planning process through analysis, prediction and prescription; and the transformation of basic data into

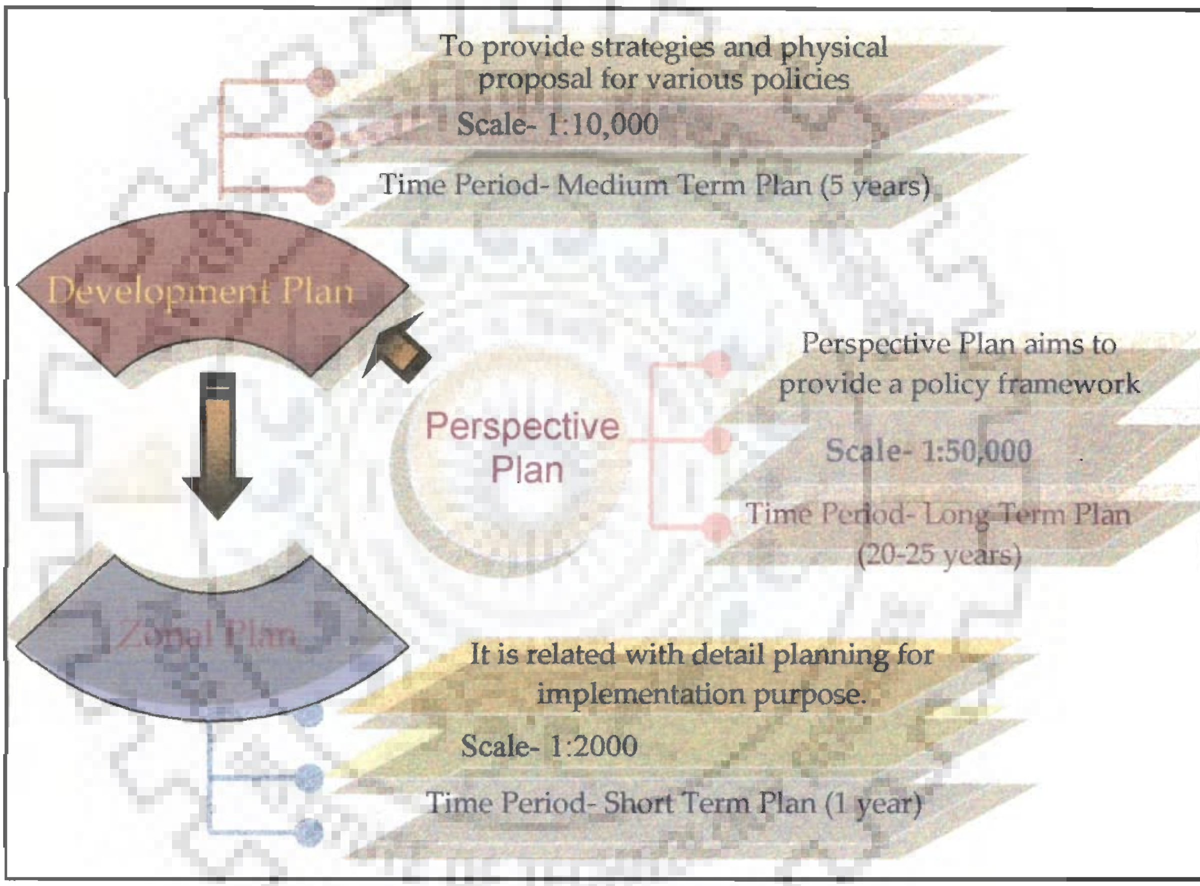


Figure 7.5: Conceptual design of planners interface

information which in turn provides the driving force for modeling and design. The system provides a framework of integrated modules, which brings together the various components – information, models and visualization – for urban planning, development and management.

7.4.3.1 Components

Planners interface consist of various cells responsible for the planning at different levels (figure 7.5). Development plan cell will be responsible for the preparation of development plans within the framework of perspective plans. Likewise, zonal plan cell will be responsible for the preparation of zonal plans and its implementation as well as monitoring. This defines the spatial structures of city, monitoring of plan implementation and plan revision in line with socio-economic development processes.

Application need implies clear definition of information required for urban planning tasks. This facilitates the use of proposed system and fills the gaps of existing system. The digitally integrated database of user interface is extended for planners and decision makers. An agency that understands professional tasks and type of information required is best placed to select the right system for integration and sharing.

7.4.3.2 Functions

Planners interface will be responsible for the preparation of various plans, standard formats and the encoding system for systematic combining of information in the professional planning process. For example, integrated land use planning considering social, economic and environmental characteristics of the trends as well as towards a holistic and comprehensive approach to strategic planning. Integrated planning has become a means for developing sustainable policies with the need for a healthy environment and support for a competitive economy while assisting urban and regional regeneration.

At city level, urban planning is carried out at two main levels: development planning and zonal planning. A development plan often encompasses a strategy for the city's spatial and infrastructure development and environment protection in the coming 5-10 years, a zonal plan of key projects in an immediate period of 2-5 years, and a set of regulations for planning controls. Based on the development plan, zonal plans specifying land-use layout, right-of-way, set back, architectural pattern, landscape and environment protection, are further prepared to guide the urban development and infrastructure planning/ provision. Successful planning requires that planners must have full assessment of urban conditions to work out alternative plans that optimize the use of land and resources, protection of the environment and preservation of heritage and landscape.

7.5 Organizational Restructuring

Many different government departments handle land-related data. The control and exchange of these data require interdepartmental co-operation and some degree of adjustment in departmental autonomy. This section discusses the restructuring of the organizations to increase the effectiveness of collaborative information system.

Two possible institutions for the role of overall coordinator are the revenue and the planning departments. Lands revenue department usually have a limited mandate and understanding of the fundamental nature of land. They concentrate on valuation and buying, selling, and leasing land for government. They are not, for example concerned with physical planning, which is usually the responsibility of another ministry. Work for integration has not received proper attention, especially in regard to the organizational setting through which information flows. The most general problem is complex nature of organizational setup. However, organizational structure cannot change completely but its working procedures can be modified according to the system. Information system is considered as one of the key supports that is provided to municipality, planning agencies and various organizations related with the infrastructure development and their maintenance. System provides an infrastructure of networking among various organizations within the city, which have significant influence on the outcome of the long-term policies. The process of organizational restructuring is critical to the diffusion of any technology innovation in daily activities of an organization. The implementation of technologies would seem to pose key question that how to integrate a new working practice into the existing traditions and norms of various organizations. The mutual dependence between the organization and the technical environment in which it is located is the key feature of the system.

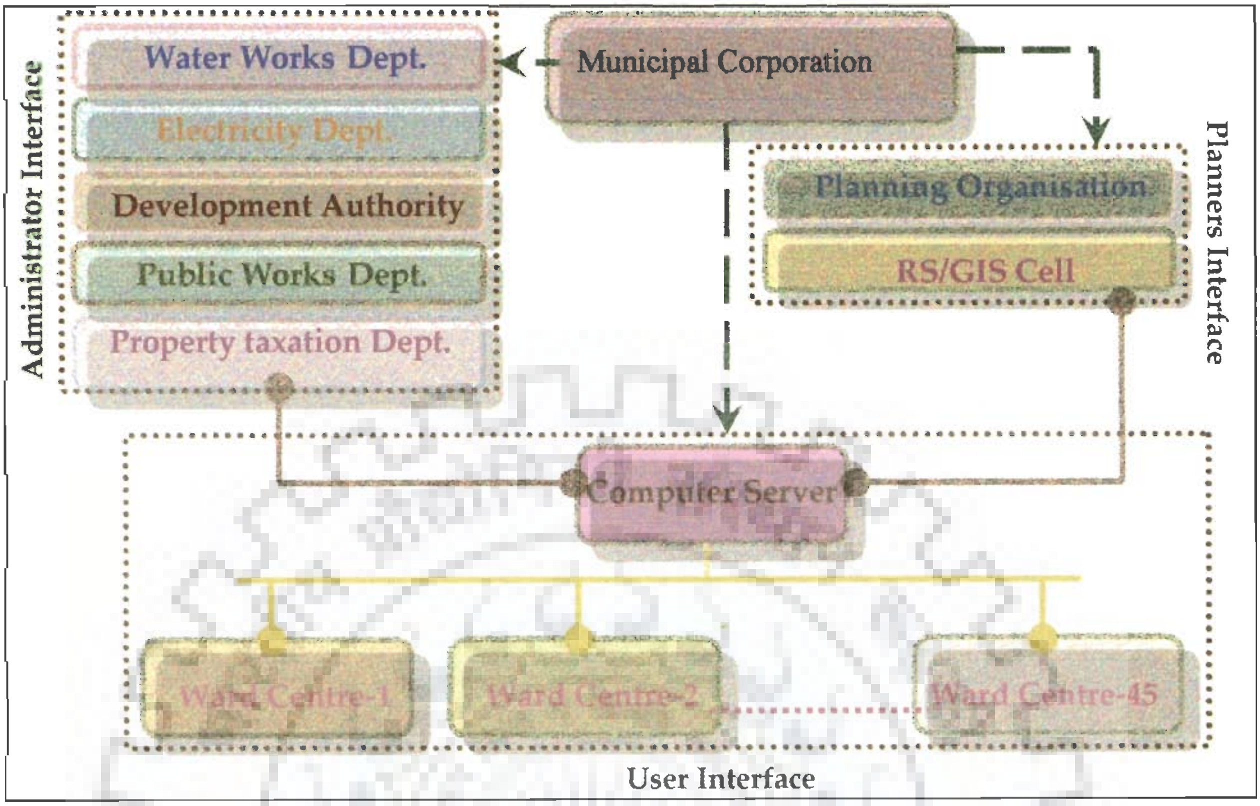


Figure 7.6: Organizational structure to support various interfaces

The relationship between technological innovations and organizations is likely to have a The need for good processing of information from various organizations gives a new organizational structure, which can be termed as virtual organization. As a 'virtual organization", made up from and responding to, the need of a number of other organizations in the city, clarity of inter-relationships and pre-set direction needed to be balanced form widespread participation in setting goals and visions. It involves integration and enhancement of several existing organizations including water works, electricity board, development authority, property taxation, and public works departments. Thus, system is implemented as a number of nodes and connecting links, in which each node represents an organization and the links represents the various relations held between the organizations (figure 7.6).

7.5.1 Organizational setup for user interface

The organizational setup for user interface is proposed at ward level. For this purpose, ward centers are proposed in each ward. Within the day-to-day operations of an information system, there are a number of specific tasks that are proposed to be carried out by ward centers. One of the key activity undertaken and implemented by ward centers is the distribution of bills and their collections, compilation of complains related to basic infrastructure and their monitoring as well as to facilitate various activities related to municipal corporation i.e. birth/ death registration, collection of different types of fees, for according approvals etc. The basic objectives of these ward centers are to provide single window service to the people and decentralization of administrative activity related to different organizations. In order to ensure effective implementation of plan as well as to explore additional resource base, it is important to have information on land use transformation at ward level. Thus, ward center are also responsible for data collection through primary survey, data entry and monitoring the land use as well as population changes.

Ward level surveys will treat parcel/sub parcel as the smallest spatial unit for data collection. The basic objective of ward level surveys is to come up with ward wise breakdown of functions, services as well as other indicators. Data gathering at ward level provides enormous flexibility of information and the opportunities it opens up for its repackaging in different ways to meet the demands of particular user groups. This survey provides information on a number of indicators at ward level including type of land use, public & semi public amenities and facilities like health and educational facilities, basic infrastructure facilities, demographic profile and spatial distribution of population as well as migration patterns among other things. A good example is the field of geo-demographics, which makes extensive use of a wide range of lifestyle classifications, derived from ward level census statistics. Therefore, it is useful to relate the system requirements closely to the mission and functions of each relevant organization. Specifically, the challenge lies in the likely mismatch between the urban planning, management and administrative functions, in which the planning takes place at regional level but management and administration are most often performed at the city level.

7.5.2 Organizational setup for administrator interface

Organizational change for the administrator interface are simpler as compared to user interface, which will lead to comprehensive assessment involving concurrent consideration of infrastructure, services as well as social and environmental impacts. A horizontally, integrated system –involves a variety of organizations, such as development authorities, public works department, water works department, electricity department, revenue departments etc. is proposed to be achieved through administrator interface.

Database developed through remote sensing in GIS environment is proposed to be distributed within a local area network. With a computerized land information system, there are likely to be many potential users working in different geographical locations with different infrastructure network at their disposal. In distributed network systems such different devices and processors are linked together electronically, thus allowing communication between various organizations and linking infrastructure network on the common base map through administrator interface.

The nature of these agencies /activities and their specific roles directly affect the types of data they generate and use, and the way in which they store and retrieve these data. The scope and nature of their activities vary greatly: (i) they comprise public sector specific interest, (ii) they perform different functions, with implications for specific data requirements, (iii) They operate within distinct time frames and degrees of regularity or continuity in their activities, all of which affect the data they collect and maintained. At this level, the derived database is integrated to perform the function related with infrastructure development and its management.

7.5.3 Organizational setup for planners interface

For planners interface, organizational setup comprises of planning organization and RS & GIS cell. Here, planning organization is responsible for the preparation of plans i.e. perspective plan, development plan and zonal plan while function of RS & GIS cell is the monitoring the plan implementation process through primary data available on proposed system as well as secondary data including remotely sensed imagery.

Monitoring of plan implementation process and its consequent effect will be helpful to planners in future planning as well as periodic revision of existing plans.

7.5.4 Organizational setup for Centralized Server Room

A number of organization are involved in the process of information collection at district level including National Informatics Center (NIC), District Statistical Office etc. A number of projects have been carried out by NIC related to information system at different levels and for different purposes. Thus, NIC is proposed as organization to look after centralized server room. It is composed of local servers, a clearinghouse server, user interface, administrator interface and planners interface servers. Each component has its own roles and functions to fulfill the requirement of different types of user's and to accomplish its objective. Server room is a centralized body, which stores high-level generalized metadata at central location. It maintains the relationship among various interfaces, such as GIS is typically managed by a separate office or department and coordinated by central server room. This provides one set of strategic components that can be used to develop diverse applications.

7.6 Database Organization

The issue then becomes how to create the linkage between the informal and the formal data set at city level. Database organization provides ways to overcome the data loss and distortion during the exchange of information between different agency systems. This section reviews current thinking about GIS database coordination within the organizational structures of local government and explores the opportunities for improving data sharing through system. The proposed data base organization is characterized as being-

- o multi-purpose, serving many different functions such as tax assessment, facilities management and planning, and
- o multi-participants, involving a number of different departments and staff.

In the process of supporting various interfaces, a fully functional comprehensive database organization is proposed. It is further subdivided into a number of key elements, which are arranged through world wide web (figure 7.7). The data base management within system employ hierarchical processing structures among various interfaces. In this process, the records are divided into logically related fields, which are connected to other fields in a tree like arrangements. In each group of records, one field is designated as the master. Groups of records are proposed to be arranged in a serial order and it would be retrieved by searching through the various levels according to a prearranged path.

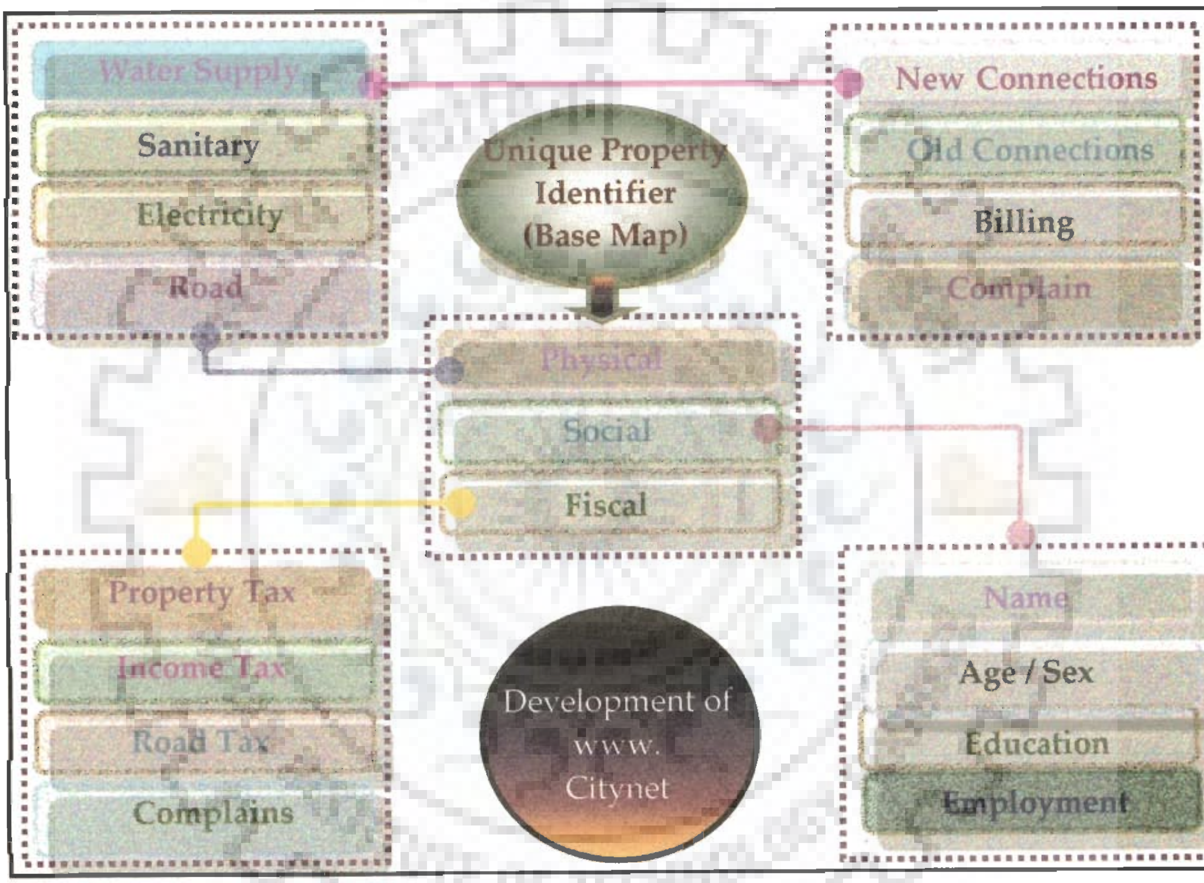


Figure 7.7: Database organization through intranet at city level

One framework for exploring the functioning of individual criteria and understanding city morphology requires unambiguous and precise measurement of the functional elements. Thus, proper coding is the pre-requisite for the integration of various datasets. Coding refers to a naming in the system to give the land related information object a unique identifier, which is an indispensable key for controlling topological semantics of information studying relationships. Coding of a specific application depends on parameter link to the system with common coding to derive the information about particular aspect. A combination of hierarchical and relational coding helps establish the information relationship within and between levels of abstraction. Despite varying application between agencies there are common objects, which are relatively static and thus practically stable for common coding, such as land administrative boundary, street block and street name. While, coding is the simplest element for any information integration, details may be optional for various logical platforms and more application-specific integration.

7.6.1 Development of Intranet at City level

To guide various agency participation from the start, however, a prerequisite condition is the adoption and management of integrated system through intranet. The key of the research has been the successful incorporation of GIS data and functionality into interactive web-based services and also its use in friendly interfaces to experimentation in decision problems with a high degree of spatial data content. "Web Services" is a broad term to describe systems that allows fundamental datasets to communicate between various organizations.

The web-based network is proposed to-

- Improve the ability to share and exchange data between organizations.
- Improve the updating and consequent timeliness of data.
- Reduce the initial cost of developing the map based and textural databases and the cost of updating that data through sharing the costs.
- Minimize duplication of efforts in maintaining land information.

At first the existing information are analyzed for selection of common elements relevant for selection of common levels: city, sector and ward. At each level, the administrative, land use and street block coding are designed for fusing statistical and land use at different hierarchical levels. The design supports multiple levels of database integrity from meta structure integration to logical data match and database building. This framework guides agencies to integrate land related information at different levels to support respective application and the subsequent data handling for sharing. A number of databases can be added to the system.

The integration issues, which have been addressed, are those relating to information exchange, data integrity and most importantly, land use nomenclature compatibility. Spatially distributed data in the form of various thematic maps and land use map have been incorporated into the system to be shared among various interfaces. This integration is further extended amongst various datasets derived form various interfaces. Thus, the database would be capable of resolving queries pertaining to change related with land use, population etc. The system consists of three interfaces that present alternative ways of presenting a map for different applications.

The research describes that single window services are non-existent in today's management practices and the web technology offers a medium of communication that can potentially address this problem. This system takes the next step by using the Intranet as a medium for to and fro communication among municipal authorities, community planners and development agencies to utilize the Web to offer information among various actors. Planners, managers and decision makers can derive valuable information so as to use it to improve the physical, social and environmental scenario of their communities. Web site (intranet at city level) presents a process for integrated planning, management and administration as well as tool to visualize various scenarios and understand their impacts. An interface, accessible via Intranet makes it possible to find datasets on different aspects easily. Through network, information pertaining to land ownership, infrastructure, demographic profile, taxation and planning, all are combined to linked together in a unified system.

Web development will provide integrated network at ward level, which would be more effective in terms of maintaining updating information on various urban issues, day-to-day functions, problems and a host of other indicators, which are of significance from planning and urban management perspectives on a continuous basis. This would help to increase the effectiveness towards good urban governance. This is fundamental to facilitating better understanding of planning and decision problems across a range of spatial scales from local to regional and national level.

New and developing web based mapping and search technologies allow general public with interactive access to textual and map-based information and tools for active participation in the planning process. The challenge is to use these tools in a manner that shares content in a clear and compelling manner to support community decision-making processes. A number of recent trends in dynamic web page generation add considerable capabilities to intranet at city level. Increasingly sophisticated tools allow for more dynamic, interactive, targeted and filtered information exchange and retrieval. Which facilitates in better planning, management and administration of cities.

7.6.2 Information flow

Information flow among various interfaces is an important parameter for system framework because the participant agencies are likely to operate from different standpoints and have unique interest and needs. Communication involving heterogeneous groups is a challenge that requires the creation of a common working language. Agreement on information sharing, its credibility and smooth flow among various interfaces as well as within the interface is the next step to facilitate inter-organizational communication and coordination. Improving the flow of data between and within organizations is made possible through intranet at city level.

The systematic development of information system is based on various data themes of sub systems. Another key to a successful information system is the ability to cross-reference between data files. It provides the facilities to several cross-referencing between data files through system. For this purpose each interface is divided into its component parts, the so-called entities related to physical, social, environmental, fiscal and legal aspects. The entities of one aspect are linked to each other, but also to entities of other aspect. The disaggregation of various aspect into component entities- though offering great benefits for associating information-can be integrated in different ways. The entities in the database are connected both horizontally and vertically. The vertical link means that a topic like 'physical' includes all documents related with infrastructure developments linked with user interface to serve day to day functions for public dealing as well as administrator interface for development and management of basic infrastructure.

Information flow refers to a way by which all the stakeholders exercise the integration and sharing (give and take) of data through common elements, as discussed above. Since different stakeholders often have different interest, the information sharing can be coordinated by centralized server room for extraction and consistency in the data-in and data-out flow between the various agencies. Sharing tools plays a key role in ensuring the participating role and capacity of involved agencies in the integrated framework. The information flow among different interfaces may be categorized into two main types: vertical and horizontal.

7.6.2.1 Horizontal Integration

Horizontal information handling is used to match or combine information of the same scale/abstract level to check the consistency in terms of attributes and study relationships. Strong coordination within each interface allows horizontal flow of information, which is prerequisite for the success of the system. Data sharing and coordination is formalized among multiple departments in partnership with each other. Its success depends on the organizational relationships and the degree of general coordination that is currently not exists between departments.

7.6.2.2 Vertical Integration

Vertical handling refers to ways to abstract information, which are often represented on relatively different scales, to more meaningful patterns or detail for decision-making. Top-down refining specifies the municipal potential and constraints to more detailed planning. Bottom-up aggregation/abstraction summarizes detailed operational information into major city development trends for reviewing the plan implementation. Vertical flow of information is necessary in the urban planning and management practices to monitor the plan implementation and its consequence effects at micro level. The system supports top down planning approach with bottom up feedback mechanism.

GIS does not change the information abstraction but becomes a useful tool for handling them between different hierarchies.

7.7 Database updation

In present urban information systems data comes form a variety of public and private sources, and quickly becomes outdated. In the case of urban planning, data is usually easy to acquire at any particular point in time but difficult to keep current at all times. To limit data redundancy and to facilitate updating, the system allows an integrated approach to define objects and their relations through a set of fundamental dataset. The maintenance of records is as important as their initial creation. Updating digital maps is relatively easy and inexpensive; printing and duplicating costs are incurred by the user; maps are potentially accessible to an exponentially large number of people; an online GIS map can be queried. This is due to the rapid development and widespread implementation of geographic information technologies, including geographic information systems, remote sensing, global positioning systems and the widespread utilization of the Web.

Once the initial land use data have been acquired, the entry can be updated whenever a change of use. Development of intranet at city level provides a regular updation of data sets. Apart from the regular updation of the database through day-to-day activities in various interfaces, periodic updation of database is suggested at local and city level.

Regular updation is an important aspect for the success of an information system. Organization of appropriate updating arrangements is required at all stages of system developments and it can also influence the scope of the subsystem. The value of a data file rapidly decreases if the file is allowed to go out of date. The maximum benefit of information system will be updating procedure in routine. If arrangements for updating appear to be difficult, the scope of planning based on system will be more limited.

7.7.1 Primary surveys

Primary surveys are suggested at ward level for the monitoring the changes related to land use as well as population once in year despite the regular updation through routine

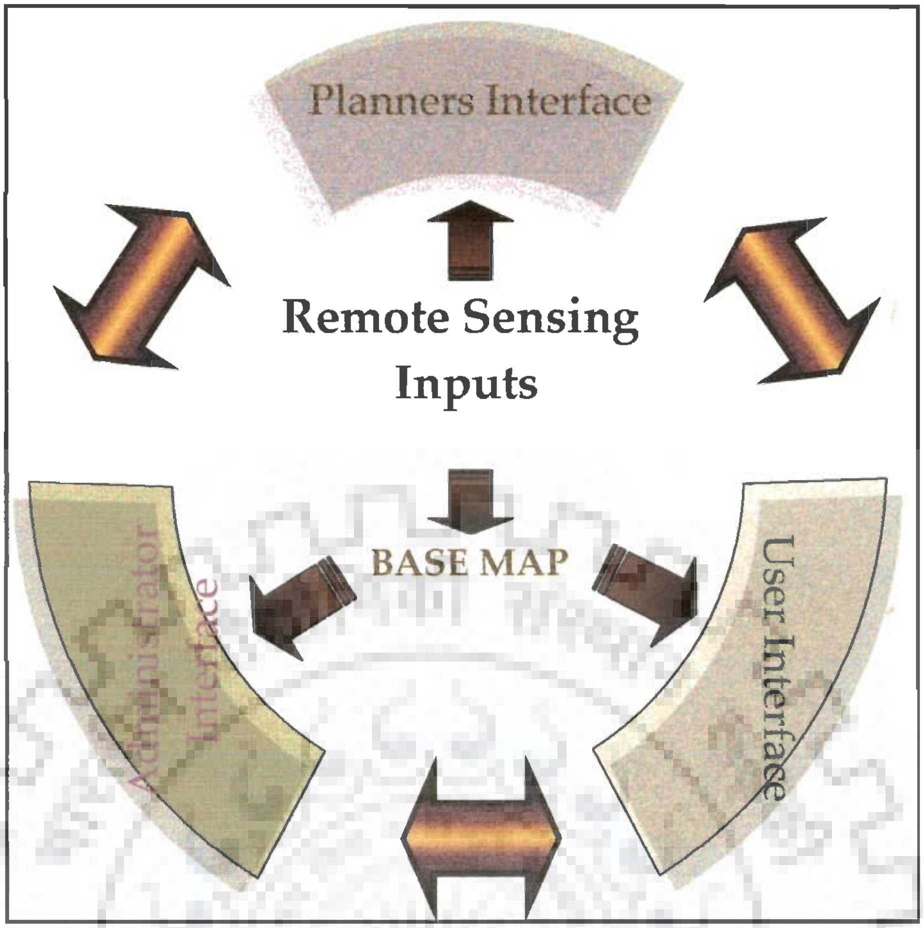


Figure 7.8: Inputs from remote sensing in proposed system.

process. It will be helpful for the regular updation of base map related to various aspects. Monitoring through remotely sensed imagery also need to be supported through primary surveys.

7.7.2 Remote Sensing

If the records are not maintained, they rapidly become out of date. The usefulness of the system is tied closely to the time at which the data is acquired. Remotely sensed imagery is proposed to be used for the regular updation of information at different levels for the maintenance of information system (figure 7.8).

Thus an independent monitoring tool such as remote sensing is proposed to use for the monitoring and regular updation of database at various levels. In system, remote sensing approach is used to land monitoring through acquiring a periodic time series of digital image data at appropriate intervals and of sufficiently high resolution to discern development or developmental progress, including outlines of individual building structures. Images are viewed as a backdrop to parcel coverage for routine, systematic checking against the associated parcel transactional database. Recent advances in high-resolution digital imaging from commercial satellites offer potential for delivering such imagery according to programmed scheduled and at reasonable cost. However, information about physical nature is used to link with socio-economic development, which is essential to a monitoring process.

CHAPTER VIII

OPERATIONALISATION OF SYSTEM

8.1 An Overview

Spatial database developed in the chapter 5 forms the input for the development of the intranet required for the operationalisation of system. Accessibility of these data to various organizations helps to carry out the analysis (as discussed in chapter 6) for the planning and sustainable management. Various issues related to the operationalisation of conceptual model of the system proposed in section 7.4 have been discussed in this chapter. The first parts of the chapter assess information structure of the system to support planning, management and operational activities. The operation of the system will enable analyzing and displaying spatial data at different scale from policy level to operational level. The data in proposed system provides information on all details relating to a given parcel, details on individual theme aspect as well as combine datasets related to various aspects. It provides a framework under which planners, managers and administrators can share and collaborate data for analysis. The second part of the chapter discuss the issues related with the implementation of the system i.e. infrastructure required for the proposed system, implementation cost and phasing of development. The proposed system would be able to provide the information for problem solving at the time when decisions are being made.

8.2 System Assessment

The system defines restructuring the organization as the legal basis for urban development and management in line with socio-economic development processes. Successful planning requires an up to date database of urban conditions to work out alternative plans that optimize the use of natural and man-made resources, protection of the environment and preservation of heritage and landscape. The complexity of planning tasks has grown extensively due to several reasons including various stake holders and their diverging interests; the increasing pace of development that shortens the time available for plan preparation and design; the need for better information on which to monitor progress and database scenarios; and the difficulties associated with enhancing participation, collaboration and partnership. As a result, request for support to fulfill a range of planning tasks in an appropriate way have grown rapidly and encouraging the development of new instruments that take advantage of the rapid advancement that have taken place in computer and information technology.

The system development has expanded the user base for parcel information, made it easier to collect, maintain and visualize spatial relationships involving with the changing land uses of developable areas. In turn, a large number of persons of different interest i.e. planners, managers, developers and administrators can access for parcel based land data. This boost the efficiency of data analysis as well as the increased volume and resolution of land data suggests new ways of monitoring the development.

8.2.1 Information Structure for Planning

The proposed system, with its potential advantages for application needs, institutional adoption and cost effective implementation, fulfills the demand to improve information structure for plan implementation and monitoring process. System applications include the design of the integrated organizational framework, the demonstrative applications in the integrated planning for different land uses, facilities, utilities and social development.

With the introduction of spatial planning at various levels from regional to zonal including village in the context of regional planning and ward in zonal planning, base maps at different scale are the necessity of the day. As the rational spatial planning and its effective implementation ensures sustainable development, brings efficiency and effects economy, the proposed system would be helpful for the same.

Planning activities are potentially interested in a full range of land information and, hence, often functions as a focal point for utilization of spatial database. However, the proposed system have potential to support all aspects as mentioned above in urban planning, which is often describe as a complicated process that involves consideration of a whole range of factors.

Planning and land management relies on many data sources to meet increasingly complex and broad ranging requirements. Planning activity utilizes both in-house data (e.g. land use, zoning, planned land use) and data produced by other agencies and departments (e.g. assessors' data, utilities infrastructure). Thus, planning process is termed as assimilation, processing and creating new data set in the form of solutions-including data on proposed land uses, long term plans for infrastructure, major policies affecting development and allocation of regional demand forecasts. These solution data sets are ultimately supplied through the system for enabling implementation of the spatial plan prepared with the help of basic data sets and its analysis. The proposed system will helps planners not only in the information gathering related to different stages of planning process but also in the revision of the plans at various levels.

The combination of digital map and database information allows for great flexibility in assessing alternative scenarios. The data are collected for the smallest basic unit and then it can be aggregated to any required zone size for different purposes. Planner takes into account both the socio- economic characteristics of population as well as the constraints of physiography and land suitability in performing their tasks.

The system will play an important role in the mid term revisions of plans depending upon the plan implementation process and its consequent effects from time to time. The proposed system will provide continuity in planning process through assisting the later stages of planning process including plan implementation and monitoring. Regulations may, for example, govern the maximum and minimum sizes of land parcels and the width of road reserves and plot frontages. At a simple level, through the system, it would be possible that town-planning boundaries coincide with land parcel boundaries. This has not happening in the present because plans showing property boundaries have not been readily available.

An integrated system is essential to public services as well as planning because it enhances the ability to estimate future service needs in growing areas (including urban expansion and infill or redevelopment). Information provided by the user interface will be helpful in the monitoring of planning process. Based on the projections of the population and economic activities, town planners major pre-occupation each to determine the levels of demand for housing and other facilities in a town. It will allow accurate calculations of the costs and benefits of extending services and new infrastructure developments.

Physical planning at a local level has direct impacts on the urban environment. Local authorities have a responsibility for creating a sustainable environment at micro level. However, system will provide simple and uniform tools that analyses and visualize the various aspects of physical plans at local level. It intended to support the work of local authorities throughout the spatial planning process, especially with regard to identifying options in the early phases of the planning process. The quality of information generated with GIS technology at ward level will allow sophisticated analysis and modeling exercises to support zonal planning process. Local bodies need to begin to embrace these new technologies and view them as a key component of the future vitality of the city. System increases the opportunity for utilizing data generated by the various departments for zonal planning, which is collected and maintained at the parcel level. It would be helpful in attempting to manage both common and area specific needs at the same time.

8.2.2 Information Structure for Management

Development management deals with the concerns of plan implementation and generates land data primarily within the realms of site or project-specific record keeping. The proposed information system gives support to land management by providing information about the land, the resources upon it and the improvements made to it. It includes the acquisition and assembly of data; their processing, storage and maintenance; their retrieval, analysis, and dissemination.

To urban managers, the term 'parcel' incorporates information on the function i.e. economic, social, administrative status, and ownership of a land parcel. The system has been supported by socio-economic and cadastral data within an integrated remote sensing/GIS framework. A closer integration of remotely sensed and GIS data leads to spatial analysis and various applications of urban monitoring may benefit from these closer links. System generates large amounts of data relevant to development management, such as records of public actions concomitant to applications for and approvals of private development, and requirements of specific regulations affecting land and its development. It is the primary function involved in plan implementation. Development management can benefit from the system to provide feedback on the effectiveness of plan implementation, including detailed information on the location, mix, and density of new development within land use areas and zoning districts. In addition, various organizations benefits from timely information on the short time developments and its consequences at micro level.

8.2.3 Information Structure for Operational

At operational level, major task involved with the infrastructure development and its maintenance. Effective management of the urban infrastructure and related problems demand good tools for diagnostic. Information derived from user interface at ward level will provide accurate and reliable information, which will be useful to quantify the current situation and to predict future trends: information on patterns of land use is one obvious example, while basic data on infrastructure (including its spatial distribution) is another. The two are interlinked with the population, since population growth creates pressure on the land in terms of increased demand for new settlements, supporting infrastructure (e.g. the supply of water, electricity and the provision of transportation and waste disposal facilities) and employment.

The provision of basic infrastructure services is an ongoing activity with significant impacts on land use. The maintenance and expansion of major basic infrastructure (water, sewer, electricity and transportation) directly services land for existing and future development. Social infrastructure, such as education, recreation and public safety have traditionally been considered to have a less direct, yet important and long-term, impact on the location and intensity of urbanization. Public organizations generate data to establish levels of service for planned infrastructure.

Data collection by the systems concentrates on various activities including land use, employment, different types of economic activities, housing conditions and costs, indicators of housing needs etc. The impact of these activities on demand- supply analysis of infrastructure is becoming important as land use restrictions and housing types shape the network of basic infrastructure. Integration of different information sources would therefore provide potential benefits of information certainty as well as effective methods and tools for development of basic infrastructure as well as its maintenance.

8.3 System Control

The control of system can be visualized from two distinct perspectives- data security and physical control. Physical control resides in mainframe of the multi-organizational interconnected network. Each organization in such a network needs a separate control. Separate control within each interface is necessary for systems for effective working of the system. Conceptually the control of various interface and server room is shown in figure 8.1.

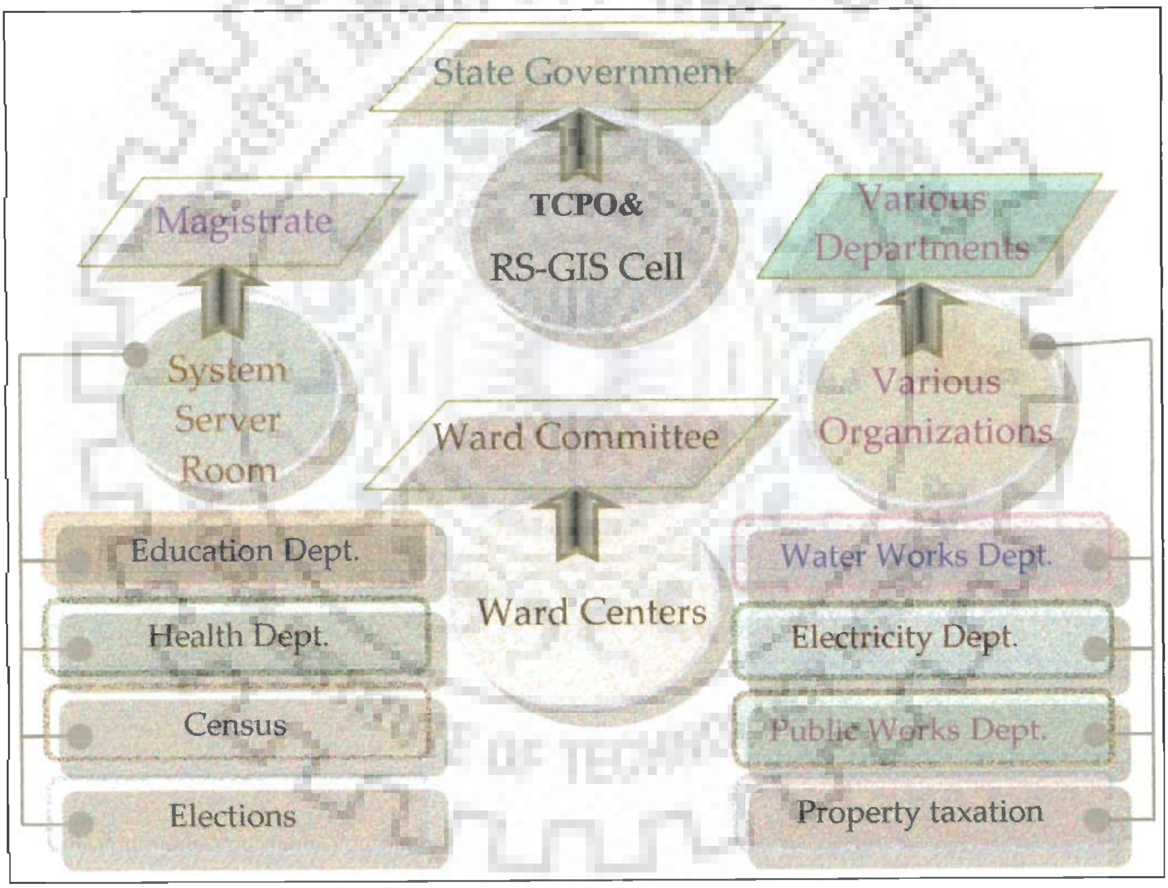


Figure 8.1: Control of various organizations involved in the information system

A separate control of system is developed to decentralized the maintenance process and ensure effective working. Control of ward centers designed for user interface is proposed under ward committees. Ward committee will be responsible for the development and regular updation of database at ward level as well as maintenance of computer and other hardware. Administrator interface is comprises a number of organization related with the development activities. Control of each organization is proposed within itself, as in the existing system. While, control of planners interface is proposed under state government.

Apart from all these, control of server room is proposed under the district magistrate or sub district magistrate. A number of other organizations responsible for the information gathering and social welfare i.e. District Statistical Office, Election Commission, Health Department, Education Department and other organizations are potential stakeholders and use data available in system for various welfare schemes through district magistrate.

8.4 Infrastructure for System

System proposed in this research refers to the integration of datasets, policies, institutional arrangements and the technical issues necessary to facilitate the dissemination of current and well-defined spatial data throughout the different levels of planning and decision making. All these can be considered as components of system. A system is similar to any other infrastructure providing public good with positive externalities.

8.4.1 Network at city level

Finally the system is shaped by the technological environment, which enabling data to be discovered, exchanged, integrated visualized and actually applied to the decision process. The advent of cost effective, powerful information and communication technology facilitates more effective handling of large quantities of spatial data. The structuring of system is viewed as a network of the node and links. Thus, the role and capacity of the network at city level is of utmost importance.

A data communication network provides the physical infrastructure for sharing information in a system. Communication of data involves transfer of information between as well as within various interfaces. City level network is proposed to link computers within various organizations. It is used to connect PCs at different geographical locations. An integrated network at ward level is proposed for the proper functioning of ward centers connected with various organizations through server room. Networking is a very important aspect for system implementation.

Croswell (2000) suggested that in a complex computer networks supporting many servers and workstations, there is an important need to manage the network. This includes such functions as –

- Monitoring and reporting on system,
- Directing and monitoring network traffic,
- Problem diagnosis and corrections, and
- Establishing access security and such high-level management tasks as automatic map updation, data back-up, software distribution and software license management.

Apart from these, network describe the format of transmission to accomplish the following tasks-

- Transfer of data from one organization to one or more destination organization on a network,
- Control routing of message between multiple networks within system.

8.4.2 Hardware

Technical issues of system are related with the hardware and software requirements for the system. The issues related with the hardware include computers and printers have far reaching effects upon the structure and relationships within organizations. The hardware requirements for the proposed ward centers include 2 PC-IV with one printer at each ward center. Dehradun has 45 wards, thus total hardware requirements for ward centers is 90 computers and 45 printers. The requirement of computers for administrator and planners interface will vary according to the individual organization.

8.4.3 Software

Since, the future of the information systems will be closely related to high technology, clear strategies for coping with the impact of such developments need to be worked out. Strategies related to technology are very important to describe the system and its implementation. All Web services strategies use a well-known and widely implemented Internet protocol for communication-HTTP- the foundation upon which all Web sites operate.

8.4.4 Man power training

Development of human resources is important aspect for system implementation. The growing complexity of data collection, handling and analysis have required extensive commitments in skilled staffing, equipment and software purchase and development. This includes training and development of both internal staff involved at various level including organizations participating in the process of planning and management. This helps improve the quality of services provided at different stages of the system. It provides tremendous potential for continuous improvement. Through paying attention to operations process control in terms of both the training of participants and reaching agreement on the standard of service to be provided, will help improve the quality of the process and outcomes.

8.5 Implementation Cost

The most immediate benefits that arise from the creation or improvement of land information system come from the fiscal scenario. For the implementation of the system within city, it is necessary to give an overlook at the resources generated by Dehradun Municipal Corporation.

8.5.1 Revenue of municipalities

A number of sources are available to Municipal Corporation for the generation of revenue at city level including special grants from state and central governments.

Earning Heads-

- Various Taxes including property tax, commercial tax, pet tax, banners tax, cinema show tax, lease tax, tanker tax etc.
- Grants including group insurance scheme, disaster management, Adarsh Vitt Anudan, development grant, revolving funds, beautyfication grant, IDSMT, house tax interest etc.

- License fees including parking fees, town hall fee, medical institutions, non-veg market fee, slaughter house fee, Theli fee, agency license fee, hotel fee, Atta Chakki fee, loud speaker fee, contract registration fee, tender fee, panelty, road cutting, Kagi house, dead body vehicle, publication fee, stamp duty fee etc.

Expenditure Heads-

It includes salary/ pension, employee beneficiary scheme, transportation, maintenance, community developments, court cases, loans, advertisement, billing (electricity, telephone etc.), announcements, emergency expenditures, computer/ photo state, city development (traffic signal, street lighting etc.).

Thus, some additional ways are needed to incur the cost of infrastructure development for system as well as for the running.

8.5.2 Infrastructure development

The implementation of system is associated with a number of economic issues that must be addressed while designing the system. A conceptual model is introduced for the funding of system at micro level. The main function of funding model is to act as a guideline to coordinating agencies on how to formalize, structure, present and source financing for the implementation and maintenance of system.

Funding for system within the city is possible through (figure 8.2)-

- Direct government funding: Role of government is very important for the establishment and development of system within a city. Basic investment can be taken from direct government funding. Government can use special taxation for the financing of system at initial stage.

- Capital market financing instruments: An investment through infrastructure bond is another way to invite investment for the development of system.

- o Special projects funding: It can be used for the development as well as time-to-time up gradation of the system.

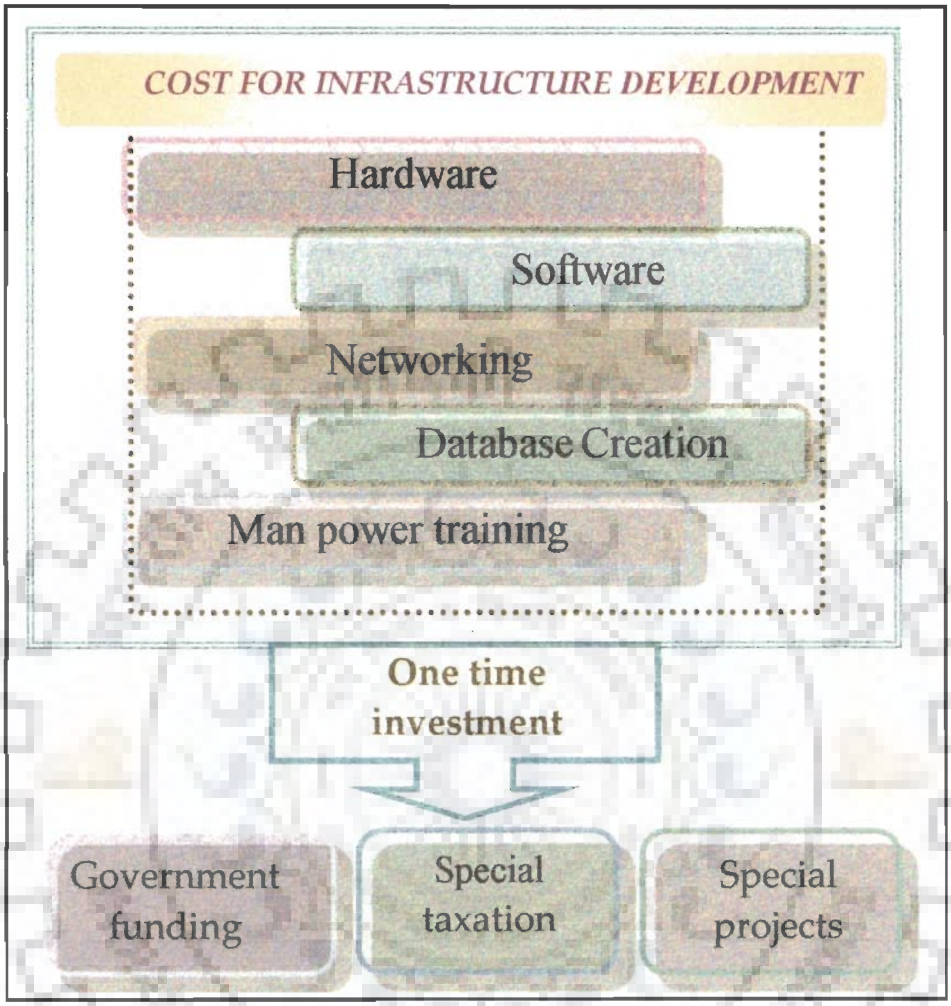


Figure 8.2: Cost related with the infrastructure development for the system and possible funding

8.5.3 Running cost

If all organizations called parcels by the same name and used the same terminology and meaning, the cost of regional planning and administrative operations would be greatly reduced. The development cost can be recovered through (figure 8.3) –

- o Funding through organizational partnership: A number of different organizations, who share and avail the information, funds for the implementation and maintenance of system. However, other partnerships amongst different levels of the public sector and national agencies are also possible.

- Public/ Private sponsorships: Financing through public/ private sponsors can be used to run the system effectively and efficiently.
- Sale of spatial data: Sale of spatial data on demand for the public uses with the concept of no profit no loss.

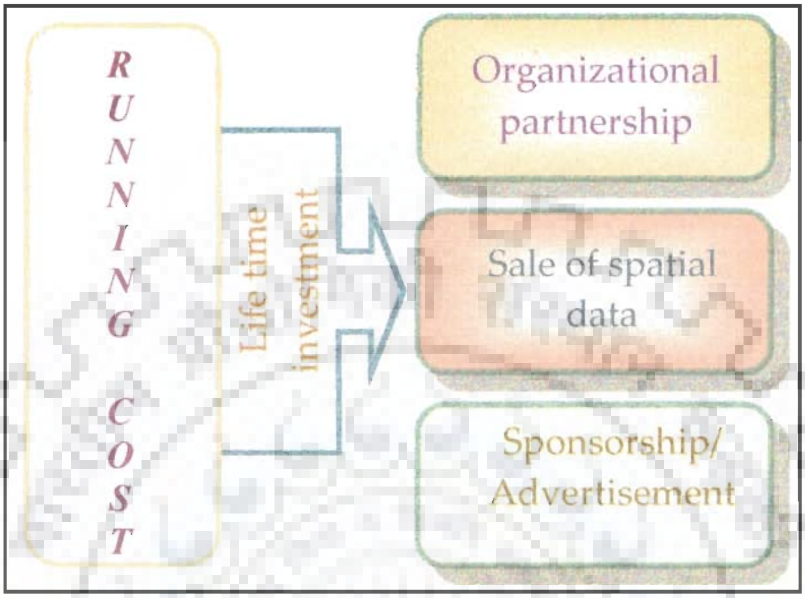


Figure 8.3: Suggested means to incur the running cost of the system

8.6 Phases of development

The system is proposed to be developed in the three phases-

Phase I: In this phase, it is suggested to prepare basic infrastructure, such as base map and protocols which are necessary for common use. This is because only the city government can bear the relatively large initial investment and long-term benefits of map making. It includes the introduction of a large-scale cadastral mapping series through development of large-scale base map in digital environment. As well as development of infrastructure at ward level. In addition, it is the right place to assign experts to prepare a set of operation rules between agencies.

Phase II: It is proposed to define and allocate the city agencies to the right functioning layers. This involves the creation of a series of infrastructure network and land records integrated with large-scale base map i.e. water distribution network, sewerage line, electricity and telephone network etc. Simultaneously, development of physical infrastructure in different organizations linked with the server room. Even in a dynamic urban change process (with incorporation and split of wards, or spatial units) the system's role in keeping such defined layers functioning is essential to maintain stability of the land related information for planning and monitoring.

Phase III: This phase propose the operationalisation of the system. It includes the development of intranet at city level and planners interface. The system role is adequate for identifying and solving conflicts in data integration within involved agencies. In addition, the recognition of fund constraints provides significant indication that in future the government may be forced to relinquish its role as central data provider and concentrates on management, which requires less investment.

The system provides a co-coordinated approach for the exchange and use of the data, in which each organization will maintain responsibility for its own data and development activities.

It is undeniable that an information system plays a decisive role for desirable urban planning and development, particularly under a decentralized process. Its role in the data integration and sharing is also equally important because it is not only the main provider of geo-spatial data for most applications but also it experts profound influence on availability and price of spatial data.

CHAPTER IX

CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The main conclusion from this research is that large-scale parcel based map, for a range of urban application can be achieved within a short span of time using current generation of high-resolution satellite data and GIS. Remotely sensed imagery when integrated with GIS has the capabilities to improve the information structure to handle the problem arising due to rapid urbanization and population growth. High-resolution satellite data is an important source of information for urban analysis at micro level. In fact, these products have demonstrated tremendous potential to be incorporated within an integrated system for planning and sustainable management.

9.1.1 High Resolution Satellite Data and GIS

Investigations show that the use of remote sensing achieves greatest success when data are combined with other secondary data related to various aspects. This research demonstrates that different types of urban objects in high-resolution satellite data are increasingly capable of capturing the physical as well as socio-economic structure of cities. Database prepared using the remote sensing and GIS are used to analyses the existing scenario related to various aspects of urban areas. Major findings of the research include-

- High resolution satellite data allows us to create detailed inventories of urban land use such as residential, commercial, public open spaces, industrial etc. either in isolation or in conjunction with various ancillary data sources. Verification through field visit confirms high accuracy of this technology. Quantitative determination of land use transformation in different wards allows us to understand the changing pattern and functions within urban fabric. Record on mixed land use are helpful in quantifying the stress on existing infrastructure i.e. transportation, parking etc.

- This study demonstrates that the high degree of socio-economic heterogeneity within small areas affects the conventional urban analysis. Social restructuring and densification of urban areas can be traced with the help of remote sensing. It helps in the quantifying the demand and supply of basic services.

- Fiscal aspects of urban development are studied in this research, which reveals the proportion of property tax contribution by residential unit of different income groups. Property tax calculated in different wards show that average dwelling unit of high income group contribute about 55%, middle income group about 32% and low income group about 12% of property tax in comparison to the an average squatter dwelling unit.

- The results show that proportion of hard surface, soft surface and green cover almost remain same in different wards of varied densities. Ratio of area under soft surfaces is about ½ and green cover is about ¼ of the hard surfaces. An accurate characterization of the surfaces allows reliable relationship and increased understanding about land cover composition at micro level, which provides scientific support and visualization for the sustainable development of the city.

- The result related the legal aspects show that temporary structures with plastic roof cover reveals near-blackish tone and can be identified easily on the fused image. This makes it possible for the extraction and monitoring of temporary structures extended across the city at marginal and eco-fragile areas.

9.1.2 Information structure

Large scale base map prepared from high-resolution satellite data integrated with various parameters in GIS environment shows the potential for the preparation of the zonal plans for the implementation of the master plan and monitoring its consequences. Analysis carried out in the first objective quantifies the general understanding about the existing scenario. Though, suitable provisions have been made in the Dehradun Master Plan for 1980-2001 and proposed for 2005-2025. Due to poor implementation, existing scenario is deteriorating in many parts of the city. Thus, contribution of the research support the information structure for the implementation and monitoring of the master plan comprises of following parameters-

(i) Large scale land use maps [section 9.1.1, (i)] are required at all three stages of planning process, which includes planning, its implementation and monitoring.

Thus, it is core dataset determining the use of each land parcel as well as deviation from the master plan over the period of time.

(ii) Social structure [section 9.1.1, (ii)] depicts the impact of physical development on the social grouping and demographic profile of population. It directly affects the economic base of the city and thus, needed as the core dataset for regular monitoring.

(iii) Fiscal scenario [section 9.1.1, (iii)] shows that unplanned developments destroy the economic base of the city. Regular monitoring of it is required to review the tax regime. Thus, it is also grouped as a core dataset.

(iv) Environmental scenario [section 9.1.1, (iv)] is helpful to maintain the quality of life at micro level. Thus, it is a supplement dataset required for the decision making and policy formulation in planning process.

(v) Development of informal settlements along the natural drainage is an alarming problem and its monitoring is a major challenge in front of local authority. Legal scenario [section 9.1.1, (v)] shows the potential of high-resolution satellite data for the monitoring of the informal settlements. Thus, it is proposed as supplement dataset for the implementation of plans.

Urban planners and managers need the fine spatial data/details and this research clearly demonstrates that the high-resolution satellite data enables creation of such data/details. Visual segmentation of the image into homogeneous land use parcels is possible through this system to meet many of the information demands. The integration of information related to various aspects within the system at ward level strengthens the management of local governments. Decentralization of the plan implementation and monitoring process also supplement top down planning approach with bottom up feedback mechanism.

The contribution of the research also support the information structure for the quantification of relationship among physical, social, fiscal, environmental and legal parameters etc. This quantification carries forward a rich understanding of urban structure as well as the relations between form and function incorporating ancillary data sources. This research demonstrates that integration of physical, social, fiscal, environmental and legal dimensions led to creation of spatial forms of urban areas. Although the use of ancillary data sources potentially extends the scope to cataloging small area activity patterns. Clear conceptions of phenomena logically precede the careful planning for the sustainable development of urban areas.

9.1.3 System development

The system evolved in this research integrates the fundamental datasets forming information structure through different interfaces.

(i) User interface is proposed at ward level integrating the core datasets related to physical [section 9.1.1, (i)], social [section 9.1.1, (ii)] and fiscal [section 9.1.1, (iii)] aspects. For this purpose, ward centers are proposed in each ward. It will help to decentralize the process of plan implementation and monitoring it consequences at ward level.

(ii) Administrator interface proposed in the system integrates the various organizations related with the infrastructure development for the sustainable management. Integration of various organizations through the common base map will lead to strengthen the management.

(iii) Planners interface is proposed for the preparation of plans at different levels. Dataset integrated with the user interface as well as administrator interface forms the input for the planners' interface. Supplement dataset i.e. environmental [section 9.1.1, (iv)] and legal [section 9.1.1, (v)] are also the inputs for the planners interface.

Formulation of ward centers for user interface will decentralize administration process and helps in sustainable management. The 74th constitutional amendment (1993) has recommended to empower urban local bodies for the better management of public affairs in the city. But, even after 10 years of the amendment, it is not fully translated to the ground. The system proposed in this research is a significant contribution towards the translation of the 74th CAA at the grass root level through catering the needs of enlarged functional domain of urban local bodies. The conceptual model of the system evolved in this research will help to strengthen the planning process through decentralized implementation and monitoring at ward level. It will also be helpful to trace the consequences of planning process through continual feed back of information on change and on the result of planning policies.

The system developed in this research will assist the implementation of National Urban Information System (NUIS) programme at grass root level. This new system with horizontally oriented urban network is induced within a traditional hierarchically oriented vertical system of cities. Computerized information system will allow flexibility in data base organization and permit multiple accesses by different departments for different purposes. It also facilitates spatial as well as statistical analyses. The organization of the system would be able to accommodate uniform base for data sharing.

System adopts different data as an inter-disciplinary meeting place, where data support our understanding of the spatial distributions of urban phenomena. It also includes information related to the operations of the utilities. The role of structural information available through system as a strategic resource in the analysis of urban scenarios is examined from two different perspectives- demand and supply. Thus, it will improve the efficiency of various departments of urban local bodies. The core of the integrated information system will be continuously updated database for urban land use planning and management.

Integrated information system and development of intranet at city level will help in successful implementation of plans and promote sustainable management. It will help to promote a common description of the most basic data sets used in most of the organizations. It provides the ability to locate and ingest another party's data with little or no human intervention in the conversion process.

9.2 Recommendations

- One of the main recommendations is to prepare large-scale base map at 1:2000 or larger using high-resolution satellite data for the preparation of zonal plans and its implementations. It will fulfill the need to develop digital spatial database for the integration of attribute data related to different aspects including physical, social, environmental, fiscal and legal. High-resolution satellite data is recommended for monitoring the growth and updation of base map from zonal level (scale 1:2000) to city level (1:10,000) from time to time. The quality of information generated with remote sensing and GIS technology at ward level will allow sophisticated analysis and modeling exercises to support planning process. Urban local bodies need to begin to embrace these new technologies and view them as a key component of the future vitality of the city.

- Keeping in view the cost involved in data acquisition, an integrated information structure is recommended for the planning, implementation and monitoring. It would be able to regularly update the information, which is required at different stages of planning process.

- The system developed in this research is recommended to deploy in all cities in India to manage their geographic information assets in the national interest. It will help to integrate various activities i.e. planning, implementation, monitoring, management and administration, grouped under the umbrella of urban regime.

9.3 Directions for future research

- Urban regime is a new emerging domain in the light of technological advancement. Thus, there is a wide scope of research for urban regime including the collaboration between various government and non-government sources.

- The basic parameters, which have been covered in present research comprehensively, may further be studied in greater details as every parameter by itself offers a challenging field for research.

- Relationships established between different parameters in this research are indicator of existing scenario, which can vary from city to city. Thus, there is a need to develop such indicator for different cities of varying characteristics.

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Appendix I - Content of NUIS At 3 Levels

Master Plan(1:10k)		Zonal Plan(1:2.5K)		Utility Mapping (1:1k)	
Spatial	**Attribute**	**Spatial**	**Attribute**	**Spatial**	**Attribute**
FORM RS IMAGES/TOPOMAPS: 01. Drainage 02. Soils 03. Slopes 04. Topography/ Relief 05. Hydro-Geomorphology 06. Geology 07. Natural Vegetation (forest) 08. Ground Water Targets 09. Landuse/cover 10. Roads 11. Rails 12. Canals **Incorporated Maps to be obtained from city administration/ TCPO:** 14. location of all heritage, sites, building and areas 15. Location of Slums Squatters and other blighted area. 16. City Planning Zone/Ward map	1. Thematic Attributes compatible to NNRMS/ NRIS Standards and generated by mapping activity 2. Developmental attributes (on ward basis) obtained from city administration/ TCPO: • Population demographics – population, growth rate, Density, Age sex ratio, literacy, worker force, Occupational structure, Birth and death rate, Mortality, Migration and socio-economic characteristics, Life expectancy • Climate data of past – rainfall, temperature • Population data: Air, Water, Noise: Source type • Types of Industrial Units (Pesticides, Glass etc.) • No. and capacity of WTP, % of Sewerage converge, no. of STP • Slums, Squatters: Numbers, Population, Household area, access to services etc.	**FROM AERIAL PHOTOS:** Detailed Base Map with following details: • Residential • Group Housing • Plotted Housing • Unplanned/informal • Other • **Commercial** • Retail & General Business • C.B.D./Sub C.B.D. • Community Centre. • Local Shopping Centre • Local Commercial Street • Wholesale and Warehousing & Depot • Hotel/Restaurant • **Industrial** • Service Industry • Light Industry • Extensive Industry • Heavy Industry • Hazardous Industry • Industrial Godowns • **Public & Semi Public** • Hospital • Dispensary • Educational Research • Library • Museum • Planetarium • Aquarium	1. Thematic Attributes compatible to NNRMS/NIRS Standards and Generated By mapping activity 2. Development attributes (on ward basis) obtained form city administration/TCPO will be as **given for 1:10k** 3. In addition the following is also to be incorporated from city/TCPO records: • Development Control Regulation Property/ cadastral records • Authorization/ Approval records/ documents • Land requirement, • Available infrastructure, • Land owner ship, • Compensation, • Land requirement for the scheme, • Past land pooling schemes • Name of owner • More than one owner	1. Utilities networks- Water, Sewerage, Power, Telecommunication network mapped through GPR/City records 2. Layers incorporated from 1:2.5K, as required.	Attributes as applicable- but containing all details of each of the utility (This has to be worked out as attribute table in consultation with city administration and TCPO). These agreed-to attribute datasets for the utilities has to be provided by city administration/TCPO.

Source: National Natural Resources Management System (2004b)

Master Plan(1:10k)		Zonal Plan(1:2.5K)		Utility Mapping (1:1k)	
Spatial	**Attribute**	**Spatial**	**Attribute**	**Spatial**	**Attribute**
16. Location of pollution generating industries/activities **Dervied Maps from NUIS Application (GIS Models to be worked out):** 17. Land use change maps. 18.Urban Suitability Maps 19. Environmental Sensitivity maps 20. Hazards Zonation 21. Polluting Area maps 22. Tourism Dev. Map 23. Road Plan 24. Rail Plan 25. Industrial plan 26. Trends of population and land use changes 27. Trends of Industrialization etc. 28. Integration to support Master Plan preparation 29. Monitoring of development activities	• **Crime:** Theft, Robbery Murder, Crime against woman reported annually. • **Income:** Per capita income, Per capita expenditure, Annual HH income by income range, at City level • **Poverty alleviation,** Population below Poverty Line, Households below Poverty line, Women/Men headed HH below poverty line • **Municipal:** Ward wise revenue and expenditure • **Informal sector:** Employed pop. trade, Commerce, Transport. • **Household:** Industries, No. of HH, No. of women headed HH, growth rate, dwelling units, rent of dwelling unit. • **Housing:** Structure type, Building Age, type of material of roof, wall and floor, type source of drinking water, tenure status, • **Land Price** - CBD, Urban fringe, etc., legally approved undeveloped • Cyclones, Floods - frequency, Past Records, Preventive Methods • **Water:** sources, demand	• Social and Cultural Centre • Religious Place • Grave Yards/Cremation ground • Government Offices • Post Offices • Telegraph and Telephone Exchange • Petrol Pump • Police Stations • Fire Station • Rest House • Theater/Cinema Hall • Television Station • Jell • **Banks** • **Public Utilities** • Water Treatment Plant • Sanitary Landfill • Electric Power Plants • Sewerage Treatment Plant • Drain • **Agricultural Land** • Cultivated Area • Vegetated Area • Fellow Area • Green Belt • Nursery • Fellow Land • Market Garden • Poultry and Dairy Farming • **Forest** • Reserved Forest • Plantation • City Forest • Open Forest • Degraded Forest	• Tenure • Revenue Survey number • Original Plot number • Area of Original plot (Sq. Mt.) • Value of Original Plot without reference to value of Structure (in Rs.) • Value of Original Plot inclusive of structure (in Mt.) • Value of Final Plot undeveloped without reference to value of structure (in Rupees) • Value of Final Plot undeveloped inclusive of Structure (in Rupees) • Value of Final Plot developed without reference to (in Rupees) value of structure • Value of Final Plot developed inclusive of structure (in Rupees) • Value of Final Plot undeveloped inclusive of structure (in Rs.) less Value of Original Plot inclusive of structure • Increment Value of Final Plot developed		

Master Plan(1:10k)		Zonal Plan(1:2.5K)		Utility Mapping (1:1k)	
Spatial	**Attribute**	**Spatial**	**Attribute**	**Spatial**	**Attribute**
	and supply, treatment capacity, no. of connections, area covered, major reservoirs, duration of supply, Access to portable water, Connections, Avg. Consumption. Per Capita Demand, Supply (LPCD) Losses (MLD), Price of water per 100 liter during the year. • **Electricity:** No. and type of power station, of power station, connections, supply and demand, Consumption, Line Losses, Electric Charges • **Road:** No. of bus depots, Terminals, Parking, Road density, intensity No. and type of vehicles, Accident vulnerability spots. • **Railway:** Railway zones, Types of rail gauge Length and Type of rail route network, No. of platforms, yards • **Sea:** area of navigable waterways, Major ports used for export and import of good, • **Air: Airports, Aerodromes, Traffic volume and passenger data**	• Orchard • National Parks, Sanctuary • **Recreational** • Regional Park • District Park • Sport Ground • Playground • Stadium • Historical Monuments • Amusement/Water Parks • Golf Course/Race Course • Divisional Sports Center • Neighborhood Play Area • Children Park • **Transportation** • Airports • Airstrip • Railway Terminal • Railway Yard • Rail Circulation • Bus Depot • Truck Terminal • Road Circulation] • Bridges • Parking Area • Port • Harbor • **Waste land** • Barren Land • Shrub • Hillock • Salt Pan • Reclamation Area • Water Bodies • River/Stream • Canal/channel • Lakes/Pond	excluding value of structure less Value of Final Plot undeveloped excluding value of structure • Contribution 50% of Increment • Addition to or Deduction from contribution to be made under other section. • Net Demand • Development costs, • Details of acquisition property, • Compensation paid to person for acquisition, • Land acquisition acts • Zoning regulations, • Details of developed/ undeveloped land • Land acquired by negotiated settlement, • Land acquisitions norms, • Compensation • Transfer development right, • Compensation • Available amenities to be transferred to Development Authority, • Compensation • Land deposal details done by the authority, • Disposal cost,		

Master Plan(1:10k)		Zonal Plan(1:2.5K)		Utility Mapping (1:1k)	
Spatial	**Attribute**	**Spatial**	**Attribute**	**Spatial**	**Attribute**
	• **Telecommunication:** ward wise No. connection, exchange, Access, Public Telephone, Efficiency, Mobile Connection, STD/ISD Booth. • **Sanitation & Solid Waste Management:** ward wise Access to Sewerage, connections, Area covered, location and capacity of STPs, Access to low Cost Sanitation Facility, Public Toilet, Waste Water treated (per capita per annum) Solid Waste generated, Solid Waste Collection rate (Tonnes per day) Disposal Method (i) Open Dump (ii) sanitary land fill (iii) Incinerated (iv) Recycle, No. of HH enjoying regular solid waste collection service, Regular Collection (quantity), Land fill sites etc. • **Sewerage** network, connections, area covered, location and capacity of STPs Drainage: Length (K.M.)/Service area, Open and covered Drain(Km.) • **Education:** No. of Primary, Secondary	• Well • Reservoirs • Marshy Land • Cantonment Area • Brick Kiln • Bench Mark • Contour • **Others** MAPS FROM CITY ADMINISTRATION/TCPO 30. City Planning Zone/Ward map 31. Urban Property cadastres 32. Land Value data **Derived Maps from NUIS Application (GIS Models to be worked out):** 33. Landuse change maps 34. Urban Suitability Maps 35. Environmental Sensitivity maps 36. Hazards zonation 37. Polluting Area maps 38. Tourism Dev. Map 39. Infrastructure development 40. Trends of population and landuse changes 41. Trends of Industrialization etc. 42. Integration to support Development Zonal Plan preparation 43. Monitoring of development activities	• Disposal rules, • Time required for disposal • Development charges, • Development cost • List of agencies on whom development charges are levied for use of land, • Increase in value of land etc. • Development plan/perspective plan, • Land use regulations		

Master Plan(1:10k)		Zonal Plan(1:2.5K)		Utility Mapping (1:1k)	
Spatial	Attribute	Spatial	Attribute	Spatial	Attribute
	schools, Colleges, teacher, students, classroom and male - female student. • **Health:** No. of Hospitals, Dispensaries, Beds Type of Diseases, No. of Patients: Respiratory, Water Borne, Contagious, No. of Doctors, Nurses. • Fire stations, • Police Stations, • Post offices and banks, • Community Centres, • Socio-cultural and religious Centres.				

Appendix II - Data Contents For Major Urban Planning Function

Sl. No.	PLANNING FUNCTIONS/ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
I	PREPARATION OF DEVELOPMENT PLAN OF LOCAL PLANNING AREA		
	• **Physical Characteristics And Natural Resoiurces**	Maps of • Drainage, • Soils, • Slopes, • Topography / Relief, • Hydro-geomorphology, • Geology, • Natural Vegetation (forest)	• Natural Drainage (Stream Order, river Systems), • Soil Types, • Slopes, • Topography / Relief, • Hydro geomorphology, • Geology, • Climate, • Natural Vegetation (forest), • Minerals, • Water resources, • Water Potential and Demand.
	• **Location and Regional Setting**	• Map showing the location of the town in regional setting	• Value of longitude and latitude (XY minimum and XY Maximum of study area), • Transportation linkage to other settlements
	• **History of Development**	• Settlement Morphology	• Historical facts and events in the growth of the settlement.
	• **Climate**	• Rainfall • Wind direction, • Temperature, • Humidity	• Wind Direction • Average /maximum/ minimum temperature, • Humidity, • Rainfall duration and its quantity

Source: National Natural Resources Management System (2004b)

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA

	• **Existing / Proposed Land use**	Types of land use classes
		• **Residential**
		  ○ Primary Residential Zone
		  ○ Mixed Residential Zone
		  ○ Unplanned/Informal Residential Zone
		• **Commercial**
		  ○ Retail Shopping Zone
		  ○ General Business and Commercial District/Centers
		  ○ Wholesales, Godowns, Warehousing/Regulated Markets
		• **Manufacturing**
		  ○ Service and Light Industry
		  ○ Extensive and Heavy Industry
		  ○ Special Industrial Zone Hazardous, Noxious and Chemical
		• **Public and Semi-public**
		  ○ Govt./Semi Govt./Public Offices
		  ○ Govt. Land (use undetermined)
		  ○ Educational and Research
		  ○ Medical and Health
		  ○ Social Cultural and Religious
		  ○ Utilities and Services
		  ○ Cremation and Burial Ground
		• **Recreational**
		  ○ Playgrounds/Stadium/Sports Complex
		  ○ Parks and Gardens-Public Open Spaces
		  ○ Special Recreational Zone - Restricted Open Spaces
		  ○ Multi-Open Space (Maiden)
			• Different types of land uses
			• Area under specific land use class
			• Deviations from the proposed land use Actions taken for implementation and regulation.

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA

		• **Transportation and Communication**
		  ○ Roads
		  ○ Railways
		  ○ Airport
		  ○ Seaports and Dockyards
		  ○ Bus Depot/Truck Terminals and Freight Complexes
		  ○ Transmission and Communication
		• **Agriculture and Water Bodies**
		  ○ Agriculture
		  ○ Forest
		  ○ Poultry and Dairy Farming.
		  ○ Rural Settlement
		  ○ Brick Kiln and Extractive Areas
		  ○ Water Bodies
		• **Special Area**
		  ○ Old Built-up (Core) Area
		  ○ Heritage and Conservation Areas
		  ○ Scenic Value Areas
		  ○ Village Settlement
		  ○ Other Uses
			• Different types of land uses
			• Area under specific land use class
			• Deviations from the proposed land use Actions taken for implementation and regulation.

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	• **6. Environment And Ecologically Sensitive Areas** *(i) Physical Environment*	• Thematic Map Depicting Air, Water and Noise Pollution, Location of Pollution generating Industries/activities.	• **Unit of Measurement** • **Air Pollution:** • Types of Industrial Units (pesticides, glass etc.) • Pollutants: Lead, Methane, Carbon Monoxide etc.) Types of Vehicles. • **Water Pollution:** No. of WTP, % of Sewerage Coverage, no. of STP • **Noise Pollution:** Decibel Limit of Noise generated by Different Types of Vehicles, Industries etc. • **Land Degradation.**
	(ii) Man Made Environment	• Map depicting the location of Slums, Squatters and other blighted area.	• No. of Slums, Squatters, area access to services etc.
	• **Conservation of Environment**	• Thematic Map depicting hazards zones polluting activities.	• Levels of pollution, • Measures for mitigation of pollution.
	• **Heritages Site, Buildings and Areas**	• Map showing the location of all heritage, sites, building and areas	• Background information of heritage sites and building and areas from the record of ASI and NGOs, listed building.
	• **Tourism**	• Tourism Dev. map	• No. of tourist spots, • No. of tourists, • Truism infrastructure,
	• **Flood Control**	• Map Showing the drainage of the city	• Past Flood Records • Type of Preventive Methods

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	• **Demography**	• Map showing the distribution of existing and proposed population, migration trends	• Existing populatin. • Natural increase • Birth and deth rate, • Mortality, • Migration and socio-economic characteristics, • Age sex ratio, • Literacy, • Life expectancy
	• Economic and Social Development *i) Formal Sector*	• City Ward/District map	• Per capita income, • Occupational structure, • Taxation, • Industrial Product, • Commercial activities, • Institutional activities, • Development control regulations
	ii) Informal Sector		• Informal sector, • Poverty alleviation, • Informal trade, • Commerce, • Transport, • Household industries.

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	• **Housing and Shelter**	• Distribution of Residential Land Use • Base map containing building / Property boundaries • Building material map • Building Age map • Land Value map	• No. Of households, • No. Of dwelling units, • Age, • Distribution of houses by predominant material of roof, wall and floor, • Distribution of households by type of (a) fuel used for cooking (b) by source of drinking water, • Availability of electricity and toilet facility, • Distribution of households by tenure status, size and no. Of rooms occupied, • Housing structure, • Housing stock, • Demand and supply
	• **Transportation** *i. Road*	• Road Network Map (existing and proposed roads with hierarchy)	• Types of roads, • Length of roads, • No. Of bus depots, • Terminals, • Parking space, • No. and types of vehicles, • Survey reports on traffic and transportation planning
	ii. Informal Sector	• Rail Network Map (existing and proposed)	• No of railway zones, • Types of rail gauge, viz broad, narrow and meter gauge, • Length of rail route network, • Type of network, • No. of platforms, • No. of yards.

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	iii. water	• Land use maps/layouts of Jetties and Ports	• No. of Major and minor ports, • Length of the coastline and area of navigable waterways, • No. of navigable rivers and canals, • Major ports used for export and import of goods, • Total no. of sailing boats, • Ships, • Oil Tankers, • Vessels • Total tonnage of items carried by ships/tankers etc., • No. of shipping yards
	iv. Air	• Maps with location of Airports, Aerodromes • Air funnel maps	• No of Airports, • Aerodromes, • Traffic volume and passenger data.
	• **Infrastructure** i. Physical Infrastructure	Map showing • Water Supply network • Power supply line network, • Telecommunication network, • Sewerage and solid waste management	• **Water:** sources, demand and supply, treatment capacity, no. of connections, area covered, major reservoirs, duration of supply. • **Electricity:** No. of power station, type of power station, no. of connections, supply and demand. • **Telecommunication:** No. of telephone connection, telephone exchange. • **Sewerage** network, No. of connections, area covered, location and capacity of STPs • **Solid Waste Management:** methods of disposal, quantity, land fill sites etc.

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	ii. Social Infrastructure	Map showing the location of • Health Centers, • Educational institutes, • Fire station, • Post offices, • Police stations, • Banks, • Community centres, • Socio-cultural and religious centres	• No. of educational institute (primary, Middle, secondary colleges, technical institute). • Health centres (dispensary hospital, others), • Fire stations, • Police stations, • Post offices and banks, • Community centres, • Socio-cultural and religious centres.
	• **Review, revision and preparation of fresh development plan of the local planning area.**	• Updated base map, • Existing land use map • Proposed plan of various sectors	• Data from the development Plan
II	**SPECIAL AREA PLANNING AND DEVELOPMENT AUTHORITY AND PLANS FOR SPECIAL AREA DEVELOPMENT**		
II	• **Declaration of Special Area.**	• Revenue/Urban Cadastre map, • Detailed land use map	• Development Control Regulation
	• **Incorporation of special area planning and development authority.**		
III	**CONTROL OF DEVELOPMENT AND USE OF LAND**		
	• **Use and development of land to be in conformity with the development plan or development scheme or land-pooling scheme.**	• Land use map, • Zonal development plan • Layout/site map	• Development Control Regulation • Property / Cadastral records • Authorization / Approval records / documents
	• **Prohibition of development.**		

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	• Permission for development.		
	• Obligation to acquire and on refusal of or on grant of permission certain cases.		
	• Removal or discontinuance of unauthorized temporary development summarily.		
	• Interim Provision pending preparation of plan.		
	• Planning and development authority to include special area planning and development authority.		
IV	INTIATE DEVELOPMENT SCHEMES		
	• Preparation of development schemes.	• Land use map, • Zonal development plan • layout/site map	• Land requirement, • Available infrastructure, • Development control regulation
V	LAND POOLING SCHEMES	•	• Land owner ship, • Compensation, • Land requirement for the scheme, • Development control regulation, • Past land pooling schemes
	• Contents of land pooling scheme		
	• Reconstitution of original plots into final plots.		
	• Declaration of intention to prepare land-pooling scheme.		
	• Preparation of land pooling scheme.		

Sl. No.	PLANNING FUNCTIONS / ACTIVITIES	SPATIAL DATA	ATTRIBUTE DATA
	• Consideration of objections and submission of final land pooling scheme to government for approval. • Effect of scheme. • Restrictions on use and development of land after declaration of intention to prepare a land-pooling scheme. • Cost of land pooling scheme. • Contribution towards cost of land pooling scheme. • Compensation in respect of property or right injuriously affected by land pooling scheme. • Exclusion or limitation of compensation in certain cases. • Provision for cases in which the owner is not provided with a plot in the final land-pooling scheme. • Payment of net amount due to planning and development authority. • Recovery of arrears. • Execution of works in the land-pooling scheme by planning and development authority.	• Land use map. • Zonal land use map. • Layout/site map. • Revenue map.	• Name of owner • More than one owner • Tenure • Revenue Survey number • Original Plot number • Area of Original Plot (Sq. Mt.) • Value of Original Plot without reference to value of structure (in Rs.) • Value of Original Plot inclusive of structure (in Rupees) • Final Plot number • Area of Final Plot (Sq. Mt.) • Value of Final Plot undeveloped without reference to value of structure (in Rupees) • Value of Final Plot undeveloped inclusive of structure (in Rupees) • Value of Final Plot developed without reference to (in Rupees) value of structure • Value of Final Plot developed inclusive of structure(in Rupees) • Value of Final Plot undeveloped inclusive of structure (in Rs.) less Value of Original Plot inclusive of structure • Increment Value of Final Plot developed excluding value of structure less value of Final Plot undeveloped excluding value of structure • Contribution 50% of increment • Addition to or Deduction from contribution to be made under other section. • Net Demand

Appendix III - Dehradun Municipal Wards

Ward No.	Ward Name	Population	Area in hectare	Population Density
1	Rajpur	7341	475.17	15.45
2	Sheshherdhara Road	7514	470.29	15.98
3	Arya Nagar	7870	180.46	43.61
4	D L Road	7107	27.95	239.28
5	Rispana	7020	23.19	302.72
6	Mansinghwala	7685	104.48	73.55
7	Karanpur	7902	80.91	97.66
8	Adhoiwala	7239	261.04	27.73
9	Dalanwala (N)	7423	119.47	62.13
10	Dalanwala (S)	8030	145.01	55.38
11	Rajiv Nagar	7030	270.08	26.03
12	Dharampur	7932	51.98	152.60
13	Ajabpur	8252	481.50	17.14
14	Bhandaribagh	7630	651.99	11.70
15	Majra	7900	383.32	20.61
16	Niranjanpur	7347	347.37	21.15
17	Kanwali	8068	202.41	39.86
18	Basant Vihar	7881	263.88	29.87
19	Maharanibagh	6864	236.97	28.97
20	Ballupur	7302	78.00	93.62
21	Kaulagarh	7764	194.31	39.96
22	Rajender Nagar	7299	181.70	40.17
23	Devsuman Nagar	6935	41.46	167.27
24	Idgah	7777	77.19	100.75
25	Shivaji Ward	7375	27.22	270.94
26	Gandhi Gram	7073	30.50	231.90
27	Laxman Chowk	7208	40.48	178.06
28	Patel Nagar	7393	112.09	65.96
29	Lakkhi Bagh	7384	40.34	183.04
30	Ritha Mandi	6884	31.49	218.61
31	Jhanda Mohalla	6907	20.97	329.38
32	Inderesh Nagar	6883	19.77	348.15
33	Khudbura	8091	22.83	354.40
34	Dandipura	7745	15.98	484.67

(Source: Dehradun Municipal Corporation, 2001)

Ward No.	Ward Name	Population	Area in hectare	Population Density
35	Lunya Mohalla	7241	23.92	302.72
36	Dhamawala	7654	25.48	300.39
37	Chandera Nagar	8241	79.29	103.93
38	Racecourse (S)	8354	89.71	93.12
39	Racecourse (N)	8249	86.98	94.84
40	Mahadevi K P	8150	119.02	68.48
41	Chukkhuwala	7713	35.79	215.51
42	Bakralwala	8030	73.35	109.48
43	Indra Colony	7613	36.50	208.58
44	Vijay Colony	8097	154.05	52.56
45	Salawala	7742	149.07	51.94

Appendix IV - Elementary key used for visual interpretation

Sr. No	Land Use/ Object	Tone	Size	Shape	Shadow	Texture	Pattern	Location/ Association
1	Carriage Way	Darker grey	Small	Linear		Moderately medium to fine	Regular to irregular	Easily identifiable with its linear fan shape curves. Presence of road bed on both sides. Presence of plots linearly on one / both sides.
2	Right of Way	Less dark grey	Small	Linear	-	Moderately medium to fine	Regular to irregular	Easily identifiable with its linear fan shape curves. Presence of tar road in between. Presence of plots linearly on one / both sides.
3	Stream/ Nalla	Dark tone	Small	Zigzag linear	-	Fine to medium	Zigzag	Identified by its dark color, zigzag shape
4	Plots	Dark to light reddish tone	Small to large	Regular	-	Fine to medium	Continuous	Easily identifiable with Continuous pattern. Regular shapes, Reddish tone of grass, trees. Discontinuity at cross roads
5	Buildings	Dark to light bluish/ greenish tone	Small	Regular	-	Fine to medium	Continuous	Easily identifiable with Continuous pattern. Regular shapes, Bluish/ Greenish tone of old/ new/ coloration of building. Discontinuity at plot boundary
6	Floors of Buildings	-	-	-	Shadow lengths of different heights of buildings	-	-	Carefully identifiable with shadow pattern of building. In comparision with a single story building nearby other buildings can be interpreted having more floors Tone/ color/ shape shifting with presence of shadow.

Appendix V - List of Publications

Jain, Sadhana and R. K. Jain (2003). An Integrated Information System for Urban and Regional Planning: Some Suggestions. *Spatio-Economic Development Record (SDR)*, vol. 10, no. 2, pp. 16-21.

Jain, Sadhana and R. K. Jain (2003). Quantification of Open Spaces vs. Impervious Surface Area in Residential Land Use. *GEOMATICS 2003: International Conference of The Indian Society of Geomatics*, November 6-8, 2003, New Delhi.

Jain, Sadhana and R. K. Jain (2004). Impact of Informal Settlement on The Environment: A Case of Dehradun. National Seminar on *Remote Sensing and Its Applications in Environmental Management*, March 25-27, 2004, Banglore.

Jain, Sadhana and R. K. Jain (2004). Population Density and Urban Ecosystem, Case Study of Dehradun Using integrated Census and Remotely Sensed Data. *Spatio-Economic Development Record (SDR)*, vol. 11, no. 2, pp. 27-32.

Jain, Sadhana, B. S.Sokhi and Ujjwal Sur (2005). Slum Identification using High Resolution Satellite Data. *GIM International,* vol. 19, no. 9, pp. 60-63.

Jain, Sadhana and R. K. Jain (2005). Evaluation of High Resolution Satellite Data (IKONOS) for Urban Database Development. *Journal of Institute of Town Planners, India (ITPI)*, vol. 2, no. 3, pp. 42-46.

Jain, Sadhana and R. K. Jain. A Remote Sensing Approach to Establish Relationship among Different Land Covers at Micro Level. *International Journal of Remote Sensing* (in press).