EFFECTIVENESS OF EIA FOR HOUSING PROJECTS IN LUCKNOW, UTTAR PRADESH

THESIS

SUBMITTED TO

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
(A CENTRAL UNIVERSITY)

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ENVIRONMENTAL SCIENCE

BY

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CERTIFICATE

This is to certify that the work incorporated in the thesis entitled **"Effectiveness of EIA for Housing Projects in Lucknow, Uttar Pradesh"** is being submitted for award of the degree of Doctor of Philosophy in Environmental Science, of Babasaheb Bhimrao Ambedkar (Central) University, Lucknow. The present research work was entirely carried out by **Mr. Vivek Kumar Tiwari** under our supervision and guidance. He fulfils the terms and conditions as laid down in the Ph.D. ordinance of this University. To the best of my knowledge, no part of this thesis has been submitted for the award of any degree either in this university or in any other University.

I wish him success in his career pursuit.

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DECLARATION

I, **Vivek Kumar Tiwari**, hereby declare that the thesis entitled **"Effectiveness of EIA for Housing Projects in Lucknow, Uttar Pradesh"** is my own work conducted under the joint supervision of **Dr. Venkatesh Dutta** (Supervisor), Assistant Professor, Department of Environmental Science (DES), Babasaheb Bhimrao Ambdkar (Central) University, Lucknow, U.P. and Co-supervision of **Prof. Mohammad Yunus,**Vice-Chancellor, Mohammad Ali Jauhar University, Rampur, as approved by the Departmental Research Committee (DRC) of DES.

I further declare that, to the best of my knowledge, the thesis work does not contain any work or part of work, which has been submitted for the award of any degree either in this University or in any other University.

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PREFACE

In a span of one decade, between 2001 and 2011, the number of million plus cities in India has increased from 35 to 53, while the number of towns and cities has increased from 5161 to 7935, leading to an overall increase in the proportion of urban population from 27.8% to 31.2 %. Out of this urban population, about 25 % lives in India's largest 10 cities (JNNURM, 2011). Urbanization as well as rural-urban migration have accounted for most of the population growth between 2001 and 2011. It is projected that India's urban population would increase from 380 million in 2014 to about 600 million in 2030. Such a massive increase in urban population would also create huge challenges for urban local bodies, mainly in maintaining the environmental quality without any compromise in the human well-being. It is beyond doubt that urban planning, infrastructural development and the resource consumption patterns of the emerging urban space will impact ecosystems both within cities' boundary as well as outside, with implications for the quality of life for people across the country (Aggarwal and Butsch, 2012). Problems in the levels of amenities as well as natural resources endowments may arise where housing projects inadequately deal with environmental impacts. One of the most pressing issues with regard to the environment is linked to human settlement in world's growing cities and towns. Environmental Impact Assessment (EIA) is a process used to predict the environmental consequences of any developmental project and recommend suitable mitigation measures to decrease possible adverse impacts. There are several guidelines and policies on housing projects with reference to India i.e.; government of India notification 1994, 2006, 2009 which guide in proper management and planning of housing or construction projects.

Present study explores the concept of EIA and carrying capacity with respect to housing projects using fuzzy AHP modeling techniques and conflict analysis. Baseline and current environmental status, long term land use change and the effectiveness of EIA system implemented in the housing projects are also studied in detail.

The whole work of study is arranged in eight chapters:

Chapter 1-provides an introduction of housing projects, Remote Sensing and GIS techniques in EIA and outlines the objectives and significance of the research study.

Chapter 2- provides the review of literature with respect to EIA, housing projects, fuzzy AHP modeling techniques, and role of Remote Sensing and GIS.

Chapter 3- provides methodological framework adopted for this study with various components.

Chapter 4- outlines brief information about the study area of the research.

Chapter 5- deals with the assessment of the baseline and current environmental status by a comparative study and outlines interpretation of the results.

Chapter 6- provides the summary and conclusions of the present research work. In this chapter an attempt has also been made to draw policy implications of the work with reference to findings.

Chapter 7- deals with the suggested strategies and recommendations. In this chapter some suggestions and strategies are recommended for the effective EIA of housing projects in Lucknow city by considering the future prospects.

ACKNOWLEDGEMENT

It is by the grace and will of the Almighty that I have reached the finishing stage of my doctoral work and it feels good. I would like to take this opportunity to humbly express my deepest gratitude for the innumerable gesture of help, co-operation and inspiration that I have received from my teachers, elders, and friends and well-wishers during the course of this research work.

I extend my sincere gratitude and appreciation to my supervisor, Dr. Venkatesh Dutta, Assistant Professor, Department of Environmental Sciences (DES), Babasheb Bhimrao Ambedkar (Central) University, Lucknow, U.P. - India, for introducing me to the exciting field of research in Environmental Sciences. I will ever remain grateful to him for his excellent guidance, valuable suggestions, unending encouragement and constant cooperation throughout the period of my research work.

I express my deep sense of gratitude and admiration to my Co- supervisor, Prof. M.Yunus, Vice Chancellor, Mohammad Ali Jauhar University, Rampur for his persistent and diligent care and illustrious guidance during course of my research work and preparation of the thesis. His generosity, incessant inspiration, gracious guidance, active co-operation and affection heled me a lot during the entire period of my Ph. D programme.

I gratefully acknowledge the University Grant Commission (UGC), New Delhi for providing financial assistance in the form of Rajiv Gandhi National Fellowship (RGNF) which buttressed me to perform my work comfortably.

At the outset I owe a deep sense of gratitude and reverence to Mr. Sudhir Kumar Singh, Assistant Professor, K. Banerjee Centre of Atmospheric & Ocean Studies, IIDS, University of Allahabad, Allahabad, for his valuable cooperation regarding research methodology and data analysis.

I take the opportunity to express my profound thanks to Mr. Sangharsh Rao, Scientist, Remote Sensing Application Centre, Lucknow, India for his warm support and valuable suggestion that served as the starting point of this research.

I am immensely thankful to teachers of Department of Environmental Sciences (DES), Babasaheb Bhimrao Ambedkar (Central) University, Prof. D.P. Singh (Head), Prof. R.P. Singh, , Dr. S.K. Dwivedi, Dr.Shikha, Dr. Narendra Kumar, Mr. N.K.S. More, Dr. Richa Tyagi, and staff members A.K. Jain, Salahudeen Khan,

Ranjeet and Aviral whose useful help and suggestion enabled me proceed smoothly toward the work.

I gratefully acknowledge the support and co-operation rendered throughout my research tenure by expperts of Paramarsh Mr. Akash Kumar, Rahul Chaturvedi, Manjul Gupta, Ankita, Alok, Pankaj, and experts of prakriti consultancy Dr. Divya (co-ordinator), Mr.Varun, Mrs. Momita Banerjee Mr. Manoj and my seniors Dr. Sudhir Kumar Upaddhyay, Dr. Jaspal Singh, Dr. A. K. Giri, Dr. Vinit Kumar, Dr. Sandeep Arya, Dr. S.K. Rawat, Dr. D.P. Gond, Dr. (Ms.) Kamini Narayan, Dr. (Mrs.) Sonal Dixit, Dr. Kuldeep Baudha, Dr. (Mrs.) Neha Vishnoi and Mr. Ram Gopal.

I would also like to thank my fellow research scholars and frends Swadesh Kumar,Shobhit, Urvashi Sharma, Vinayak, Samsad, Rachana, Jitendra, Pramod Kumar, Ateeq Ahmad, Rose Pratima Minj, Namita Gupta, Anjali Verma, Preeti Shukla, Sangeeta Anand, Dhananjay, Susheel Bharti, Mahesh, Varunika and Poonam for providing a constant source of encouragement, support, and cheerful company.

Lastly I would like to thanks to my parents Mr. Ramakant Tiwari and Mrs. Janki Devi Tiwari ,my brother Pankaj Tiwari and my sisters Mansa, Archna and Kalpana Tiwari for their love, support and encouragement. They are the piller of strength throughout this period and motivativate me to do a good and sincere work.

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ABBREVIATIONS

AHP	Analytical Hierarchy Process
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
FAO	Food and Agricultural Organization
FEIS	Fuzzy Environmental Impact Study
CPCB	Central Pollution Control Board
GIS	Geographical Information System
GPS	Global Positioning Systems
GHG	Green House Gas
ISD	Impact Significance Determination
IAIA	International Association for Impact Assessment
KML	Keyhole Markup Language
LULCC	Land Use and Land Cover Change
MoEF	Ministry of Environment and Forest
MCDM	Multi Criteria Decision Making
NH	National Highway
NEPA	National Environmental Policy Act
NGO s	Non Governmental Organizations
RS	Remote Sensing
RSPM	Respirable Suspended Particulate Matter
SEIAA	State or Union territory Level Environment Impact Assessment Authority
SO_2	Sulphur Dioxide
SOI	Survey of India
SPM	Suspended Particulate Matter
TDS	Total Dissolved Solids
TH	Total Hardness
WCED	World Commission on Environment and Development
WHO	World Health Organization

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INTRODUCTION

Rapid urbanization, environmental pollution and resources scarcity greatly influence the ability of town planners to deliver sustainable housing to citizens in developing countries. This has resulted in development of housing colonies that is unsuitable for occupancy generating negative consequences to the surrounding communities and the environment in the long run (Moja and Mnguni, 2014; Poom *et al.,* 2014; Dutta, 2012). Developing more resilient and sustainable settlements requires planners to anticipate and take account of changing socio-ecological and physical conditions (Fitzgerald *et al.,* 2015). Understanding the complex interactions between dynamic environmental, technological, infrastructural and governance systems in relation to housing provisions forms the starting point for impact assessment within the framework of Environmental Impact Assessment (EIA). EIA is the process used to identify, predict, evaluate and mitigate the environmental, social, and other potential impacts and consequences of developmental projects prior to major decisions being taken and commitments made to recommend suitable mitigation measures and to decrease possible adverse impacts (International Association for Impact Assessment (IAIA), 1999; Kaya and Kahraman, 2011). Human activities are both beneficial and harmful for environment such as biological, cultural, social, economic impacts and so on and they must be taken into consideration when the development projects or plans are evaluated (Puri *et al.,* 2015; Deng, *et al.,* 2014). The rapid growth in the population in urban areas has increased the demand of land and cost of living, and it has also increased the housing load and housing projects activities (Jiao, 2015). This high demand of urban land and housing is often in short supply and out of the economic reach of the majority of the urban households (Oladapo and Olotuah, 2007; Olotuah, 2010).

The urban areas in developing countries are crowded by a large mushrooming growth of settlements. These parts of the urban population needs special attention and is constrained with limited services, insufficient resources, crowded and squatter settlements and a generally poor environmental quality (McGranahan, 2015; Galbraith, 1968). These are the urban poor that are subjected to a life characterized by precarious conditions of housing, nutrition and health, little or poor material possessions (Walter *et al.,* 2015; Mabogunje, 1975). In India, urbanization trend shows a dramatic shift. Total population has increased from 23.84 crores in 1901 to 102.7 crores in 2001, and number of town has grown from 1827 in 1901 to 7935 in 2011 (Census of India, 2011). The number of urban agglomerations has increased from 384 in 2001 to 475 in 2011, whereas the number of population living in urban areas has increased from 2.58 crores in 1901 to 28.53 crore in 2001.

1.1 EIA for Housing projects

EIA comes from Sec. 102 (2) of the National Environmental Policy Act (NEPA), 1969, USA. In many European countries, it came into trend with the introduction to the concept of sustainable development after the report of World Commission on Environment and Development (WCED) came in 1987. In India, EIA came into existence informally through isolated project assessment on environmental criteria around 1978-79, it was made a mandatory provision in 1994.

The vast majority of urban residents in India continue to live in sub-standard or informal housing, with few basic amenities (Tiwari and Hingorani, 2014). EIA is a planning and management tool that seeks to identify and assess the type, magnitude and probability of environmental and social changes likely to accrue form a proposed development or policy and to design the possible mitigation plans (Harvey, 1998; Momtaz, *et al.*, 1998; Thomas, 1998). EIA is being used worldwide in order to reduce the harmful consequences of development. It is an illustration of the precautionary principle (Debbarma, 2012) because it focuses on prevention during the early stage of project development. The primary goal of EIA is ensuring environmental protection and management (Bailey, 1997; Morrison and Bailery, 1999). EIA is generally concerned with the prediction and identification of impacts at a pre-decision level focusing only on the steps before and up to the planning decision, but ignoring post development follow-up actions, such as post-project monitoring and auditing (Arts *et al.*, 2001; Glasson, 1994; Petts and Eduljee, 1993). Moreover, the procedural emphasis of EIA upon the pre-decision investigation keeps it isolated from its final goal, i.e. environmental protection. In a major study on international EIA effectiveness (Sadler, 1996; Cashmore *et al.*, 2004)**,** it is found that there was a deficient or poor performance of follow-up activities in EIA. This is considered to be a major weakness of EIA internationally (Arts *et al.*, 2001; Bisset and Tomlinson, 1988; Buckley, 1989; Dipper *et al.*, 1998; Glasson *et al.*, 1994; Ortolano and Shepherded, 1995; Sadler, 1996; Wood, 2003).

The living space becomes the centre and instrument for mankind's socio-economic and moral well-being (Wang *et al.*, 2015). Since living space affects the very foundation of an individual's life, the house becomes an integral part of it. Besides it is fundamental to people's physical, physiological, social and economic well-being (Kraatz *et al.*, 2015). Housing is the physical structure that man uses for shelter. The quality of life of human being can not be fulfilled without safe, secure and comfortable housing. But, in most of India's towns and growing cities, people are not fortunate to have housing of their own which is safe, sustainable and comfortable. Housing is the biggest challenge associated with urbanization in India. In the absence of proper assessment of environmental significance of ongoing housing projects, the living standards of urban as well as rural area are deteriorating. Thus, the sustainable human settlement and construction of eco-cities or green housing can be achieved by implementing the policies of EIA in housing and construction projects (Kulkarni *et al.*, 2014).

1.2 Application of RS and GIS in EIA

Geographical Information System (GIS) is a computer based system which can be used to store, integrate, analyze, and display spatial and non spatial data for undertaking an EIA study. The first GIS system was evolved in the late sixties, and by mid seventies, it was used for EIA. Overlay technique method is one of the main methods of analysis in GIS. In 1972, a computerized version of the GIS technique was used for siting of power lines and roads (Munn, 1975). First GIS (Canada GIS or CGIS) was used for EIA in the late 1970s for the preparation of an EIS for a dam on the river Thames. GIS processes are related to environment for considering the spatial properties of the housing projects. Most of the environmental issues can be handled properly with the use of GIS techniques (Schaller, 1990). Due to the evolution of computer technology, and their graphic capabilities, GIS's have become more users friendly and powerful.

The availability and quality of digital spatial data sets have improved for routine analysis (Batty, 1993). The use of GIS in EIA process is common for scoping in terms of time and money relative to the time and budgets allocated for EIA preparation, and especially for scoping studies.

GIS is widely utilized in EIA of housing projects, however, its use is largely limited to the fundamental GIS functions such as map production, classic overlay or buffering (Joao, 1998). The key advantage of GIS for EIA is its ability to perform spatial analysis and modeling (Joao and Fonseca, 1996) for future urban growth projections in world's developing and upcoming urban townships.

There are several advantages of RS and GIS techniques in EIA of housing projects which are outlined below:

1. *Space management* which is a major issue concerning the provision of limited space to meet housing goals, minimize operating costs, and promote an effective and productive environment. The ideal uses of space in successful manner decreases the building's per capita functional costs. There are several cases where GIS is effectively used in the management of spaces for different housing projects.

2. The *suitable site selection* is the primary and essential part of eco-city/housing projects planning (Laprise *et al.*, 2015). GIS can be utilized to visualize whether a particular site meets the predefined criterions or not. It helps to visualize the spatial interlinks or errors between various factors with that of chosen site for planning. GIS techniques help to generate several important functional maps for the master plan such as the location of the waste management sites, green space, parks and open areas etc.

3. Housing and construction industry is one of the major sources for Green House Gas (GHG) emission. *Reducing the GHG emission* from the construction activities is one of the critical challenging issues in construction industry. So, GIS technique helps in monitoring GHG emission from the construction activities (Fouquet *et al.*,

2015). The maps generated from several sources could be overlaid to prepare the emission scenario and its impact on settlements (Denga, 2014).

Many applications are enhanced by the use of 3-D spatial information, such as visualization of planning development proposals, flood predictions, modeling urban sprawl, tourist visit simulations and the design of transportation networks. Some GIS software also predicts the future growth with the help of modeling techniques.

1.3 SATELLITE DATA AND ANCILLIARY DATA

The satellite data is being used to observe land use/land cover changes, losses of water bodies and losses of flora / fauna by using Expert GPS, ARC VIEW GIS 3.3 and ARC GIS 9.2 software. While, ancillary data such as environmental clearance reports, analytical monitoring data, compliance reports etc can be collected from CPCB and SPCB, and Directorate of Environment as well as district Gazettes, the ancillary data helps in conflict analysis (comparing the compliance and non-compliance data) of the EIA system implemented in the housing projects.

1.4 Carrying Capacity and EIA

In an environment of the biological species the carrying capacity is the maximum population size of the species that the environment can sustain indefinitely, given the, habitat, water, food and other requirements available in the environment (Xilian, 2010). Thus, the carrying capacity is the number of biological species in an environment that can be supported without significant negative impacts to the given organism and its environment. The carrying capacity is directly or indirectly connected with EIA process which is used to determine the carrying capacity of the region due to any developmental projects like housing and construction projects.

1.5 Application of modeling techniques in EIA

FUZZY AHP (Analytical Hierarchy Process) which was developed by Saaty (1977, 1980), is a modeling technique based on multi-criteria decision making method. The method is specially used where different criteria sets are used in project evaluation and the criterion is found to be incapable of dealing with the problems of uncertainty in decision-making situation. Buckley (1985) applied the fuzzy set theory to depict the fuzziness of the decision-makers. This process comprises of both group decisions and fuzziness. Examples for the proper application of the fuzzy AHP are, amongst others, the assessment of water management plans (Sredjevic and Medeiros, 2008); decisions in new product development (Buyukozkam and Feyziog, 2004); flexible manufacturing systems (Chutima and Suwanfuji, 1998); safety management in production (Dag deviren and Yuksel, 2008); selection of enterprise resource planning systems (Cebeci, 2009); evaluation of success factors in e-commerce (Kong and Liu, 2005); personnel selection (Gungor *et al.,* 2009); affordable housing (Bei *et al.,* 2014) and weapon selection (Dag deviren *et al.,* 2009). In a similar study, land capability of Shandiz urban region, northeast of Iran, was assessed for spatial development using multi-criteria evaluation framework

(Afshari and Mafi, 2014). AHP and GIS was used to find the most important parameters that affected the spatial development in the study area.

AHP is a mathematical method for the determination of the priority of the process and criteria in the evaluation process and decision making. The main reason of applying AHP is that it helps decision makers to solve the complex problem into a hierarchical structure. The AHP analysis creates better and clear rationale for selecting the various options in a complex decision environment such as impact assessment for housing projects (Bei *et al.,* 2014). Fuzzy models have many interesting features that make them ideal for such conceptual models (Wieland and Gutzler, 2014) in addition:

- Fuzzy models are represented as a set of fuzzy sets to describe outputs and a set of rules.
- Fuzzy models can easily be understood by experts.
- Fuzzy models can easily express complicated nonlinear relations.

1.6 Research Objectives

EIA has been used as a practical and effective tool in decision making process to identify environmental factors, and consequences for a proposed development project needed to arrive at socio-economic development. This study uses the EIA framework as a lens to evaluate current and future environmental impacts in developing housing projects by both public and private agencies and also evaluates the post-project conflicts through primary and secondary data. This research work quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India's largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models within a framework of environmental assessment. The methodology provides a cost effective and rapid land evaluation framework for EIA which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth and impacts of housing projects on the environment.

There are three main research objectives which are formulated as follows:-

- ❖ To assess the baseline and current environmental status (such as air, water, noise, and socio-economic parameters) for housing projects in Lucknow.
- ❖ To do a comparative study of the housing projects in the study area on different parameters using Leopold Matrix method.
- ❖ To review the effectiveness of EIA systems implemented in housing projects through conflict analysis and post-project monitoring using Fuzzy AHP models and GIS.

The study was used to observe the effectiveness of EIA for housing projects in Lucknow by studying and reviewing the Government of India EIA

notifications, with the help of spatial and non-spatial data, use of Fuzzy – AHP modelling techniques, Leopold interaction matrix, land use/cover change detection, and conflict analysis. The methodological framework is schematically outlined below in the figure 1.1.

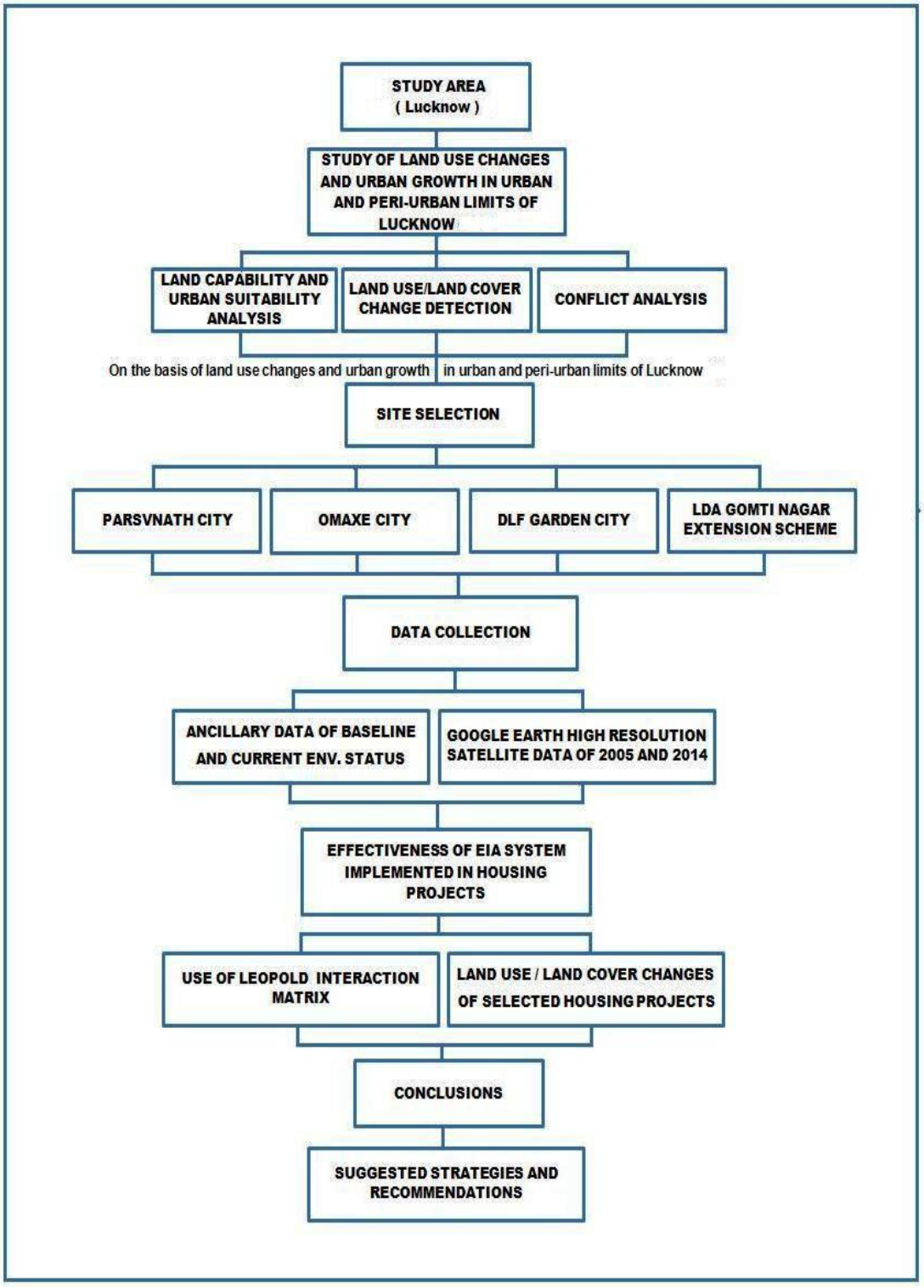


Figure 1.1 Methodological framework adopted for the study

1.7 About the Study Area

Lucknow is located in the central region of Uttar Pradesh and is the capital of the largest populated state in India. The city is governed by Municipal Corporation which comes under Lucknow Metropolitan Region. Lucknow district administers 2,528 square kilometers of areas. In 2001 census, Lucknow had a population of 3.64 million with a density of 1816 people per sq. km which rose to 4.58 million in 2011 having a density of 1443 people per sq. km (Census of India, 2011). Floating population in the city is increasing every year, and with the growing infrastructure, the demand and expectation of quality housing has also gone up. The main urban areas of Lucknow are situated on both sides of the river Gomti which divides the city into two parts. Residential colonies like Gomti Nagar, Indira Nagar, Vikas Nagar, Jankipuram, Aliganj, Mahanagar, Rajajipuram and several integrated townships along the Faizabad Road are located trans-Gomti, while colonies like Aashiyana, Eldeco, South City, Vrindavan, Alambagh, Krishna Nagar etc. are situated in southern-western part of the city. Most of the colonies in these areas are developed with mixed land-use and commercial infrastructure, however, in some of the colonies in the far south and north, social and physical infrastructure is still developing. Three National Highways and other five Provincial Highways serve the region of Lucknow. During the last two decades, the city of Lucknow expanded rapidly and became less compact and more dispersed. However, the city grew faster and showed more sprawl between 2005-2014. The growth mainly spurred due to real estate markets becoming a popular investment avenue in India's million plus cities. Good connectivity with the adjoining towns with the rest of the city also aided people to come and settle in different parts. The earlier work on Lucknow's growth pattern and urbanization trends reveal that the growth in Lucknow city is not linear nor nodal, rather radial with minimal influence of transport infrastructure; change drivers are many and site-specific. Urbanization follows two physical processes, (i) envelopment (North, North-western, Southern sites): annexation of surrounding landscape and (ii) Attainment (North-eastern site): occupation of rural built-up clusters in landscape (Dutta, 2012).

A short description of high growth areas of Lucknow is provided below which are exhibiting rapid expansion of residential colonies:

(a) Northern site along Sitapur Road: It is located in Bakshi Ka Talab, a suburban town in Lucknow district, connected to Lucknow City via National Highway 25 which further leads to the neighbouring Sitapur City. The area has been primarily agriculture-intensive and has been experiencing significant urban development with increasing number of educational and research institutions coming up in the area. The peri-urban areas which had much lesser population and less explored by the real estate markets, are now becoming preferred destination for private developers.

(b) North-Eastern site along Faizabad Road: It is located in Chinhat Area situated along National Highway 28, around 15 km from Lucknow city connecting it to Faizabad city. The site is situated between the National Highway and River Gomti

and has a railway route running through it. The area has been agriculture- intensive with very fertile croplands due to proximity to river Gomti and presence of canal network. Owing to its numerous industries, the area has is the industrial hub of city and has been experiencing significant development since a decade owing to establishment of new industries and some higher-education institutions.

(c) Southern site located along Raebareli Road: Raebareli road in the south is one of the six crucial roads of Lucknow which is currently expanding. The road starts from the Telibagh colony, just after the cantonment and extends up to the Mohanlalganj area. The area is in between Uterethia-Amausi situated 15 km from Lucknow city centre and is surrounded by National Highway 25 connecting to Kanpur city on one side and National Highway 24B connecting to Raibareli city on other side. It is a transportation hub due to the presence of Amausi international airport. The area has been historically marked by presence of numerous ponds/ lakes, vast scrublands and numerous sporadic clusters of plantations. The area is currently experiencing rapid development due to several real-estate development plans under implementation. Many builders and buyers have shown interest in the area. Along this road, many renowned and city-based builders have started their housing projects and are offering a wide range of properties ranging from apartments in a group housing society to independent plots. The Amar Shaheed Path acts as a dividing line between the developed and the developing regions along the road. Areas within the Amar Shaheed Path or close to it are completely developed in terms of social and physical infrastructure. As one go away from the city in further south, an array of residential housing projects can be seen on both sides of the Raebareli road. Not only the private developers, the city's Lucknow Development Authority (LDA) and UP Housing and Development Board has also acquired a good amount of land bank from the farmers in this region and coming with several housing projects.

(d) South-Western site located along Kanpur Road: Kanpur and Lucknow are separated by 80 kms. Land along the Lucknow-Kanpur road has become an area of intense interaction reflected by changes in land use and mushroomed development. Many interested investors are buying plots as they are relatively less expensive when compared to other areas of the city. Several buyers hope to construct homes after their retirement while investors wait for capital appreciation based on the infrastructure development in the future. It is one of the regions where future development is being aimed by both public and private developers.

(e) Northwestern site located along Hardoi Road: It is situated 12 km from the city centre and has two major roads and northern rail route passing through it. State Highway 40 connects Lucknow to Kannauj, finally leading to Agra and State Highway 25 connects Lucknow to Hardoi via Malihabad. The area though being dominated by agriculture has a significant amount of plantations on private lands which have been steadily increasing.

1.8 Significance of the Study

Better understanding of the overall dynamics and linkages of environmental parameters and their relative importance within and among housing and infrastructure sectors can guide more targeted and productive investment and policies for future to devise better and more holistic interventions. The outcome of this study revealed that EIA regulations were not adequately implemented in housing projects and there are conflicts with respect to post-project compliance. The study further reveals that zoning regulations and land-use suitability is not well considered in deciding housing projects. This land suitability addresses the question of how location and morpho-land use influences overall environmental impacts. The morpho-land use and location of settlements are considered one of the key determinants of the patterns of settlements and resource consumption, and their associated environmental load in future. The outcome of present study may be helpful as a tool for planners, decision makers, engineers and others to consider the impact of housing projects on environment for effective planning. The results of this research work would contribute in determining the effectiveness of EIA for housing projects in Lucknow, Uttar Pradesh which could be applied to other towns and cities. Urban transition is a major challenge in growing Indian cities. Disorderly urban sprawl creates war on cities' dream to become engines of growth and threatens the future growth and vibrancy of cities' economy. Urbanization in the Indian context should be looked at beyond mega-cities like Mumbai and Delhi with a holistic view to include second-tier towns and medium size agglomerations such as Lucknow which has not been studied in detail. This research work quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India's largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models within a framework of environmental assessment. The methodology provides a cost effective and rapid land evaluation framework which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth and implications of housing projects on the environment. The outcome can also help in better design of EIA studies, especially in the post-project monitoring and evaluation of housing projects.

2 REVIEW OF LITERATURE

In the recent years, there has been a remarkable growth of interest in environmental issues and sustainability. Associated with this growth of academic and research interests emanating from several national and international agencies that improve the understanding between environment and development, Environmental Impact Assessment (EIA) is an important example. The option of EIA as a key tool of environmental management and planning has brought about significant policy actions over the last 40 years. EIA techniques have improved by the changing need of decision-makers and the decision-making process itself as well as by the research experience put into practice (Morgan, 1998).

2.1 Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a process to assess the environmental consequences of any development projects and design proper mitigation measures to minimize the possible adverse impacts (Sadler and Verheem 1996). It is a planning and management tool to predict the type, magnitude and probability of environmental and social changes likely to occur as direct or indirect result of a plan or policy and to decrease adverse impacts (Vanclay and Bronstein, 1995; Harvey, 1998; Momtaz *et al.*, 1998; Thomas, 1998). National Environmental Policy Act (1969) is the legislative basis for EIA, which was the result of widespread recognition in the US in the 1960s that some adverse environmental impacts were created by developmental projects. This legislation required that all federal agencies would consider the environmental consequences of their actions. Within a few years time, many developed and developing countries have designed their EIA legislation.

2.1.1 Origin of EIA

Before the First World War, due to rapid urbanization and industrialization in western countries, loss of natural resources continued even after the Second World War that adversely affected quality of life and the environment. In early 60s, people realized that their developmental projects were affecting the environment, resources and raw materials. The USA decided to take action to these environmental issues in order to consider its goal in terms of environmental protection, and established a National Environmental Policy Act in 1970. The USA became the first country to use EIA legislation. This was the first time that EIA became the official process to be used to protect the environment. In 1972 United Nations Conference on the Environment in Stockholm and subsequent conventions formalized EIA. In recent, years all developed countries have enacted environmental laws whereas some of the developing countries are still adopting it (Lee, 1995). Multilateral and bilateral lenders included EIA needs in their project eligibility criteria (OECD, 1996) in order to safeguard environmental and socio-economic interests. The evolution and history of EIA are shown below in table 2.1.

Table 2.1: Evolution and history of EIA

Pre-1970	• Project review based on the technical/engineering and economic analysis. • Limited consideration given to environmental consequences. • EIA introduced by NEPA in 1969 in US.
Early/mid-1970s	• Basic principle: Guidelines, procedures including public participation requirement instituted and formalized. • Standard methodologies for impact analysis developed (e.g. matrix, checklist and network). • Canada, Australia and New Zealand became the first among countries to follow NEPA in 1973-1974. Unlike Australia, which legislated EIA, Canada and New Zealand established administrative procedures. • Major public inquires helped in process's development and subsequent follow up actions.
Late 1970 and early 1980s	• More formalised guidance was developed. • Other industrial and developing countries introduced formal • EIA requirements (France, 1976; Philippines, 1977), began to use the process informally or experimentally (Netherlands, 1978) or adopted elements, such as impact statements or reports, as part of development applications for planning permission (Germany and Ireland). • Use of EA by developing countries (Brazil, Philippines, China, Indonesia) • Strategic Environment Assessment (SEA), risk analysis included in EA processes. • Greater emphasis on ecological modelling, prediction and evaluation methods. • Provision for public involvement. • Coordination of EA with land use planning processes.
Mid 1980s to end of decade	• In Europe, EC Directive on EIA established basic principle and procedural requirements for all member states. • Increasing efforts to address cumulative effects. • World Bank and other leading international aid agencies established EA requirements. • Spread of EIA process in Asia.
1990s	• Requirement to consider trans-boundary effects under Espoo convention. • Increased use of GIS and other information technologies. • Sustainability principal and global issues receive increased attention. • India also adopted the EIA formally in 1994. • Formulation of EA legislation by many developing countries. • Rapid growth in EA training.

***Source**: International Study of the Effectiveness of Environmental Assessment, final report, Environmental assessment in a changing world, Prepared by Sadler, (1996)*

2.1.2 EIA in developing countries

EIA as a novel idea was not willingly understood and accepted as a screening tool in developing countries, because policies supporting EIA dictated that land developments causing adverse impacts should be discontinued. EIA was considered as a stumbling block in the way of development projects. Secondly, EIA was conceived anti development by which industrialized nations intend to stop developing countries from breaking the vicious cycle of poverty. Thirdly, the experts in the developing countries were outsiders who were viewed as agents of colonization. The requirement of EIA has become ever more significant and is now a statutory necessity in several developing countries.

Historically, the selection of projects was primarily based on one criterion: economic viability but today, projects are based on environmental and social impacts, and have become a strong yardstick, hence the triple bottom-line approach (economic, environmental and social) to project viability (Modak and Biswas, 1999) is followed by project planners.

2.1.3 Process of Environmental Impact Assessment (EIA) in India

The commencement of EIA studies in India was made in 1976-77 by the Planning Commission when it asked the Department of Science and Technology to examine the river-valley projects from environmental angle. Consequently, in 1978 the Department of Environment and Forests (DoEF), prepared the guidelines for EIA process for river valley projects. These guidelines were prepared and circulated among the development project authorities through the planning commission for site selection and mitigative measures. It was aimed that each river valley projects should be assessed of their environmental impacts with necessary mitigative measures. In the guidelines it was made crucial to analyze whether the implementation of environmental measures is going to result in any short or longterm social and economic benefits or not. Special focus was laid on the environmental factors like health effects, plant genetic resources, aquatic life, water logging, and salinity of irrigated soils, deforestation and soil conservation for considering the techno-economic viability of the project. Ecological factors were also considered at every stage of planning and construction of developmental projects.

Afterward, in 1979 the Union Ministry of Irrigation set-up a committee to prepare complete guidelines for the preparation of project reports of major River Valley Projects. The working group considered the soil management significance in the catchment of River Valley Projects which suggested consideration of mineral resources, ground water levels, flora and fauna in vicinity, long-term impacts on human settlement and impact on historical monuments etc. in site selection for River Valley Projects. Afterward in 1980 the Forest (Conservation) Act made it compulsory for all the proposed River Valley Projects to be cleared by the Government before its construction, in case any submergence or deforestation of forestland is involved.

Subsequently, the Environment (Protection) Act was enacted by the Government of India on 23rd May 1986 to achieve the objectives and decisions to carry EIA. A notification was issued on 27th January 1994 and was then amended on 4th May 1994, 10th April 1997 and 27th January 2000 (Annexure 1) on EIA for 30 activities. Presently, EIA is carried out on the basis of EIA notification, 1994. The Government of India under Environment (Protection) Act 1986 issued a number of other notifications, which are also associated with EIA process.

2.2 EIA as a decision-making tool for housing projects

One of the most pressing issues with regard to the environment is linked to human settlement in world's growing cities and towns. Cities present significant thereat as well as opportunities for new landscape perspectives that can help inform policy makers on important environment and development parameters (Steiner, 2014). It has been widely discussed in the literature that unplanned urban growth or sprawl has high environmental and economic costs (Forman, 2014). In general, settlements in sprawling cities generate more carbon emissions due to higher energy and resource consumptions.

Several agencies use procedures for environmental impact assessment (EIA) of housing projects which might result in significant environmental impacts. The EIA study is necessary to prepare a detailed account of environmental impact of the proposed activity so that appropriate interventions could be taken. In India's rapidly growing cities, sprawl development and informal settlements have been the dominant growth trend, and has accelerated since last two decades. It is being spurred by growing housing demands, urban migration, transportation network and rising quality of life.

The new urban space is characterized by a large mushrooming growth of people with irregular houses, commercial areas and markets and lack of open space. Therefore, the main role of EIA in housing projects is to determine the impact on the environmental quality and human wellbeing.

2.3 Objectives of EIA in housing and settlement projects

EIA has been used as an effective tool in decision making process for housing projects affecting environmental factors. Objectives of EIA which are considered for housing projects can be summarized as follows:

1. Predict environmental impacts of projects due to land use change or modifications.
2. It assists decision makers in considering the environmental costs and benefits and sometimes alternatives before housing projects are started.
3. Find ways to reduce adverse impacts during construction phase.
4. Shape projects to assist local environmental conditions positively.
5. To ensure that the environmental considerations are explicitly addressed and incorporated into the development and decision-making process.

6. To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects.
7. To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions.
8. To promote colonies that are sustainable and can optimize resource use as well as management opportunities in future.

2.4 EIA Notifications in India and their subsequent amendments

2.4.1 EIA Notifications 1994

1. S.O. 60 (E) Whereas a notification under clause (a) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 inviting objections from the public within sixty days from the date of publication of the said notification, against the intention of the Central Government to impose restrictions and prohibitions on the expansion and modernization of any activity or new projects being undertaken in any part of India unless environmental clearance has been accorded by the Central Government or the State Government in accordance with the procedure specified in that notification was published as SO No. 80(E) dated 28th January, 1993; And whereas all objections received have been duly considered; Now, therefore, in exercise of the powers conferred by sub-section (1) and clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986, the Central Government hereby directs that on and from the date of publication of this notification in the Official Gazette, expansion or modernization of any activity (if pollution load is to exceed the existing one, or new project listed in Schedule I to this notification, shall not be undertaken in any part of India unless it has been accorded environmental clearance by the Central Government in accordance with the procedure hereinafter specified in this notification;

2.4.2 EIA Notification, 2006

S.O. 1533 Whereas, a draft notification under sub-rule (3) of Rule 5 of the Environment (Protection) Rules, 1986 for imposing certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects or activities based on their potential environmental impacts as indicated in the Schedule to the notification, being undertaken in any part of India1, unless prior environmental clearance has been accorded in accordance with the objectives of National Environment Policy as approved by the Union Cabinet on 18th May, 2006 and the procedure specified in the notification, by the Central Government or the State or Union territory Level Environment Impact Assessment Authority (SEIAA), to be constituted by the Central Government in consultation with the State Government or the Union territory Administration concerned under sub-section (3) of section 3 of the Environment (Protection) Act, 1986 for the purpose of this notification, was published in the Gazette of India ,Extraordinary, Part II, section 3, sub-section (ii) vide number S.O. 1324 (E) dated the 15th September ,2005

inviting objections and suggestions from all persons likely to be affected thereby within a period of sixty days from the date on which copies of Gazette containing the said notification were made available to the public; And whereas, copies of the said notification were made available to the public on 15th September, 2005; And whereas, all objections and suggestions received in response to the above mentioned draft notification have been duly considered by the Central Government; Now, therefore, in exercise of the powers conferred by sub-section (1) and clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986, read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 and in supersession of the notification number S.O. 60 (E) dated the 27th January, 1994, except in respect of things done or omitted to be done before such supersession, the Central Government hereby directs that on and from the date of its publication the required construction of new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to this notification entailing capacity addition with change in process and or technology shall be undertaken in any part of India only after the prior environmental clearance from the Central Government or as the case may be, by the State Level Environment Impact Assessment Authority, duly constituted by the Central Government under sub-section (3) of section 3 of the said Act, in accordance with the procedure specified hereinafter in this notification.

2.4.3 EIA Notification, 2009

MOEF, through Notification#S.O.195 (E) dated 19th January 2009, published a *Draft Notification* to make amendments5 in the *EIA Notification 2006,* for information of the public likely to be affected, thereby inviting any objections or suggestions on the proposals contained in the *Draft Notification* within 60 days from the date of its publication in the Official Gazette (the 60 days period expired on 20th March 2009).

The main reason for issuing the *Draft Notification* was that more than two (2) years had passed since the *New EIA Notification* was notified on 14th September 2006. Based on the experience of these two (2) years, the MOEF was considering certain amendments in *the New EIA Notification* mainly to provide for increasing societal vigil on environmental projects by making it compulsory for the project proponents to make public the terms of *Environmental Clearance*. The intent of the proposed amendments was to ensure that the conditions of *Environmental Clearances* were strictly complied with by the Project Proponents and in case of any gaps these could be brought to the notice by the local population or its representatives.

Reportedly, the Central Government received comments/objections/suggestions from 136 stakeholders including Central and the State Governments and their Agencies, Industry and their Associations, Non Governmental Organizations (NGOs), Civil Society Groups and the General Public. In order to have discussions with these stakeholders and consider their comments before finalizing the *Draft Notification*, the MOEF constituted a *Committee* [through an *Order* (*Reference#J-11013/56/2004-IA. II (I)*)] dated 3rd July 2009, under the Chairmanship of Mr J. M. Mauskar, Additional Secretary, to examine the

comments, have meetings with various stakeholders, and thereafter give its recommendations for finalization of the *Draft Notification(Indus environ 2009).* The *Mauskar Committee (*hereafter referred to as the *Committee)* was given three (3) months time to complete its task. The *Committee* had its First Meeting on 30th July 2009, took stock of the comments received on *the Draft Notification* and decided to arrange category-wise hearings with all the stakeholders, namely: (i) Central Ministries and their Agencies; (ii) State Governments and their Agencies; (iii) Industries and Industry Associations; and (iv)Civil Society including NGOs. Accordingly, separate hearings were held with all these Agencies on 26th - 27th August 2009 and 3rd - 4th September 2009. In addition, a Meeting was also held with the officials of *the Ministry of New and Renewable Energy (MNRE)* on 7th September 2009 to specifically discuss the issues relating to biomass based power plants. Based on the comments received from various stakeholders and deliberations in these hearings, the Committee made recommendations to MOEF. Accordingly, in the final version of *the EIA Notification 2009*, the MOEF decided not to include several proposed amendments and to revise and modify several other amendments that were proposed in the *Draft Notification* of 19th January 2009.

Now, the Central Government (i.e. MOEF), through Notification#S.O.3067 (E) dated 1st December 2009 and in exercise of powers conferred to it by *Sub-section (1)* and *Clause (v)* of *Subsection (2) of Section (3)* of *EPA 1986* has published *the EIA (Amendment) Notification 2009 (*hereafter referred to as *the EIA Notification 2009)* and made the following amendments in *the EIA Notification 2006.* We have reviewed *the EIA Notification 2009* in detail and in the following sections we have presented *Summaries of Amendments in the EIA Notification 2009 including - (i) Specific amendments that were proposed in the Draft EIA Notification but were subsequently deleted by the Review Committee, (ii) Amendments in the Notification itself, (iii) Amendments in Schedule to the Notification, (iv) Amendments in Form-1 of Appendix-I of Notification,(v) Amendments in Appendix-IV related to Procedure for conduct of Public Hearing, (vi) Amendments in Appendix-V related to Procedure Prescribed for Appraisal, etc.*

The EIA Notification amendments from 2006 to 2015 are given below in the table 2.2.

Table 2.2: EIA Notification amendments from 2006 to 2015 (Source: MoEF)

S.No.	**S. No. & Date**	**Amendments in EIA Notification, 2006 onwards**
1.	1737(E) 11/10/2007	• Mineral prospecting is exempted provided the concession areas have got previous clearance for physical surveys. • Seismic surveys which are the part of exploratory surveys are exempted provided the concession areas have got previous clearance for physical surveys. • Expansion of National Highways greater than 30km involving additional right of way greater than 20m involving

		land acquisition. • Expansion of State Highways greater than 30km involving additional right of way greater than 20m involving land acquisition. • The members of EAC shall be experts with the requisite expertise and experience in the following field or disciplines. In the event that persons fulfilling the criteria of experts are not available, professionals in the same field with sufficient experience may be considered.
2.	3067(E) 01/12/2009	• All decisions of the SEIAA shall be taken in a meeting and shall ordinarily be unanimous: Provided that, in case a decision is taken by majority the details of views, for and against it shall be clearly recorded in the minutes and a copy thereof sent to MoEF. • For the word and letter "In the absence of the duly constituted SEIAA or SEAC, category 'B' projects shall be treated as a category 'A' projects, the word and letter "In the absence of the duly constituted SEIAA or SEAC, category 'B' projects shall be considered at the central level as a category 'B' project" shall be substituted. • Maintenance dredging provided the dredged shall material shall be Disposed within port limits. • All Building or constructions projects or Area Development projects (which do not contain any category. A, projects activities) and and Townships (item 8 (a) and 8 (b) in the schedule to the notification). • In respect to category 'A' projects, it shall be mandatory for the projects proponent to make public the environmental clearance granted for their project along with the environmental condition and safeguards at their cost by prominently and advertised it at least in two local news papers of the district or state where the project is located and in addition, this shall also be displayed in the project proponents website permanently. • In respect to category 'B' Projects, irrespective of its clearance by MOEF / SEIAA, The project proponent shall prominently advertise in the news papers indicating that the project has been accorded environment clearance and details of MOEF website where it is displayed. • The MOEF and the State / Union Territory level Environmental Impact Assessment Authorities (SEIAAs), as the case me be, shall also place the environmental clearance shall be submitted by the project proponents to the heads of

		local bodies, panchayats and municipal bodies in addition to the relevant of offices of the government who in turn has to display the same for 30 days from the date of receipt.
3.	695(E) 04/04/2011	• An application seeking prior environmental clearance in all cases shall be made by the project proponents. • prior environmental clearance is as well required at the stage of renewal of mine lease for which application should be made up to one year prior to date of renewal. • Mineral prospecting is exempted. • The Built up Area for purpose of this notification is defined as the built up or covered area on all the floors put together including basement (s) and other services areas, which are proposed in the building / Construction projects. • Public consultation is not mandatory; the appraisal shall be made on the basic of prescribed application form-1 and EIA Report, in the case of all projects and activities other than item 8 of schedule. In case of item 8 of schedule, considering its unique project cycle, the EAC or SEAC Concerned shall appraise project or activities on the basis of form-1, form 1A, Conceptual plan and the EIA report (Required only for projects listed under 8 (b)) and make recommendations on the project regarding grant of environmental clearance or otherwise and also stipulate the conditions for environmental clearance.
4.	2896(E) 13/12/2012	• prior environmental clearance is as well required at the stage of renewal of mine lease for which application should be made up to one year prior to date of renewal. further, a period of two years with effect from the 04/04/2011 is provided for obtaining environmental clearance for all those mine leases, which were operating as on the 04/04/2011 with requisite valid environmental clearance and which have fallen due for renewal on or after the 04/11/2011.
5.	674(E) 13/03/2013	• In the schedule under the heading 'project or activity' in item 1(a) in column (5), under note (1) the following provision shall be inserted, namely:-"provided that no fresh environment clearance shall be required for a mining project or activity at the time of renewal of mining lease, which has already obtained environmental clearance, under this notification".
6.	2559(E) 22/08/2013	• Following shall not require Scoping-(1) all projects and activities listed as category B in item 8 of the Schedule (Construction or Township or commercial Complexes or housing).(2)all Highway expansion projects covered under

		entry (ii) of column (3) and Column (4) under sub-item of 7 of the schedule. • The project and activities referred to in clause (i) shall be apprised on the basis of Form 1 or Form 1A and the conceptual plan. • The projects referred to in clause (ii) shall prepare EIA and EMP report on the basis of model TOR specified by MOEF.(a) Expansion of National Highways greater than 100 Km involving additional right of way or land acquisition greater than 40 m on existing alignments and 60m on re-alignments or by-passes".
7.	2731(E) 09/09/2013	• General conditions shall apply except for project or activity of less than 5 ha or mining lease area for minor minerals; provided that the above exception shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that or existing operating mines and mining projects which were accorded environmental clearance and are located within 500 meters from the periphery of such projects or activity equals or exceeds 5 ha.
8.	637(E) 28/02/2014	• In exercise of the powers conferred by section 23 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby delegates the powers vested in it under section 5 of the said Act to all the State and Union Territory Environment Impact Assessment Authorities (Hereinafter referred to as the said Authorities) constituted by the Central Government under sub-section (3) of section 3 of Environment (Protection) Act, 1986, to issue show cause notice to project proponents in case of violation of the conditions of the environment clearances issued by the said Authorities to projects or activities within their jurisdiction and to issue directions to the said project proponents for keeping such environment clearances in abeyance or withdrawing them, if required, for violations, subject to the condition that the Central Government may revoke such delegations of powers or may itself invoke the provisions of section 5 of the said Act, if in the opinion of the Central Government such a Course of action is necessary in the public interest.
9.	1598(E) 25/06/2014	• Any project or activity specified in category 'B' will be appraised at the Central level as Category 'A', if located in whole or in part within 5 km. from the boundary of: (i) Protected areas notified under the Wildlife (Protection) Act, 1972 (53 of 1972); (ii) Critically polluted areas as identified by the Central Pollution Control Board consisted under the Water (Prevention and Control of Pollution) Act, 1974 (6 of

		1974) from time to time; (iii) Eco-sensitive areas as notified under sub-section (2) of section 3 of the Environment (Protection) Act, 1986, and (iv) inter-State boundaries and international boundaries; provided that for River Valley Projects specified in item l(c), Thermal Power Plants specified in item I (d), Industrial estates/parks/complexes/areas, export processing zones (EPZs), Special Economic Zones (SEZs), biotech parks, leather complexes specified in item 7(c) and common hazardous waste treatment, storage and disposal facilities (TSDFs) specified in item 7(d), the appraisal shall be made at Central level even if located within 10km. Provided further that the requirement regarding distance of 5 km or 10 km, as the case may be, of the inter-State boundaries can be reduced or completely done away with by an agreement between the respective States or the Union Territories sharing the common boundary in case the activity does not fan within 5km or 10 km, as the case may be of the areas mentioned at item (i), (ii) and (iii) above".
10.	2601(E) 07/10/2014	• General conditions shall apply except for project or activity of less than 5ha of mining lease area: Provided that the above exception shall not apply for project or activity if the sum total of the mining lease area of the said project or activity and that of existing. Operating mines and mining projects which were accorded environment clearance and are located within 500 meters from the periphery of such project or activity equals or exceeds 5 ha.
11.	811(E) 23/03/2015	• Paragraph 11 shall be renumbered as sub-paragraph (1) therefore, and after sub-paragraph (1) as so renumbered, the following sub-paragraph shall be inserted, namely:-(2) "Where an allocation of coal block is cancelled in any legal proceeding, or by the Government in accordance with the law, the environment clearance granted in respect of such coal block may be transferred, subject to the same validity period as was initially granted, to any legal person to whom such block is subsequently allocated, and in such case, obtaining of "no objection "from either the holder of environment clearance or from the regulatory authority concerned shall not be necessary and no reference shall be made to the Expert Appraisal Committee or the State level Expert Appraisal Committee concerned".

2.5 EIA procedure for housing projects

EIA is a procedure to examine the environmental consequences or impacts, both beneficial and adverse, of a proposed development project and to ensure that these effects are taken into account in project design. The housing projects fall under category – 8 (a) of EIA Notification, 2006 (as amended). The built up area for the purpose of this Notification is defined as "the built up or covered area on all the floors put together including basement(s) and other service 8(b) of EIA notification deals with townships and area development projects.

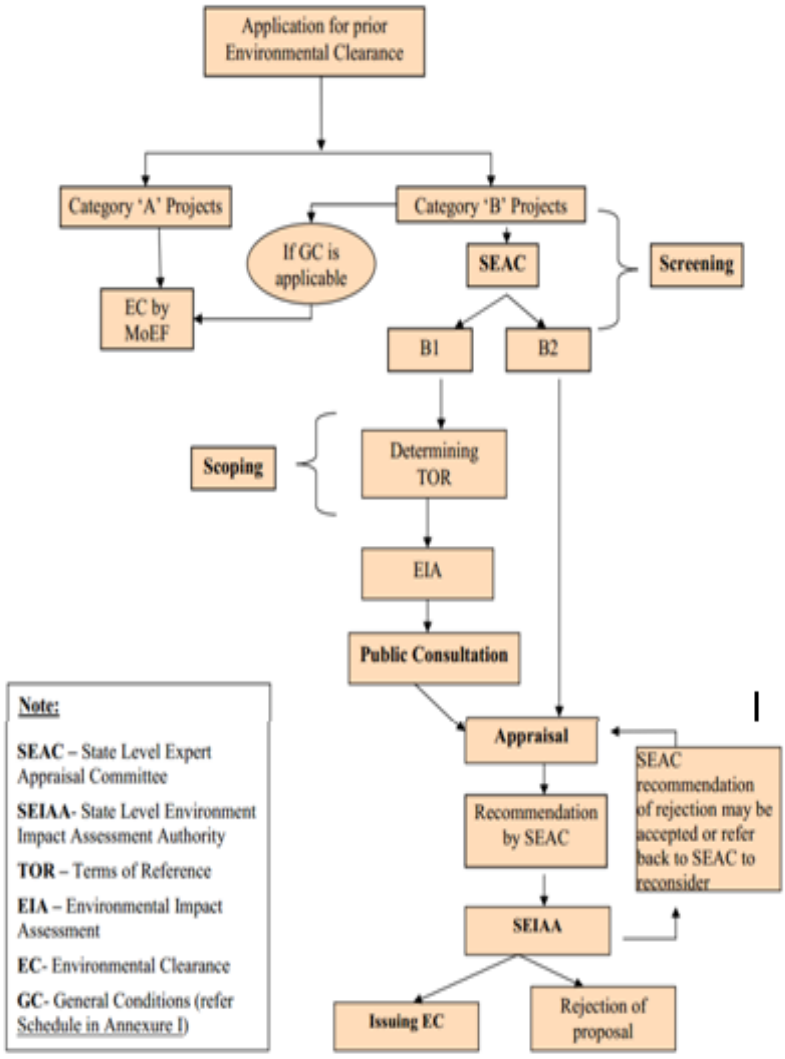


Figure 2.1 Schematic flow diagrams for environmental clearance for housing projects

The EIA is therefore based on predictions. These impacts can include all relevant aspects of the natural, social, economic, and human environment. The study, therefore, requires a multi-disciplinary approach and should be done very early at the feasibility stage of a project. These are: (a) Project Proposal: Proponent embarking on any major development project shall notify independent assessment agency (IAA) in writing by the submission of a project proposal; (b) Screening: Screening is done to see whether a project requires environmental clearance as per the statutory notifications. At this stage, the project proponent decides the type of project and also about a requirement of Environmental Clearance; (c) Scoping: Scoping is used to identify the key issues of concern at an early stage in the planning process; (d) Baseline data collection: This refers to the collection of background information on the biophysical, social and economic settings proposed project area; (e) Impact predictions and assessment of alternatives: Impact prediction is a way of mapping the environmental consequences of the significant aspects to the project and its alternatives. For every project, possible alternatives should be identified and environmental attributes compared. Alternatives should cover both project location and process technologies; (f) Preparation of EIA Report: An EIA report provides clear information to the decision-maker on the different environmental scenarios without the project, with the project and with project alternatives; (g) Public hearing: After the completion of EIA report, public must be informed and consulted on a proposed development; (h) Decision-making: Decision-making process involve consultation between the project proponent and the impact assessment authority; (i) Monitoring and clearance conditions***:*** Monitoring has to be done during both construction and operation phases of a project. It is done not just to ensure that the commitments made are complied with but also to observe whether the predictions made in the EIA reports are correct or not. Monitoring also enables the regulatory agency to review the validity of predictions and the conditions of implementation of the Environmental Management Plan (EMP).

2.6 Previous studies of EIA in city and housing sectors and their major findings

EIA is being used worldwide in order to reduce the harmful consequences of development. It is an illustration of the precautionary principle (Debbarma, 2012) because it focuses on prevention. The primary goal of EIA is ensuring environmental protection and management (Bailey, 1997; Morrison and Bailery, 1999). EIA is typically concerned with the prediction and identification of impacts at a pre-decision level focusing only on the steps before and up to the planning decision but ignoring post development follow-up actions, such as monitoring and auditing (Art, *et al.,* 2001; Glasson, 1995b; Petts and Eduljee, 1993). Moreover, it would seem that the procedural emphasis of EIA upon the pre-decision investigation keeps it isolated from its goal, i.e. environmental protection. In a major study on international EIA effectiveness (Sadler, 1996; Cashmore *et al.,* 2004), it is

found that there was a deficient or poor performance of follow-up activities in EIA. This is considered to be a major weakness of EIA internationally (Arts *et al.,* 2001; Bisset and Tomlinson, 1988; Buckley, 1989a; Dipper *et al.,* 1998; Glasson *et al.,* 1994; Ortolano and Shepherded, 1995; Sadler, 1996; Wood, 2003). There are several previous studies done on the EIA of housing sectors which are summarised with their significant findings in the following table:

Table 2.3: Review of EIA studies in housing sectors and their major findings

S.No.	Authors	Key sectors / parameters	Major findings of the study
1.	Tiwari (2001)	Housing, affordability and development objectives in India	• Affordability of a house and accessibility of building materials for its construction are the most important determinants of access to shelter.
2.	Morel *et al.* (2000)	Building houses with local materials: environmental impact of construction	• By adopting local materials which can be hindered by the loss of traditional building crafts and a lack of appropriate building standards, the amount of energy used in building decreased by up to 215% and the impact of transportation by 453%.
3.	Waddell (2000)	Behavioral simulation model for metropolitan policy analysis, residential location and housing market components	• The rising demand for better coordination of metropolitan land use and transportation planning has led to the need for new analytical tools to observe the potential impacts of land-use and transportation policies and investments. • The residential and market-clearing components of the recently developed Urban Sim land-use model, which is currently being implemented in Hawaii, Oregon, and Utah. • The model is based on parcel-level land-use data which simulates the interface between demand and supply of real estate by using a dynamic behavioral approach that operates on an annual time schedule.
4.	Song and Knaap (2003)	New urbanism and housing values	• The measures of urban form capture meaningful differences in the characters of urban neighborhoods that could well have

			direct impacts on the utility of urban residents. • Some but not all of the design features of new urbanism provide benefits for which urban residents are willing to pay.
5.	Thomson *et al.* (2003)	Health impact assessment of housing improvements	• Consultation with local stakeholders requires to be incorporated to the final assessment. • The lack of data and the difficulties in collecting and reviewing data mean not all HIAs will be able to be informed by research evidence. • Well conducted prospective validation of HIAs would contribute to the development of healthy housing investment by informing future housing HIA.
6.	Song and Knaap (2004)	Effects of mixed land uses on housing values	• Housing prices are higher in communities of single-family use and in which multi-family residential, commercial, industrial, public institutional and public park uses are evenly distributed and prices are also higher with relatively more service jobs. Service jobs in this context include retail, personal services, entertainment, health, education and other professional services. • The research reveals, for example, that proximity to multi-family residential units can depress the prices of nearby single-family housing. • Single family homes were adversely affected by dwelling unit density,
7.	Jim (2004)	Green-space preservation and allocation for sustainable greening of compact cities	• Realization of the green city ideal has changed with prevailing social–economic–political regimes and landscape styles. • Variations in land use and development mode have generated green spaces of different geometry, distribution and composition. • The compact city incurs inherent physical and institutional obstacles, restricting the quantity and quality of amenity vegetation. • A multidisciplinary interpretation distils relevant principles and practices to facilitate

			greening in packed neighborhoods and overcome major constraints. • Measures are proposed to guard green spaces from intrusion, intensification and infilling to preserve both sites and conditions for plants, wildlife and ecological functions.
8.	Gonzalez and Navarro (2004)	CO_2 emissions in the construction field	• A great quantity of CO_2 is emitted to the atmosphere through the different phases of a building life cycle: in the production of materials and products, in the construction of the building itself, in the setting on site, in the exploitation, the renovations, the later rehabilitations, up to the final demolition. • It shows the possibility of reducing the CO_2 emissions up to 30% in the construction phase, through a careful selection of low environmental impact materials.
9.	Camponovo *et al.* (2006)	Building construction systems	• The mass of the building is not a accurate indicator for the environmental impact assessment of buildings. • The nature and the quantity of the insulation influences considerable environmental balance of a building. • The type of material (as steel) needs a lot of non renewable energy for its manufacturing in comparison of wooden materials, thermal insulating bricks and concrete block.
10.	Gerilla, *et al.* (2007)	Environmental assessment of wood and steel reinforced concrete housing	• It was identified that carbon emissions were the topmost pollutants from the housing construction. • The operation phase from both types of housing construction generated the highest carbon emissions. • The construction phase generated the highest emissions from nitrogen oxides (NOx), sulphur oxides (SOx) and SPM. • A longer design life for a residential house gives a reduction of around 14% in carbon emissions. • Also, using solar energy for the operation

			phase has gained a decline of 73% in the total life cycle carbon emissions. • A combination of a 75 year design life and the use of solar energy in the operation phase of the household give around an 84% decline in total life cycle carbon emission. • Planning and design of a housing is required to achieve a reduced emission of carbon dioxide pollutants.
11.	Roy (2007)	Planning Norms for Educational Infrastructures in Planned Townships	• The upcoming norms as adopted in New Town Kolkata are indicative and need proper support in other circumstances like hill areas, bay area etc and also for other economic and social conditions. • The study reveals the modalities, norms, legislations for providing the educational amenities in the planned townships.
12.	Kosal *et al.* *(*2007)	Health Impact Appraisal of eviction versus a housing project in a colony-dwelling Roma community	• HIA (Health Impact Appraisal) identified numerous positive and some probable negative health effects of a housing project. • Despite the uncertainty around some of its predicted effects, the overall health benefit of a housing project clearly outweighed that of eviction. • Although the immediate financial advantages of eviction for the municipal government are clear. It also provides an example that other Roma communities can emulate.
13.	Hoapio and Viitaniemi (2008)	A critical review of building environmental assessment tools	• The study observed that comparison of the assessment tools and their analysis is difficult on different phases of the life cycle, and also have different databases, guidelines and questionnaires. • The environmental assessment tools for building frequently use the predicted service life of a building in the assessments. • EIA includes the environmental aspects, sustainable building assessment and the economic as well as the social aspects.

14.	Altes and Tambach (2008)	Housing on industrial estates as part of compact-city policies in the Netherlands	• Promoting mixed-use development is part of policies aimed at enhancing urban quality. • It was found that traditional amenities such as waterfronts can provide ample potential for housing development.
15.	Xing *et al.* (2009)	A framework model for assessing sustainability impacts of urban development	• It was noted that urban development has special relation with sustainability. • In view of the mounting complexity of managing the swiftly developing urban environment and cities in Europe, there is a need for integrated approaches that assist city planners, developers and councilors in this undertaking. • The start of a procedure of which attempts to build up of an cutting edge of using UD-SAM (in which some UD-SAM; Urban Development Sustainability Assessment Model influences classes were developed by combining current eco friendly growth indicators around various machines) which enables allow decision makers to distinguish sustainability indicators.
16.	Pittet and Kotak (2009)	Environmental impact of building technologies in Kutch District, Gujarat State, India	• The study shows that there are substantial variations of energy consumption and water utilization as well as CO_2 emissions between different walling technologies. • Rammed earth, brick and block as well as stabilized earth technologies represent possible alternatives, in particular if they make limited use of cement/lime mortar and plaster. • The utilize of lime instead of cement as a stabilizer and for mortar and plaster results in an significant augmentation of energy utilization. • Water consumption is presenting totally different figures, in the sense that the technologies that are performing good in terms of energy consumption, CO_2 emissions and destruction phase (unstabilized earth walls and wattle and daub) are those consuming severely higher amounts of water, especially during the maintenance phase.

			• Though, the relevance of this issue could be lowered when maintenance activities that require huge amounts of water are planned according to seasonal variations taking benefit from the plenty of water during the rainy season.
17.	Howley (2009)	Attitudes towards compact city living residential behaviour	• Policy prescription in most Western societies has increasingly favoured urban intensification policies in order to ensure a more sustainable development pattern. • In particular, it is now widely felt that residential decisions concerning where to live profoundly affect, among other things, environmental pollution, resource use and land and habitat loss.
18.	Jie *et al.* (2010)	Environmental Impact Assessment of Land Use Planning in Wuhan City Based on Ecological Suitability Analysis	• Ecological suitability analysis is introduced to the environment impact assessment on land use planning to evaluate the layout of industrial land in urban master plan of Wuhan City. • The land is usually divided into suitable, basic suitable and unsuitable for industrial use related with frequency curve method. • The percentage of suitable, basically suitable and not suitable for land use is 20%, 28% and 52%, respectively. • The land use planning is based on the ecological suitability analysis with evaluation of indicators.
19.	Molnar *et al.* (2010)	Health impact of a Roma housing project in Hungary	• Health Impact Assessment offers purpose as well as multi- disciplinary application for healthy public policy and wellbeing support. • HIA utilize already recent epidemiological as well as social research knowledge. • The case study reveals about HIA (Health Impact Assessment) that is the evaluation of a small-scale housing project for the assessment of health causes of housing initiatives in Roma communities.
20.	Kavgic *et al.* (2010)	Energy consumption in the residential sector	• The lack of publicly available detailed data relating to inputs and assumptions, as well as underlying algorithms, renders any attempt to reproduce their outcomes problematic. • Uncertainty as to the socio-technical drivers of

			energy consumption how people use energy and how they react to changes in their home as a result of energy conservation measures.
21.	Song (2011)	Ecological city and urban sustainable development	• The design of ecological town is a way to solve the problem of sustainability through the construction of ecological city. • The detection of economic and social benefits can also pay more awareness to eco -efficiency, to achieve social, economic and environmental sustainability.
22.	Rasoolimaneshet *et al.* (2011)	City Development Strategies (CDS) and Sustainable Urbanization	• Due to universal changes and changes in urban area the cities face new challenges, and require different approaches in urban planning. • In order to compare the content of CDS (City Development Strategies) and the aspects of sustainable urbanization, three concepts of CDS and one set of elements and activities of sustainable urbanization were pulled out.
23.	Rani (2011)	Housing Finance in India	• Housing finance assistance from the formal institutions found limited to middle and high income groups. • Companies have not been able to go through on rural areas. • Greater part of the financial institutions and banks focus on salaried class people who have regular income. • A large section of the Indian population is out of the formal system housing finance. • Housing finance requires novel steps both at administration level and commercial levels.
24.	Alyamia and Rezguib (2012)	Sustainable building assessment tool	• The comparative study reveals the most reliable and commonly used schemes in the overall context (BREEAM, LEED, SBTool and CASBEE), with particular attention given to the domain of credits distribution (weighting system) and sustainable development criteria in each scheme. • As a significant aspect of the sustainable construction delivery system, these evaluation

			tools are essential to the sustainability in the construction sector. • Certain categories that are considered in both SBTool and CASBEE, such as Economic aspects and Quality of service, have been consolidated in the potential new system, in addition to the most important environmental categories evaluated by BREEAM and LEED.
25	Rai (2012)	Townships for sustainable cities	• It reveals that integrated townships can contribute the required economic and socio-cultural environment favourable to overall development of swiftly developing cities. • Townships would make possible for the appearance of consolidated, economically and environmentally sustainable corridors; also facilitate to create new livelihood and employment opportunities and will support for the growth of tourism, medical and educational infrastructure; as well as enable the sector to meet the infrastructure needs of new sectors of economy such as IT, Biotech, R&D Institutions, etc. • Integrated Townships are the approach for sustainable urban expansion.
26.	Kundu and Roy (2012)	Urbanization and de-sanitation	• In India growing urbanisation is less as compared to many developing and developed countries in the world. • With respect to water supply, all the Government schools rely on public water supply (by the Municipality) whereas the private schools do get water supplied by tankers. • With regard to wastewater treatment, all Government schools have their pipelines attached to the sewer lines, whereas the private schools do have cases of on-site treatment system.
27.	Abdullah (2012)	City Competitiveness and Urban Sprawl:	• The regional planning in 1960s and 1970s has sent poor farmers to the government agencies to develop new towns in the boundary of less

		Socio-economic and Cultural Life in Malaysian Cities	developed places. • A few city centres became rather unattractive urban enclaves devoid of some culturally important elements which existed some time ago.
28.	Li *et al.* (2012)	Public participation in infrastructure and construction projects in China: EIA-based to a whole-cycle process	• The current participatory mechanism at the project level exists only as part of the environmental impact assessment (EIA) process. • With an increasing demand for social equality and PIC (public infrastructure and construction) projects which is quite limited, particularly in the crucial earlier stages, primarily due to traditional culture and values, uneven progress in the adoption of participatory mechanisms, the risk of not meeting targets and lack of confidence in public competence. In China, suggests a need to bring the participatory process in line with international practice. • A process flowchart is proposed to guide construction practitioners and the community in general.
29.	Ren *et al.* (2012)	Local-community-level, physically-based model of end-use energy consumption by Australian housing stock	• To model a housing stock a representative set of 288 dwellings was used, and five key variables: building type, age, family type, occupied time, and primary energy. • The method was validated using actual energy consumption at CCD (Census Collection District—CCD) level in NSW and against the published model by DEWHA (Department of the Environment, Water, Heritage and the Arts) and ESAA (Energy Supply Association of Australia) data at state level. • The model tracks actual energy consumption at CCD level and agrees well with the DEWHA model and actual consumption data at state level. • The model is powerful tool for estimating hourly, daily and monthly energy and residential energy consumption at a range of geographical scales (from CCD to nation). • In Australia, no existing tools combine building physics with explicit occupant patterns at such

			scales.
30.	Zanganeh *et al.* (2013)	Criteria for Housing Sustainability in the Metropolitan Mashhad	• In social indexes, district 9 occupies the highest rank and district 4 the lowest on. • In economical indexes, district 5 is the highest and district 13 the lowest. • In physical indexes, district 11 is on the top and district 7 on the bottom. • In biological indexes, district 12 enjoys the highest rank and district 6 suffers the lowest rank. • Average in the composite index is 0.2526 where district 11 is in the best condition and district 9 in the worst one. • Totally, 15.4% of Mashhad districts are located in beyond-upper-development level, 38.4% in upper-development level, 30.8% in middle-development level and 15.4% in lower-development level in terms of housing. • In sum, dispersion coefficient of 0.7455 shows so much inequality among districts.
31.	Mpofu (2013)	Urbanization and urban environmental challenges in Sub-Saharan Africa	• Urbanization in Sub-Saharan Africa is growing swiftly, due to limited resources and services in the urban areas. • Many cities also cause serious environmental damage to their surroundings and increasingly contribute to global warming. • While the resources are in limited quantity due to urbanization, Wastes degrades the urban environment in Sub-Saharan Africa. • There were millions of preventable deaths each year due to environment-relate diseases and injuries, that is children's before the age of five in many squatter settlements are 40 to 50 times more likely to die than in Europe or North America. • In the majority of cases, there are political causes that create many problems, including unplanned and poorly managed urbanization, as well as ineffective and unaccountable governments.

32.	Zope (2013)	Planning strategies, urban land use pattern	• For the survival of Pune as a Metropolitan city, the sustainable development of the city through effective land use pattern is a challenge. • The complete balanced development in the physical and social infrastructure helps for increasing the economic base of the city.
32.	Betey & Godfred (2013)	EIA and sustainable development in Africa: A Critical Review	• EIA studies do not directly decrease poverty, or bring development or control poor environmental management and performance on the continent. • In EIA, some of the factors that control environmental management include high population growth, illiteracy and low level of environmental awareness. • An informed population is more likely to demand for the adverse impacts of developmental activities. • EIA review and public participation are critical stages that need involvement and inputs from well-informed and interested stakeholders. • Communities do not posses benefit from projects located in their area because of ignorance on their part, and corruption and lack of accountability of officials and localities.
33.	Sharifi and Murayama (2013)	A critical review of seven selected neighborhood sustainability assessment tools	• Most of the tools are not doing well regarding the coverage of social, economic, and institutional aspects of sustainability; there are ambiguities and shortcomings in the weighting, scoring, and rating; in most cases, there is no mechanism for local adaptability and participation; and, only those tools which are embedded within the broader planning framework are doing well with regard to applicability.
34.	Vatalis *et al.* (2013)	Sustainability components affecting decisions for green building projects	• The study indicates how participants prioritized the sustainability components ensuring a better quality of life inside buildings based on the principals of "green" buildings economy. • Energy efficiency and renewable energy is considered of high priority followed by the

			reduction of toxic materials, indoor pollution and water saving. • At the moment due to deep economic crisis, there is no strategy for green construction projects in Greece. • The development of experience, knowledge of economic benefits and competence will encourage developers, occupiers and authorities to support an interactive strategy among the different actors involved in construction in the country.
35.	Wang *et al.* (2014)	Improving benefit-cost analysis to overcome financing difficulties in promoting energy-efficient renovation of existing residential buildings in China	• Benefit-cost analysis is extended to include the ratio of energy-saving benefit to investment cost (EnIR), the ratio of environmental benefit to investment cost (EvIR), and the ratio of economic benefit to investment cost (EcIR). • The modified ratios can increase awareness of residents in respect of their individual benefits from the adoption of the optimum plans, and can attract them to co-invest. • The ratios are applied to a case study building in Hangzhou. Based on the results, a "win–win" model, consistent with market principles, is developed, in which both the government and residents can co-invest and co-benefit. • The model has proven to be an effective decision-making tool in promoting the building renovation policy in China.
36.	Medineckiene *et al.* (2014)	Multi-criteria decision-making system for sustainable building assessment/certification	• ARAS (Additive Ratio Assessment) method (MCDM; Multi-criteria decision-making method) is applied to solve problem under investigation. • The developed assessment method involves LEED system's criteria.
37.	Li *et al.* (2014)	Methodology for ex-post assessment of social impacts of an	• Affordable housing projects are becoming increasingly important in China, and they have remarkable social impacts. Yet, there is lack of appropriate methodologies for ex-post assessment of those social impacts.

		affordable housing project	• The project has produced quite positive social impacts, and reveals the improvement directions at category level, where SE (socio- economic effects) should be the emphasis and SR has the largest potentiality. • At indicator level, reducing crime cases around the studied project, providing better communication and water supply facilities of the studied project and improving the outbound public transport of the studied project are pressing issues.
38.	Koo *et al.* (2014)	New energy efficiency rating system for existing residential buildings	• The correlation between the household size and the CO_2 emission density was negative (–0.456), indicating that there is the irrationality in the conventional energy efficiency rating system. • The large-household-sized building has a lower CO_2 emission density just because it has a larger area; thus, it will get the more carbon point. However, this is caused by the irrationality of the conventional carbon point system, which is based on the historical energy consumption.
39.	Moja and Mnguni (2014)	EIA regulations in the Construction of Low Cost Houses in Newcastle, South Africa	• EIA regulations were not adequately implemented and several residential sites were unsuitable for the construction of RDP (Reconstruction and Development Programme) houses. • The study further reveals that public participation is not highly considered yet high participation from the public leads to a comprehensive and better decision making. • The findings indicate that there may be lack of proper implementation of EIA following main steps, in line with international practice. This could be due to lack of enforcement from Environmental Management bodies. • The study concludes that there's a need to improve the EIA administration system to ensure sustainable development.
40.	Islam *et al.* (2014)	Life cycle cost and environmental	• Two sets of objective functions, namely life cycle cost and environmental impacts were evaluated for each housing design using life

		impacts on residential building design	cycle costing and life cycle assessment approaches, respectively. • The use of Linear Programming helped to identify alternative best designs depending on single-objective (SOO) or multi-objective optimization (MOO). • Outcomes from SOO depended on the choice of particular objective function, while outcomes from MOO depended on the decision-makers preferences in terms of weightings. • A high star-rating weatherboard house with ceramic tiles and wooden floor, and skillion flat roofing was the best design if the weighting of all five objective functions were equal. • A house designed with these optimal wall, floor and roofing had a much higher rating (by 1.3 stars), lower environmental impacts (by 10–20%) for the same life cycle cost.
41.	Ye *et al.* (2014)	Green Building Standards in China	• There are 17 green building standards (including those under development) at country level and another 50 or more at provincial level in China. • Based on background and status overview of green building standards, problems are analyzed. • It is followed by a systemic scheme for green building standard system, which includes 3 layers of basic, general and specialized standards, and its development planning as well.
42.	Wang and Holmberg (2014)	Energy-demand savings and cost effectiveness of retrofitting in existing Swedish residential buildings	• Swedish residential buildings are typically retrofitted on a case by-case basis. • The model indicates that the energy saving potential of retrofitting is 36–54% in the archetypes. However, retrofits with the largest energy-saving potential are not always the most cost effective. • The long-term profits of retrofitting are largely dominated by the building types. • The finding can contribute to the standardization of future retrofitting designs on municipality scale.

43.	Cetine and Edis (2014)	Retrofitting of residential buildings, LCA approach	• It reveals about a method for evaluating the retrofits applied to the building elements of existing separated residential buildings with a natural gas-fired central heating sys-tem to increase their environmental and economic sustainability by reducing space conditioning energy consumption during their remaining life. • In environmental concern, it is based on the LCA approach. • The overall sustainability performance can be calculated by both environmental and economic performances together. • Energy consumption and environmental impacts of each building type were determined by computer simulations.
44.	Lutzkendorf *et al.* (2015)	Embodied impacts of Net-zero buildings	• The design and assessment of net-zero buildings commonly focus exclusively on the operational phase, ignoring the embodied environmental impacts over the building life cycle. • The consequences of integrating embodied impacts into the assessment of the environmental advantageousness of net-zero concepts. • Fundamental issues needing consideration in the design process – based on the evaluation of primary energy use and related greenhouse gas emissions – are examined by comparing three net-zero building design and assessment cases: (1) No embodied impacts included, net balance limited to the operation stage only; (2) Embodied impacts included but evaluated separately from the operation stage; and (3) Embodied impacts included with the operation stage in a life cycle approach.
45.	Kumar *et al.* (2015)	Climate, food security and poverty: Agent-based assessment of policy options for farm	• According to the majority of regional climate projections, Sub-Saharan Africa (SSA) will likely become warmer in the next decades and rainfall patterns will substantially shift. • Understanding the effect of climate variability on food security and poverty and identifying effective adaptation measures in the context of subsistence agriculture is imperative to ensure

		households in Northern Ghana	food security now and in the future. • Substantial difference in the poverty and food security status of households due to climate and price variability. • Provision of agricultural credit and access to off-farm employment are found to be highly effective policy entry points that deserve more empirical research.
46.	Wernham and Teutsch (2015)	Labor on housing reconstruction : A system perspective	• The designed model presents the dynamics of labor acquisition including vacancy creation, hiring and layoff for housing projects. • The aspects of training and experience for the workers in the laboratory or force can be explored more deeply with the objective of improving the hiring policies and stability of the system. • The financial aspect is also an area for exploration, to analyze the economic implications, in short and long term, deriving from the management policies.

2.7 Sustainability, green city concepts and housing projects

In 1980, for the first time the term sustainability was used by IUCN as World Conservation Strategy followed by the United Nations Food and Agricultural Organization (FAO) in 1988 as sustainability is the handling and conservation of natural resources and the orientation of technological and institutional change so as to ensure the continuous satisfaction of human needs for present and future generations. Sustainability is the capacity of the earth to maintain and support life and to persist as a system (Li *et al.,* 2009). In other worlds, sustainable development means the capacity to meet the needs of the present generation without compromising the ability of future generations to meet their own needs. The concept of sustainability is debatably significant to systems from the global to the local scale. Sustainable housing is actually a form of affordable housing, which contains eco-friendly and community-based practices. It is an attempt to reduce a detrimental influence that homes can have on the environment through the way of deciding on greater creating supplies and environmentally friendly designs (Gilkinson and Sexton, 2007). A number of studies have evaluated environmental sustainability indicators that support Strategic Environmental Assessment (SEA) and EIA (Gonzalez *et al.,* 2013).

Several practical applications are also discussed by the urban planners for the urban planning (Kennedy *et al.,* 2011). Green city and infrastructure are a new term but not a new idea (Benedict *et al.,* 2006). The concept basically links green areas to human habitat for improved health benefits. They are desirable, green cities in the form of private gardens largely depends on the socio-economic status of individuals and thus may not provide enough opportunity for everybody to enjoy benefits to health and well being. Green cities will help the government reach targets to increase levels of physical activity and to provide a significant economic reason to maintain green space. In the Green areas, the stress level was found to be much lower than in built-up areas (Ulrich, 1997). Less sickness was reported among prisoners who had greater contact with green areas (Moore, 1981). Residents of areas with good green infrastructure demonstrated increased longevity, a higher level of physical activity as well as better health among senior citizens (De Vries *et al.,* 2003). Viewing green spaces from the residence is shown to reduce psycho-physiological stress, intra-familial aggression as well as improving blood pressure, muscle tension and skin conductance (Hartig, 2008; Kaplan, 1995; Lafortezza *et al.,* 2009; Li *et al.,* 2005).

2.8 Land use planning and EIA of housing projects

Land use planning plays an important role in sensible distribution of land resource and organization of land use (Steiner et *al.,* 2000). Excellent distribution of land resources can be achieved by proper land use planning taking into account in the aspects of land scale, land use arrangement and spatial distribution. Improper land use planning disturbs the regional eco-environmental quality, ecosystem services, and also effect regional social-economic environmental system by changing land use patterns and structure. Rational land use planning can endorse rapid development of regional economy and sustainable usage of land resources (Marull *et al.,* 2007).

Studies of environmental impact assessment on land use planning have been initiated in China, and are still on the exploratory stage (Cheng and Wang, 2002; Ge *et al.,* 2009). Those studies are mainly concentrated on improving the evaluation system, exploring the evaluation methods and so on (Cai *et al.,* 2003; Ge *et al.,* 2009; Dong *et al.,* 2006) and (Jia et *al.,* 2009). Quantitative analysis of environmental effects and processing of spatial information are the most challenging procedures which have no generalized evaluation approaches at present.

Ecological suitability analysis of land use is a comprehensive utilization of ecology, earth science, system science, environmental science and computer science to figure out land development and utilization suitability for searching the best pattern and planning of land use. Checklists, matrix methods, overlay methods, scenario analysis, GIS and RS play a significant role in environmental prediction. Ecosystem service valuation method, Delphi

method, fuzzy AHP modeling techniques, GIS and RS, are helpful in identifying, forecasting, and analyzing hidden the environmental importance of housing projects and Land use planning.

Different kinds of EIA models have been used by different scientists to study the different environmental impacts like Marull and their coworkers (2007) used the land suitability index, which is a transparent and standard hierarchical system, for the critical environmental assessment in the metropolitan areas, Stoms *et al.* (2002) used the land use suitability as a method in fuzzy assessment for research reserves, and Steiner *et al.* (2000) used the ecological suitability analysis for upper Gila River watershed.

2.9 Remote Sensing and Geographical Information System (GIS)

Remote Sensing is defined as- " the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation". Recent advancement in RS technology are of great importance in acquiring data in more efficient way which is beneficial in quick change detection and effective resource management. Remote sensing technology may be divided into three phases: (i) data collection from a sensor mounted on a platform eg. a satellite; (ii) data handling; (iii) data interpretation which end up in producing some thematic maps of the investigated surfaces. Data acquired by RS is interpreted with the help of GIS software's.

Geographical Information System (GIS), is composition of traditional sciences, contemporary science and technology. GIS is a tool for management, manipulation, analysis, modeling, representation of geographical information recorded with the help of RS. Data entry, data display, data management, information retrieval, and analysis are the functions of GIS. In GIS software's geo-referenced data is analyzed in four steps captures, stores, analyses, manages, and presents data, which is linked to locations or having spatial distribution . It is a computer-based system that provides four sets of competence to handle geo-reference data like data capture (digitized, converted from existing data), data storage and manipulation, data analysis (database query, spatial analysis and modeling), and data display (maps and reports).

Data acquisition refers to the process of identifying and collecting the data required for the application. After data acquisition, the methods used to covert a dataset into a suitable format for input into the GIS is known as pre-processing. Data format conversion, such as digitization of maps and printed records and recording this data into a computer database, is the key step in preprocessing. Preprocessing also contains map projection, data reduction and generalization, error detection, and interpolation. Generally, data sets are manipulated before and after entering into the computer in such a way that they are

mentioned to a common geodetic coordinate (e.g. Universal Transverse Mercator (UTM)), orientation and scale. There are many GIS software's as per your needs e.g; ERDAS, ArcView, ArcGIS, SWAT, which allow developers to add dynamic mapping, improves image quality, overlapping etc.(Ormsby *et al*., 2010)

The datasets can be manipulated as needed by the analysis. Some of the operations used in data manipulation are analogous to those used in pre-processing. Many types of analyses are feasible within a GIS; among these are mathematical combinations of layers, Boolean operations and, with external programs using the GIS as a database, complex simulations. Final output of GIS is fully classified map or image which is easy to understand and pass minimum noise.

2.10 Role of Fuzzy logic in EIA

EIA is based on a series of mathematical, satellite based knowledge as well as techniques which try to localize, describe and assess the positive and negative hazards that any human activity has on our environment, generally causing it to deteriorate the balanced environmental conditions. The major agenda of EIA is to predict and minimize the adverse impacts suffered by the environment as a result of sustaining all human activity (Moron *et al.,* 2009). The significance of the fuzzy set theory (Zadeh, 1976) can improve the study of EIA. A fuzzy logic knowledge based idea can be used for the EIA study of housing and construction projects.

Fuzzy logic has been fruitfully applied in different field of environment. A number of index examples of such applications can be quoted in the last two decades, such as surface water and ground water remediation (Tzionas *et al.,* 2004; Nasiri *et al.,* 2007), soil management (Busscher *et al.,* 2007), air pollution management (Fisher, 2003) and diverse air, water and terrestrial ecosystem environmental studies (Astel, 2007). The use of remote sensing and geographical information system help to collect the information related to land use, urban sprawl, unifying water quality sampling data, disasters associated information and is also used to predict many types of non-point source (NPS) pollution and many more. For this type of study GIS was proved an excellent tool as it eases the integration of many layers of information over a large area. To develop a comfortable environment housing project and housing project societies.

Spatial database produced by this study is also helpful for architecture, researchers and planners. EIA is a advantageous method for preserving natural resources and protecting the environment (Peche and Rodriduez, 2011). Therefore, most advanced countries have introduced EIA into their policy and for the subsequent approval of all projects (like Council of European Union, 1996; EPA, 2007). The EIA of any project requires the evaluation of the effects of every different action on a number of various

environmental factors. The uncertainty and imprecision being inherent in the process of finding values to environmental impacts carried out by a panel of experts, stakeholders and affected population and for these reasons fuzzy logic is a suitable and useful tool to implement or carry out with EIA (Peche and Rodriduez, 2011). The unique features of it is also monitoring of construction works specially as being long period projects including tough processes, abominable environment, financial strength and dynamic organization structures (Smith, 2003; Tyalan, *et al.,* 2014).

Tam *et al.* (2004) conducted a survey to examine the fate of poor construction safety management. Patrick, *et al.*(2002) presented eighty-eight risk factors associated with construction project agenda in terms of cost, time, quality, environment and safety. Tah and Carr (2000) proposed the application of fuzzy logic for risk assessment of construction projects. Similarly, fuzzy system is a very useful technique in tackling the complex problems of construction risk assessment. On the other hand, Kuchta (2001) applied fuzzy numbers in risk evaluation of construction projects. Zeng, *et al.* (2007) applied fuzzy set theory to aggregate the performance of cost and time in management of construction projects, risk management and utilization.

2.10.1 Fuzzy AHP method and fuzzy number

Fuzzy AHP method was applied to create favorable weights for fuzzy linguistic variable of construction project risk assessment. Fuzzy AHP method is a systematic method to the alternative choice and justification of problem by using the approach of fuzzy set theory and hierarchical structure study (Wang, *et al.,* 2009). In this way the decision maker can specify preferences in the form of natural language or numerical value about the importance of each performance criteria. The system combines these preferences using FAHP with accessible data. In FAHP method, the pair-wise distinctions in the judgment matrix are taken as fuzzy numbers. It uses fuzzy arithmetic and fuzzy summing operators. Then the procedure calculates a series of weight vectors which is used to choose the main attributes (Gungor, *et al.,* 2009).

In construction projects overall risk assessment is a multi criteria decision making (MCDM) approaches which in complication in reference of decision making, each factors are given suitable attributed values and relative weights are typically toned by fuzzy numbers (Torfi *et al.,* 2010). A fuzzy number is a convex fuzzy set, characterized by a given interval of real numbers, each with a grade of membership between 0 and 1. The most familiar used fuzzy numbers are triangular and trapezoidal fuzzy numbers. The membership or non-membership to a fuzzy set is plane and gradual. The membership degree of a set is characterized by membership functions that give fuzzy sets flexibility in modeling with normally used linguistic expressions, such as ‘the project threat is high’ or

'the time extent of project is short,' and 'the quality of construction project is poor' or 'the cost of project is high etc.

As it is presented in Table 2.4, fuzzy linguistic values are frequently presented by specific terms in the real life, but they can also be represented by fuzzy numbers. It is typically suitable to characterize the degree of subjective judgment in qualitative side than in crisp value (Chen *et al.,* 2011). The word risk is a qualitative and vague concept that can be defined by fuzzy linguistic terms.

Table 2.4: Fuzzy linguistic variables and their terms

Fuzzy linguistic variables	**Linguistic terms**
Time	Short, average, long, very long
Cost	Low, average, high, very high
Quality	Poor, average, high, very high
Safety	Unsafe, average, safe, very safe
Environmental sustainability	Unsustainable, little-sustainable, sustainable, highly-sustainable

Source: *Taylan et al., 2014*

2.10.2 Fuzzy Logic Method

Zadeh (1965) set forth fuzzy logic theory as an approach for dealing with conditions where classes were not transparently defined. Zadeh noted that imprecisely defined classes describe much of human thoughts. In classic set theory, an item is either a member of the set (1) or not a member of the set (0), Fuzzy logic grants for gradations between full membership and full non-membership (Guertin *et al.,* 2000). Fuzzy logic, though, can model the conclusion of gradients or variables between high and low as well as the analogous significance of diverse environmental issues (Openshaw and Openshaw, 1997). Fuzzy logic also allows the use of expert idea and experience in the modeling process. One big benefit of the fuzzy logic approach is that it provides a composite fuzzy score, a value between 1 (high) and 0 (low). The composite fuzzy score is easy to decode and understand the significance of cases (Openshaw and Openshaw, 1997). Fuzzy logic analysis is well flourish to data poor environments. Unknown data points can be handled within the fuzzy membership function. Extra variables can be added to produce a complex system of modeling to point out the association between management agenda and environmental parameters (Guertin *et al.,* 2000). The analytic hierarchy process (AHP) is frequently interrelated to the fuzzy logic method. Bascetin (2004) noted that AHP and fuzzy logic have been systematically used as tools to deal with "inherent imprecision" in a wide range of problems. Saaty (1980) developed the AHP method which aids the decision

makers to take suitable decisions at finer level, working throughout the goal, objectives, sub-objectives and another parts of action. Decision makers continue through a series of simple pair-wise distinct judgments throughout the hierarchy to produce overall priorities. Siddiqui et *al.* (1996) showed how AHP could be used to find the most useful site for a solid waste land filling. Fuzzy logic study results in a combined fuzzy score, which is a continuous range between zero and one. This continuous range gives improved spatial variability found in natural systems as well as appropriateness of any projects.

2.10.3 Fuzzy Logic Modeling

Fuzzy logic is significant at modeling uncertainty or gradations (Guertin *et al.*, 2000). In fuzzy set theory, an item is either part of a set (1) or not parts of the set (0) are given marks or numbers. Though, most environmental variables cannot be described effectively in a binary mode. Fuzzy logic takes into consideration of old areas (Reynolds, 2001). Another advantage of fuzzy logic study is that it incorporates opinion of expert and stakeholder values (Guertin *et al.*, 2000; Reynolds, 2001). The weights and fuzzy membership functions were finding in discussion with Dr. D. Phillip Guertin of the University of Arizona and experts from ADEQ. Fuzzy logic analysis is particularly well suitable for data poor environments management (Guertin *et al.*, 2000; Reynolds, 2001). Inability of AHP to deal with the imprecision and subjectiveness in the pairwise comparison process have been improved in Fuzzy AHP.

Instead of single crisp value, in Fuzzy AHP use a range of value to incorporate decision maker's uncertainty. From this range decision maker can select the values that reflect his confidence and also he can specify his attitude like optimistic, pessimistic or moderate (Jeganathan 2003). Optimistic attitude is represented by the highest value of range, moderate attitude is represented by the middle value of the range and pessimistic attitude is represented by the lowest value of the range

Fuzzy AHP modeling techniques was used after the calculation of carrying capacity. In Fuzzy AHP triangular or trapezoidal fuzzy number are used to represent the decision maker’s assessments on alternatives with respect to each criterion. The concept of fuzzy extent analysis is applied to solve the fuzzy reciprocal matrix for determining the criteria importance and alternative performance. The alpha-cut analysis is used to transform the fuzzy performance matrix representing the overall performance of all alternatives with respect to each criterion into an interval performance matrix, to avoid the complex and unreliable process of comparing fuzzy utilities. An overall performance index is obtained for each alternative across all criteria by applying the concept of the degree of similarity to the ideal solution using the vector matching function (Deng, 1999).
The steps required for Fuzzy AHP developed by Hepu Deng (1999) and then modified by Jeganathan (2003) for the assessment is as follows:

1. Acquisition of Normal (crisp) Pairwise Comparison Matrices (PCM)
2. Fuzzifying the crisp PCM to Fuzzy PCM
3. Fuzzy Extent Analysis for Calculation of Performance ratings
4. Weightage Multiplication from Hierarchy
5. Alpha cut analysis for embedding uncertainty of Decision Maker confidence
6. Lambda function for embedding Attitude of the Decision Maker
7. Normalizing the Effect table
8. Positive and Negative Similarity Vector Identification
9. Similarity measurement using Vector Matching Function
10. Final Performance Index Measurement.

The current research uses the same procedure from step 1 until step 7, then using the weight summation method and normalization to obtain the final actual performance and passing performance. To perform Fuzzy AHP assessment the current research use Mathlab and Microsoft Excell software.

2.10.4 AIEIA: Software for fuzzy environmental impact assessment

AIEIA is a software program for the complete management of environmental projects which was developed using the fuzzy set theory (Zadeh, 1976), object-oriented programming methodology and information management with databases. Not only does this software tool to execute the fuzzy environmental impact study (FEIS), but it also implemented with fuzzy decision-making tools (Moron *et al.,* 2009). These techniques are used to find out the best implementation of results and alternative for a project. Taking it into consideration not only the environmental impact produced in each choice, but also other variables such as those of an economic, political, social or cultural nature of cases. This software has a number of functions for the study of EIA of a project management, and Information management as well as calculation of the fuzzy environmental impact study (FEIS). The benefits of AIEIA software can improve the EIA model and EIA mechanism.

2.11 EIA Methodologies

The EIA methodologies can be categorized into following classes.

2.11.1 Adhoc Methods

Adhoc methods are the easiest methods of conducting EIAs, as they do not create problem and is more amenable to systematic study. In this procedure a team of multidisciplinary experts assembles to recognize broad areas of environmental impacts and ultimately comes to the result of probable impacts, which are in the terms of positive (+), negative (-), no effect, problematic, beneficial, adverse, short term, long term, reversible and irreversible etc. conclusions of each expert's are based on a particular combination of

experience, training and intuition. The generated conclusions are eventually assembled into a report.

2.11.2 Checklists

A checklist contains a list of environmental parameters to be investigated for probable impacts. They therefore ensure complete coverage of environmental aspects to be studied. Checklists may or may not contain guidelines about how impact-relevant parameters are to be measured, interpreted, and compared. They are a more formalized version of adhoc approaches in that particular areas of impact are listed and information are provided for impact detection and estimation.

2.11.3 Matrix Methods

A matrix method includes interactions between various project actions and environmental parameters and components. They incorporate a list of project activities with a checklist of environmental components that might be affected by these activities. A matrix of potential synergy is produced by combining these two lists (placing one on the vertical axis and the other on the horizontal axis). Matrices require information about both the environmental components and project activities. The cells of the matrix are replete in using subjective (expert) judgment, or by using wide data-bases.

There are two general types of matrices i.e. simple interaction matrices and significance or importance-rated matrices. Simple matrix methods simply identify the potential for interaction whereas significance or importance-rated methods need either more extensive databases or more experience to prepare. Values given to each cell in the matrix are based on scores or assigned ratings, not on measurement and conducting tests. For example, the significance or importance of impact may be classified (no impact, insignificant impact, significant impact, or uncertain). On the other hand, it may be assigned a numerical score (for example, 0 is no impact, 10 is maximum impact).

2.11.3.1 Leopold Interaction Matrix in EIA

Interaction matrices are one of the most primitive methods used in assessment of environmental impacts. The simple matrix refers to a display of project actions or activities on one axis, with suitable environmental factors listed on the other axis of the matrix. The matrix method developed by Leopold *et al.,* 1971, is an illustration. Leopold interaction matrix is a comprehensive matrix, which had initially 88 environmental characteristics, along the top axis, and 100 project actions in the left hand columns (Leopold *et al.,* 1971). This method is flexible and allows extension of component or characteristics to be affected by the environment. It shows the relations between causes and effects or actions and impacts relationship. It enables the researcher to make unbiased decision which depends on experience. This method employs the use of scaling to rate environments quality. Possible impacts are marked in the suitable cell and a numerical values are assigned to indicate their

magnitude and significance. Typically the numerical value ranges from 1, for small magnitude, to 10, for large magnitude. The assignment of numerical values is based on an assessment of available facts and data. In the same way, the scale of importance also ranges from 1, for very low interaction, to 10, for very important interaction. The numbers are used to identify concern arising from the interaction of project activities with the environment (PME/UNEP, 1989; Ghurayba and Alfarhan, 2000). Assignment of numerical values for significance is based on the subjective judgment of the interdisciplinary team working on the EIA study.

2.11.3.2 Previous studies of Leopold Matrix in EIA

The use of Leopold interaction matrix in the EIA processes has been cited in several literatures. The EIA of Nigeria national petroleum corporation mega station was done using Leopold matrix and other environmental assessment techniques to find out the impact of interactions between the station developmental activities like temperature, rainfall, soil, water and air qualities (Akintunde and Olajide, 2011). Impact Significance Determination (ISD) is one of the most important tasks in EIA activity of IMPERIA project using Leopold matrix (Marttunen *et al.*, 2013). According to (Petra, 2009), the Leopold matrix method helps to represent the interactions between project activities and environmental components and also identify the environmental effects and impacts. Environmental impact of Uakari Floating Lodge, through an adaptation of the Leopold Matrix, evaluates the magnitude and importance of their environmental impacts (Pedro, 2012). It was found that 28 environmental aspects in Uakari Lodge, being 'generation of domestic wastewater' and 'accumulation of used batteries' are the most important internal aspects, and 'consumption of lubricating oil and fuel in motor boats rides' and 'production of gases from fuel combustion in boat rides' are the most important external aspects. All of them were recognized as environmental aspects with potential for Direct 84.6%, Reversible 76.9%, Insignificant 46.2% or Moderated 53.8%, and Local 100% impacts. The results specify the environmental aspects raised have low impact to the natural environment, considering the enterprise scale. Evaluation of possible environmental impacts for Barapukuria thermal power plant and coal mine was done using Leopold matrix (Alam, *et.al.*, 2011). Graded matrix system was used to indicate the magnitude and importance of the impacts by numerical values (Leopold *et al.*, 1971). The Leopold matrix depicted a result of totalling + 950 positive scores, definitely favors to environment. It is clear from the analysis that the Mn concentration was found in the acceptable range. The pH was found slightly alkaline and surface water was bacteria infected. SO_4^{2-} concentration was in the range of WHO standard. Calculated SO_x loading was almost same of monitored release. Corresponding estimated concentration of SO_x was in satisfactory range, which may not bring any matter of concern. In the study, an attempt was also made to assess the health impacts of SPM suspended particulate matter emitted from the combustion of coal in the power plant. The socio economic situation was also considered a dominating factor, for the EIA along with

the chemical parameters since increased employment for the project. Kaur and Arora (2012) studied the importance of EIA in the sustainable development of a construction project with a case study of an upcoming Multiplex in Ballo, Majra near Mohali Punjab using leopold matrix method and the project scored -350 points with mitigation measure. This indicates that there would not be significant impact on the environment with suitable environmental control measures.

2.11.4 Network diagrams

A network diagram is a technique to illustrate how impacts are associated and what the results of impacts are. Network diagrams provide a means to display first, secondary, tertiary, and higher order impacts. To develop a network, a series of questions related to each project activity (such as what are the primary impact areas, the primary impacts inside these areas, the secondary impact areas, the secondary impacts within these areas, and so on) must be answered. In developing a network diagram, the first step is to recognize the first order changes in environmental components. The secondary changes in other environmental components that will result from the first order changes are then identified. In turn, third order changes resulting from secondary changes are identified. This process is continued until the network diagram is finished to the practitioner's satisfaction. The network helps in exploring and understanding the fundamental association between environmental components that produce higher order changes that are often overlooked by simpler approaches.

2.11.5 Overlays and GIS techniques

Overlays & GIS are spatially based methods. Overlays provide a technique to illustrate the geographical extent of different environmental impacts. An overlay is based on a set of transparent maps, each of which represents the spatial distribution of an environmental. Information for an array of variables is collected for standard geographical units within the study area, and recorded on a series of maps, typically one for each variable. These maps are overlaid to produce a composite. The resulting composite maps characterize the area's physical, social, ecological, land use and other relevant characteristics, relative to the location of the proposed development. To examine the degree of related impacts, any number of project alternatives can be located on the final map. Essentially, the overlay method divides the study area into convenient geographical units based on consistently spaced grid points, topographic features, or differing land uses. Field surveys, topographical land inventory maps, aerial photography, etc., are used to assemble information related to environmental and human factors within the geographical units. Factors are composed by assembling concerns that have a common basis, and regional maps are drawn for each factor. GIS techniques are popular in situations where the computer technology and trained personnel are accessible. Computers are used normally to

do cluster analysis of complex overlays. The important application of GIS is the construction of real world models based on digital data. Modeling can inspect trends, identify factors that are causing those, reveal alternative paths to solving the given problem, and specify the implications or consequences of decisions. A GIS approach can point out the change in quantitative terms (for example, in new area development). The impact of development plans on the environment can be assessed by integrating data on land use with topographic and geologic information. GIS is also used in determining optimal routes for communications, irrigation, and road maintenance. Network modeling to connect various data bases can also be done.

3 STUDY AREA

Among its vastly populated world of towns and cities, the state of Uttar Pradesh is the largest sovereign national jurisdiction (state) in the world, having a population of 199.6 million (Census of India, 2011). It is the second largest state-economy in India contributing 8.17% to India's total GDP between 2004 and 2009. Lucknow is located in the central region of Uttar Pradesh and the Capital of the biggest populated states in India. It is located between 26º 30' and 27º 10' in the north latitude and 80º 30' and 81º 31' east longitude with a population of 4.5 million and a geographical area of about 2528 sq. km out of which the city occupies about 300 sq. km (Figure 3.2).The main urban areas of Lucknow are situated on the southern part of the river Gomti. Three National Highways and other five Provincial Highways serve the region of Lucknow. Kanpur and Lucknow are separated only by 80 km. In recent years, Lucknow-Kanpur; Lucknow-Sitapur and Lucknow-Faizabad areas have become regions of intense interaction reflected by changes in land use, mushroomed development in all sectors of the economy. The city is situated 23 meters above sea level. It is surrounded on the eastern side by District Barabanki, on the western side by district Unnao, on the southern side by Raebareli and on the northern side by Sitapur and Hardoi districts. River Gomti flows through the city. Some of the tributaries of this river are Kukrail, Loni, Beta etc. Sai river flows from the south of the city and in the east enters district Raebareli. Lucknow is accessible from every part of India through Air, Rail and Road. It is directly connected with New Delhi, Patna, Calcutta, Mumbai, Varanasi and other major cities by Amausi airport. Similarly city is linked to north, east, south and west through rail and road links.

Lucknow has changed from small, isolated population center in early 1990s to large, interconnected urban complex today having diverse economic, physical, and environmental features. The temporal and spatial dimensions of the land use changes that shaped urbanization are little known. The city has seen a steady increase in population arising from natural growth, incorporation of peri-urban areas in 1980's and large-scale migration. The population growth projected in the Master Plan 2021 varies between 3.51 to 4.37 per cent per year over different 5-year periods until 2021, somewhat higher than for average growth rate of cities of similar size in the country and state (Table 3.1).

Table 3.1: Urban sprawl and population growth in Lucknow starting 1901

Year	Area		Population		Density/ sq.km.
	sq.km.	**% growth/year**	**(000)**	**% growth/ year**	
1901	44.03	-	256	-	5814
1973	80.00	1.13	857	3.26	10712
1988	143.32	5.29	1224	2.50	8540
1992	159.26	3.99	1723	10.19	10819
1997	196.50	7.45	2012	3.36	10239
2011	303.63	3.89	3200	4.21	10539
2021*	414.34	3.65	4500	4.06	10861

*(**Source:** compiled from various historical maps, survey of India toposheets and census data, *projected in the Master Plan 2021)*

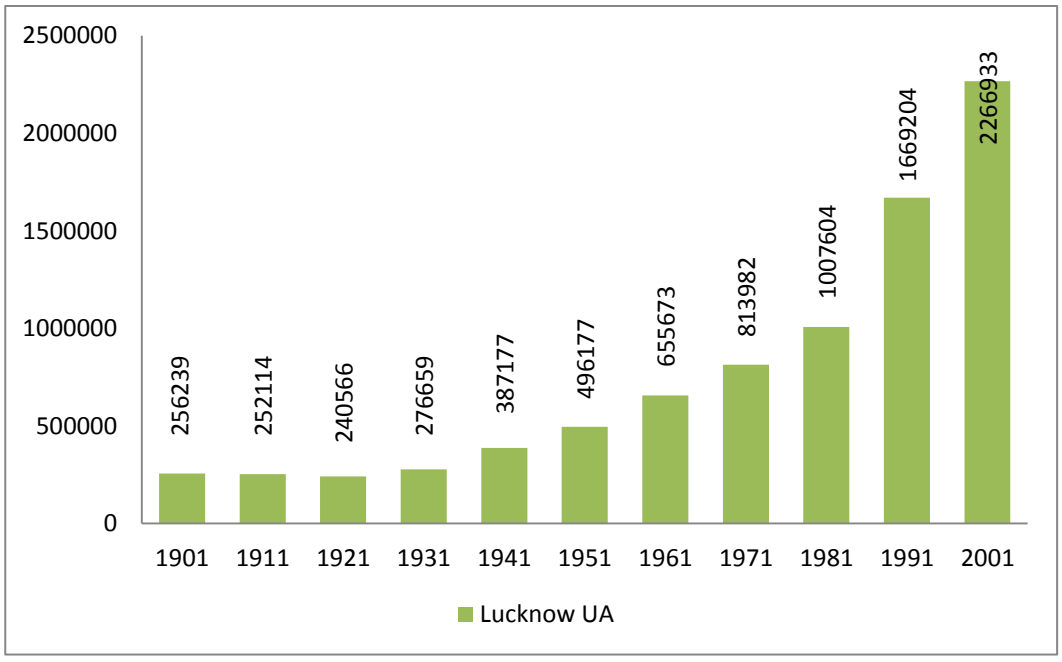


Figure 3.1: Population growth of Lucknow (Urban Agglomeration) during 1901-2001

3.1 Historical background of Lucknow's urbanization

According to Hindu legends, the Lord Lakshmana is considered to be founder the town, which eventually grew in to today's Lucknow. The first settlements flourished around a mound on the southern banks of the river Gomti in the western part of the city bearing the name, *Lachmantila*. The sheikhs who held Lucknow in the 13th Century developed the area between present day Machhi Bhavan and Residency. At the site of Machhi Bhavan they built a fort called Quila Lakhna. During the Tughlak and Lodhi period i.e. around the end of the 15th century, haphazard development took place around the south of the Quila. The area in an around the Quila received prominence during the Mughal period. During the Akbar's reign several mohallas (colonies) were added to the south of Quila. A monument of this period is the Akbari Darwaza built by the Subedar of Auadh, Jawahar Khan. At the same time, Shaikh Rahim developed the area to the east of the Quila. His tomb today stands in as Nadan Mahal. During the Shajahan's rule Mohammed Arif was the Subedar of Auadh. Development took place in Asharfabad to the south of the Quila. Towards the end of the Mughal period especially in the regime of Aurangajeb, the development took place in a great extent in the present day Alam Nagar to the west of the Quila. According to the architectures view, the buildings of this period are the specimens of the Indo-Islamic architecture.

Lucknow grew at a rapid rate under the patronage of the Nawabs. Sadat Khan, the first Nawab commonly called for the expansion of some mohallas. The major contribution to the development of Lucknow was made by the Nawab Asaf-Ud-Daulah. During his reign, significant numbers of colonies were added to the western part of the Quila. These are Aishbagh, Charbagh, Tahiyaganj, Wazirganj, Amaniganj, Fatehganj, Rakabganj, Daulatganj, Begumganj and the Nakkhas, Prominent places built by the Nawab Asaf-Ud-Daulah are the Bara Imambara, Romi Darwaza, Bibiapur palace and the Residency.The architecture of this period shows the sign of European influence. The responsibility of this lies with Major General Claude Martin who advised these Nawabs on military matters. During the pre independence war period rapid development of the city took place especially in the central and western part.

Saadat Ali Khan developed the area between Dilkusha and Kaisarbagh. Significant numbers of colonies in the south as well as western parts of the city were developed by him. Some of them are Saadatganj, Mohiganj, Mughalganj, etc. Like-wise the prominent monuments developed during this period are HyatBuksh, NurBuksh, Beily Guard, Tekri Kothi, Lal Bara dan, Dilkusha Palace, Khurshed Manzil, etc. Next phase development of the city of Lucknow was during the reign of Gazi-Ud-Din Haider and Nazir-Ud-Din Haider. The important monuments constructed during the period are along the banks of the river Gomti, namely Chattar Manzil, Moti Mahal. Hazrat Ganj, Hussain Ganj and Kaisar Bagh were developed in the later period. The three rulers of the Shah dynasty developed these areas. Iron Bridge, Kanpur Road, Chotta Immambara and Jama Masjid and Aminbad market are the other important development works

undertaken during this dynasty. Moreover the architecture during the period was treated as the distinct blend of the Indo-Islamic and European designs.

After 1847, Lucknow was under the hands of the British rule. For overall development of Lucknow, a master plan was prepared by the Brigadier General of the British Army, Robert Napier. This plan was treated as the first Master Plan of Lucknow for overall development. This British Military Plan had Machhi Bavan as the nodal point from which three roads, 150 feet wide radiated. This road led to Talkatora in the south, Mosa Bagh in west and Char Bagh in the southeast part of Lucknow. In 1915 Patrich Geddes chalked out the schemes for the development of the city especially giving the importance to housing, communication, landscaping, basic infrastructure for the requirement of people in Lucknow. In 1930, Nazul land was occupied for the construction of houses for the Britishers living in Lucknow. The well known posh areas of Lucknow are Hazrat Ganj, Blunt Square, Lawrence Terrace, Harlock Road, and Crompton square.

3.2 Land use patterns and current growth trends

The present growth of the city of Lucknow was limited during post-independent India on manifolds: on the northwestdue to water logged reservoirs, south and south east by the pressure of considerable big areas of use and undefined development. Therefore, for a long period of time, the development of Lucknow city was towards northern part of the cityonly. However, during the last two decades, Sitapur and Faizabad roads and Sitapur roads on the southern sides and Kanpur road sides are also given vital attention by the physical planners for developing the city of Lucknow for future.

As any other fast growing developing Indian city, Lucknow faces an uncontrolled urban sprawl. The rapidly growing urban population in the city and high rate of migration spills into the peri-urban and rural areas surrounding the city boundaries. The city apparently represents a typical urbanization process taking place throughout India as it has witnessed swift urbanization in recent years, leading to multifold increase in employment opportunities but a rapid degradation of basic natural resources like land and water (Dutta *et al.*, 2010). Once dominated by agriculture, the region is fast converting into a mosaic of interspersed rural-urban landscape with depleting natural land covers and increasing paved surfaces of urban land use (Figure 3.1). The peri-urban sites of interest in present study were located at distances ranging from 14 km to 17 km from the centre of urban core in different directions. The main consideration for including a location in the PUI was presence of abundant cropland in competition for land from non-agricultural uses outside the demarcated urban territory of land development authority.

Figure 3.2 showing the study area of Lucknow city and peri-urban areas showing transitional peri-urban rim which gets engulfed in urban core as urbanization proceeds and figure 3.3 showing the Extent of urban sprawl in Lucknow from 1972 to 1992 (drawn from older maps and toposheets)

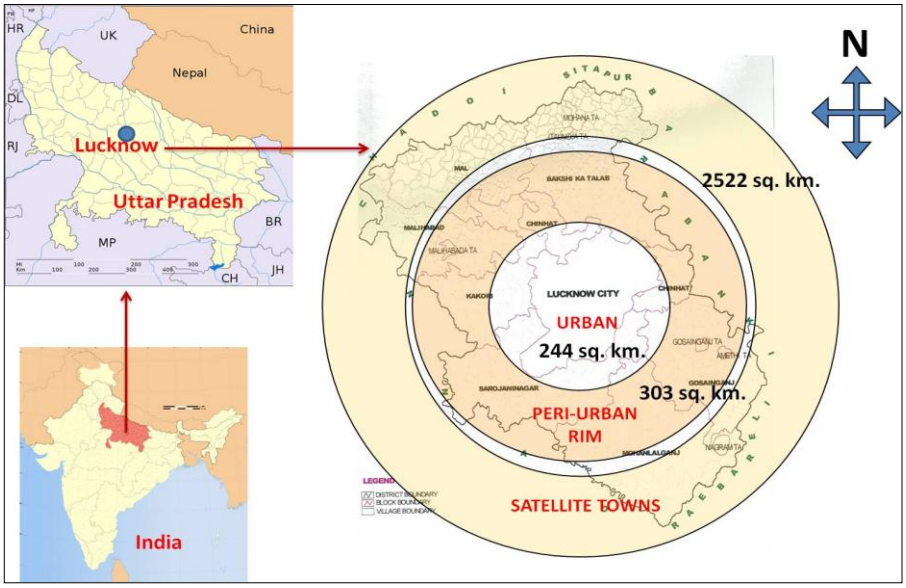


Figure 3.2: Study area – Lucknow city and peri-urban areas showing transitional peri-urban rim which gets engulfed in urban core as urbanization proceeds

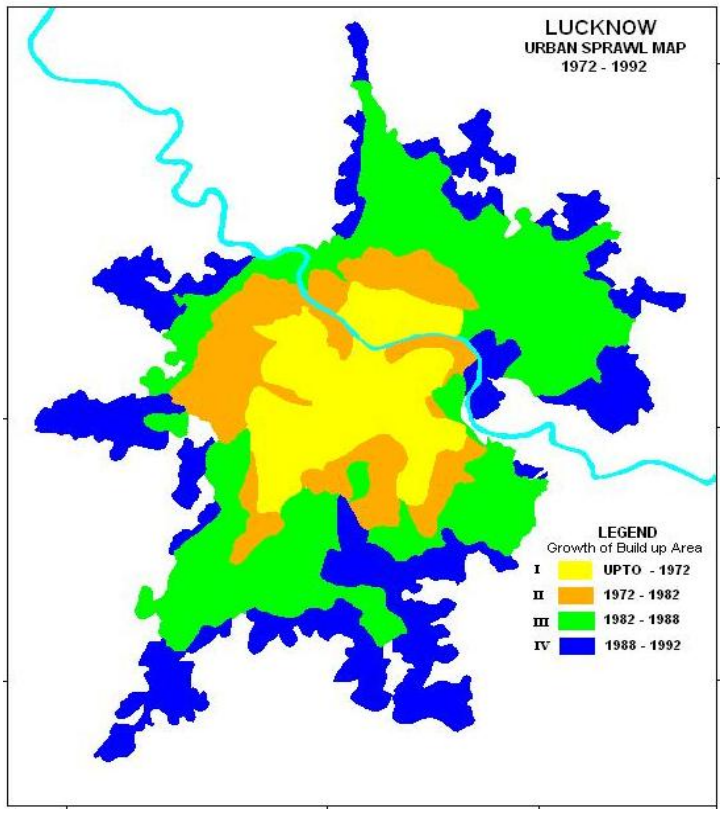


Figure 3.3: Extent of urban sprawl in Lucknow from 1972 to 1992 (drawn from older maps and toposheets)

Urbanization takes place when the major economic activity of the particular area moves from primary agricultural sector to a secondary called industrial sector and tertiary/service sectors. The primary agricultural activities mainly concentrate on labour intensive techniques and major activities are not in a spatial manner. While on the other hand, the secondary and tertiary activities are mainly adopting capital intensive techniques and activities are concentrated for attaining optimum level of development. Therefore, the elasticity of substitution between land and non-land factors mainly labour, capital and entrepreneurs in industrial sector and service sector is greater than that in agricultural sector, a greater use of capital and labour per unit of land is available in secondary and tertiary sectors.

Land is the basic and most important input in urban planning. Primary land use must be correlated to number of activities, which the concerned area performs. In addition, the change in the pattern of land use is a very difficult problem especially in urban area. The reasons behind this may be due to the interest of the individuals in the area, legislation, government policies and plans, decision of the property dealers, real estate agents, moneylenders, infrastructure development programs, nature of land itself or availability of technique for the development of the land. For finalizing the land use of the concerned area in the Master Plan, the importance aregenerally given to the economic efficiency of the land and problems related to the management of urban governance without giving much significance to land-suitability and morpho-land use patterns. Land use pattern of Lucknow as observed in 2001 by the Lucknow Master Plan is presented in the table 3.2 below.

Table 3.2: Land Use Pattern of Lucknow –2001

No	Land use	Existing		Proposed	
		Area (hectare)	%	Area (hectare)	%
1	Residential	4485.98	48.91	13913.80	66.30
2	Commercial	223.77	2.43	912.50	4.30
3	Industrial	596.22	6.50	732.30	3.50
4	Offices	474.69	5.20	400.40	1.90
5	Community Facilities & Services	902.02	9.83	1128.00	5.40
6	Parks & Playground	346.48	3.78	1352.90	7.40
7	Transportation	952.00	10.38	2159.70	10.30
8	Water Bodies	193.66	2.11	188.90	0.90
9	Open Spaces	996.14	10.86	-	-
Total		9170.96	100.00	20988.50	100.00

Source:*Lucknow Master Plan, 2001.*

It may be inferred from Table 3.2 that near about one half of the existing land used is for residential purpose. This has increased to near about two third in the proposed land use pattern of Lucknow. The area proposed in the master plan of Lucknow had increased from the existing 9170.96 hectares to 20988.5 hectares, showing the growth at 128.9 per cent of the area. In absolute terms it increased to 11817.54 hectares. The land proposed for commercial purpose had increased from 2.43 per cent of the total area of the existing land use to 4.3 per cent of the total proposed area. This is a positive sign as far as the economy of Lucknow is concerned. On the contrary, industrial allocation of the land from the existing to a proposed one has dramatically reduced from 6.5 per cent to 3.5 per cent in the proposed land use pattern. Likewise the proportion of land used for community facilities and services has reduced from 9.83 per cent to 5.4 per cent in the proposed land use pattern. While transportation purpose the existing as well as proposed land use system in Lucknow was more or less same. The proposed land use pattern tries to reduce the water bodies in Lucknow. Moreover in the open space category, the proposed land use pattern has not mentioned any figure and treated as nil, clearly narrates the fact that all the areas are fully utilized. The proposed Land use pattern of Lucknow during the year 2001 as per the Master Plan of Lucknow is depicted in the Figure 3.4.

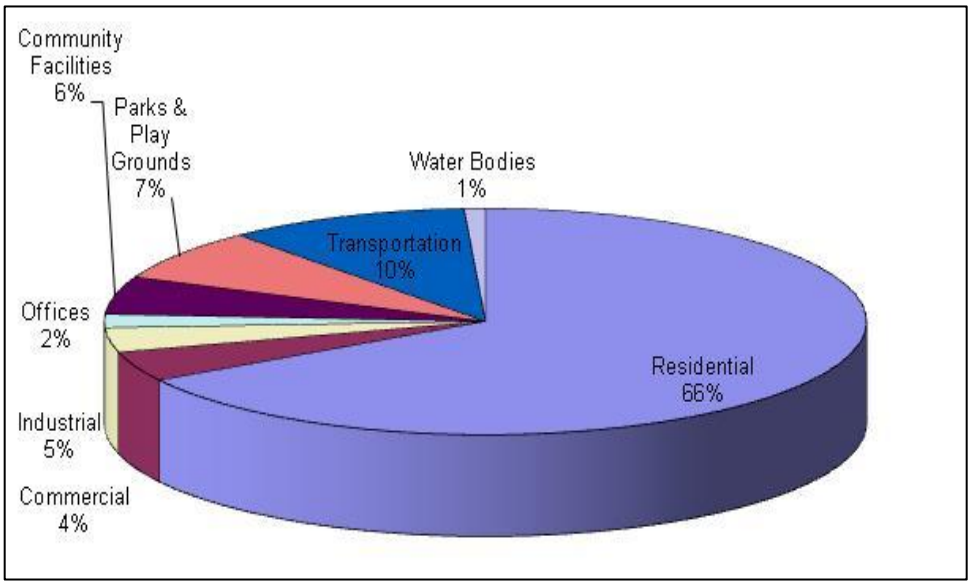


Figure 3.4: Proposed Land Use Pattern in the Lucknow Master Plan 2001

Lucknow district reports a very low proportion of area under forest. The total area under forest (4.66 percent) is much less as compared to state average which is barely around 7 percent. The district with such a high urban component of total population is obviously dependent on non-agriculture to a high degree and so the net area sown isbarely 54.85 percent and that too declined from 60.59 percent of total reported area in 1991 (See table 3.3).

Table 3.3: Land use Pattern observed in Lucknow in 1991-92 and 2004-05

Land use categories	1991-92	%	2004-05	%
Total Reported Area	252162	100.00	251845	100.00
Forests	11408	4.52	11726	4.66
Culturable Wasteland	11372	4.51	8628	3.43
Current Fallows	26408	10.47	15102	6.00
Land put to Non -Agricultural Uses	24382	9.67	40607	16.12
Grazing land	3411	1.35	3145	1.25
Area under Trees & Orchards	5451	2.16	2182	0.87
Net Area Sown	152781	60.59	138148	54.85
Area Sown More than Once	56524	22.42	80072	31.79
Gross Cultivated Area	209305	83.00	218220	86.65
Net Irrigated Area	112938	44.79	123225	48.93
Gross Irrigated Area	152308	60.40	184101	73.10

***Source**: District SankhyakiPatrika, Lucknow, 2005; Statistical Dairy, Uttar Pradesh 2005*

The district is not solely dependent on agriculture since only one third of totalpopulation resides in rural areas (36.37 percent). This had already been indicated by the fact that cultivators and agricultural labourers put together account for around 37 percent of the main workers in the district. However, the district is fortunate in terms of irrigation since around 48.9percent of the net area is irrigated. In fact, this has shown an improvement over 1991-92 figures where only 44.79 percent area was irrigated.

According to Water Resource Agency of UP, Uttar Pradesh has a wide network of around 73637 km canals, 27600 State owned tube-wells, 17768 deep tube wells and 3.96 million shallow tube-wells owned by individual farmers (‘Jal Sandesh’, Second Issue (Jan-March 2010) published by State Water Resources Agency, Uttar Pradesh). These systems irrigate around 13.08 million ha area in which canals share 18 %, State Tube-wells 3% and Private Tube-wells share 70.2 % (‘Statistical Diary Uttar Pradesh 2009’, page 133, published by Planning Department, Government of UttarPradesh). According to an estimate these systems irrigate at an efficiency of 30-45%. There are good possibilities of improving efficiency, effectiveness, economy and equity of water use in agriculture, thus making it available to other development sectors and

environmental needs. As groundwater pumping contributes to 70.2% irrigation in U.P., the saving in irrigation water will cause saving of energy also.

3.3 Study area description

Cities in all parts of the world especially developing countries, face mounting challenges such as haphazard suburban development, spread of informal settlements, loss of open space, inadequate and aging infrastructure, water and air pollution, land degradation and traffic congestion. Most of these problems are related to poor urban planning. Such patterns of urban growth, if left unchecked, could result in substantial economic and environmental loss in future. There are several ongoing housing projects and new sub-urban colonies in Lucknow city, the capital of Uttar Pradesh, which are coming up in response to rising demands from public for their growing housing needs. So on the basis of peri-urban growth the selected study area includes four different test sites of housing projects of Lucknow city namely: Parsvnath City, LDA Gomti Nagar Extension scheme, DLF Garden City, and Omaxe residency (Figure 3.8**).** Short descriptions about the four test sites of the housing projects in Lucknow are provided below:

3.3.1 Omaxe Residency: It is situated near Sarsawan village near Arjunganj. The proposed site for group housing is connected to surrounding areas through national highway, namely NH-56 connecting Lucknow to Gosaiganj, NH-25 connecting Lucknow to Kanpur, NH-24B connecting Gosaiganj to Barabanki. The proposed land uses (table 3.4) and site maps (figure 3.5) of Lucknow Group housing-Omaxe Residency are given below:

Table 3.4 Propose land uses in the Lucknow Group housing-Omaxe Residency

S.No.	Land use	Area (acres)	Area (sq.m)	Area (ha)
1.	Residential	1.95	7876.35	0.79
2.	Green Area	1.98	8006.44	0.80
3.	Water body	0.12	454.32	0.05
4.	Commercial	0.13	540.393	0.05
5.	Educational institutions	0.52	2125.90	0.21
6.	Club	0.09	352.755	0.04
7.	Roads	2.77	11234.5	1.12
8.	Parking	4.12	16692.5	1.67
9.	Open spaces	2.20	8910.392	0.89
	Total G.H Area	13.88	56193.55	5.62

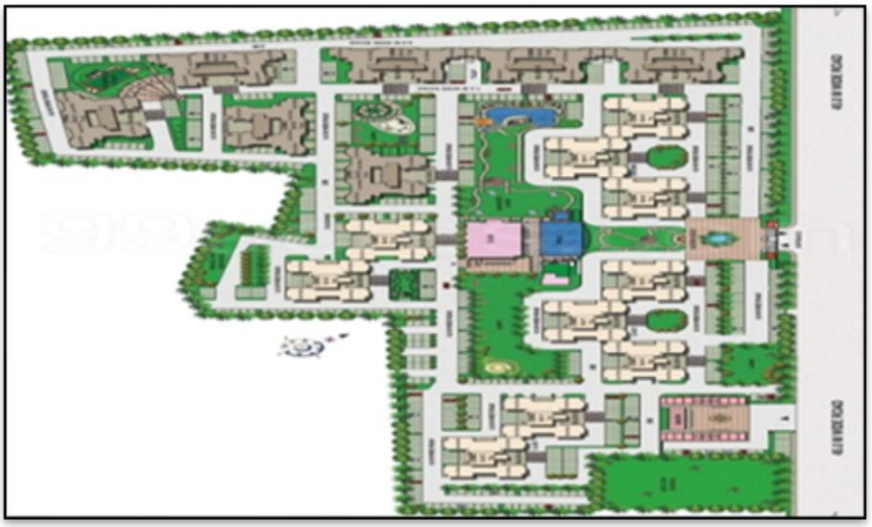


Figure 3.5: Site maps of Lucknow Group housing-Omaxe Residency

The built-up area on each plot is governed by the norms of Lucknow Development Authority.The proposed site for group housing is connected to surrounding areas through national highway, namely NH-56 connecting Lucknow to Gosainganj, NH-25 connecting Lucknow to Kanpur, NH-24B connecting Lucknow to Raebareali, NH-28 connecting Lucknow to Barabanki and NH-56A connecting Gosainganj to Barabanki. Additionally, an existing road passing through the southern side of the plot connects the site to Gomti Nagar. Further, 45 m and 24 m wide road that are connected to the proposed Amar Saheed Path are under construction. Hence the site is well connected to different cities the surrounding area.

3.3.2 Parsvnath (Township): This site is located on Faizabad road near village Uttardhanua. The township spreads over an area of 34.8 acres (1,40,844,8 sq.m), adjacent to NH-28 which connects Lucknow to Barabanki. The project being a well-planned activity will result in organized open spaces and green areas. The project will be developed so that 47% of the area is designated for open spaces and landscaping. The proposed township will comprise community facilities like schools parks, local shopping areas commercial area club etc. will have a positive impact on the existing land use as it is a planned activity to provide well planned housing with various infrastructural facilities as per the local byelaws. The main reasons for erosion are overexploitation of groundwater instable slopes, and landslides etc. The proposed construction will involve cutting and filling operations. The proposed area is primarily a flat land and is not prone to erosions. The project would involve construction of roads and development of green areas which would also reduce the chances of erosion subsidence.

3.3.3 DLF Garden City: It is located on Raebareli Road near Purseni village, Mohanlalganj. This site is totally open area in which the construction is in process. It poses sensitive area (SGPGI) on Raebareli Road. The proposed land uses (Table 3.5) and site map (figure 3.6) of DLF Garden Cityare given below:

Table 3.5 Propose land uses of DLF Garden City (Total Area: 445.76 acres)

S.No.	Land-use	Acre
1	Controlled Area	6.61 Acres
2	Area of development	245.39 Acres
3	Residential area	90.l6 Acres
4	Area of common facilities	20.56 Acres
5	Area of hospital	4.49 acres
6	Area of school	12.21 acres
7	Club	3.86 acres
8	Miscellaneous	107.67 acres
9	Rain water harvesting provided	
10	Green Belt Area	33.04 acres
11	Road area	60.6 acres
12	Police chowky	1.00 acres
13	Sub- post office	0.14 acres
14	132 KVA Electric substation	5.09 acres

Total Cost of Project = 4000 crore.

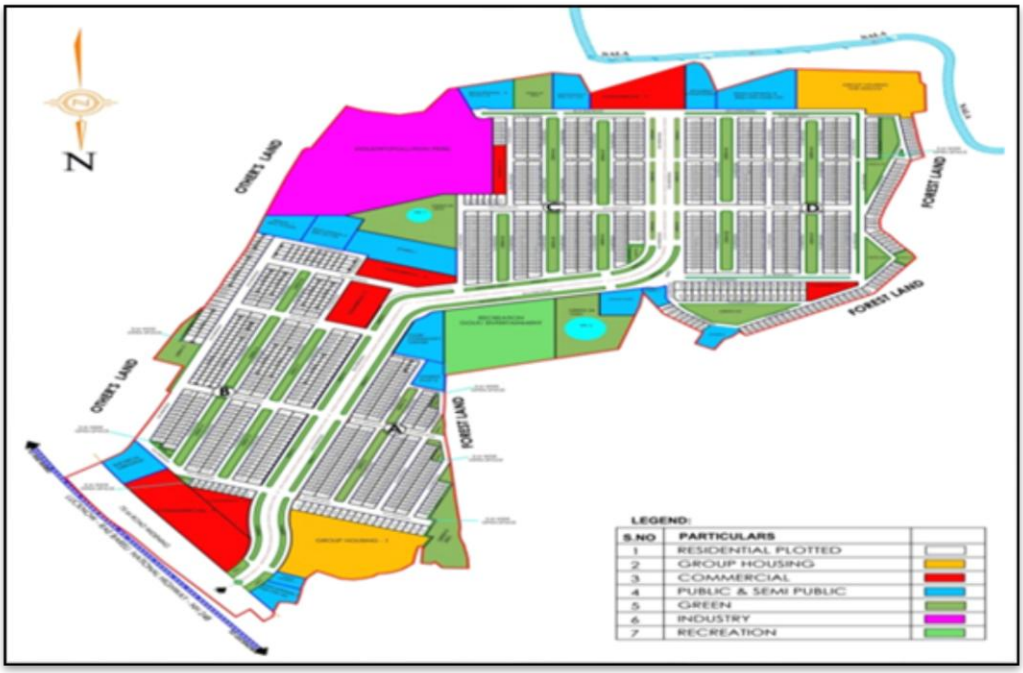


Figure 3.6: Site map of DLF Garden City

3.3.4 LDA Gomti Nagar extension:

This site is located towards the east of the existing city at a distance of about 6 Km. from the central business district Hazratganj. The "East West Corridor" (Connecting Lucknow-Kanpur Highway, Lucknow-Raibareli Highway, Lucknow-Sultanpur Highway and Lucknow-Faizabad Highway) passes through the township.

The River Gomti also passes through the scheme, hence divides the entire scheme into two parts for the purpose of infrastructural planning. The present part of the scheme covers an approximate area of 475 Hectare (1174 Acre) which comprises of Sector 1, 2, 3, and 4. The boundaries of these sectors are River Gomti, East West Corridor, Amar Shaheed Path (Lucknow Ring Road) and N. R. Line (Lucknow- Varanasi). However, the total Approx Area of entire Gomati Nagar Extension Scheme is 5500 acre including is Gomti part of scheme, which extends up to the Vrindavan Housing Scheme of U. P. Awas Vikas Parised. Figure 3.7 indicating about the LDA Gomti Nagar extension given below:

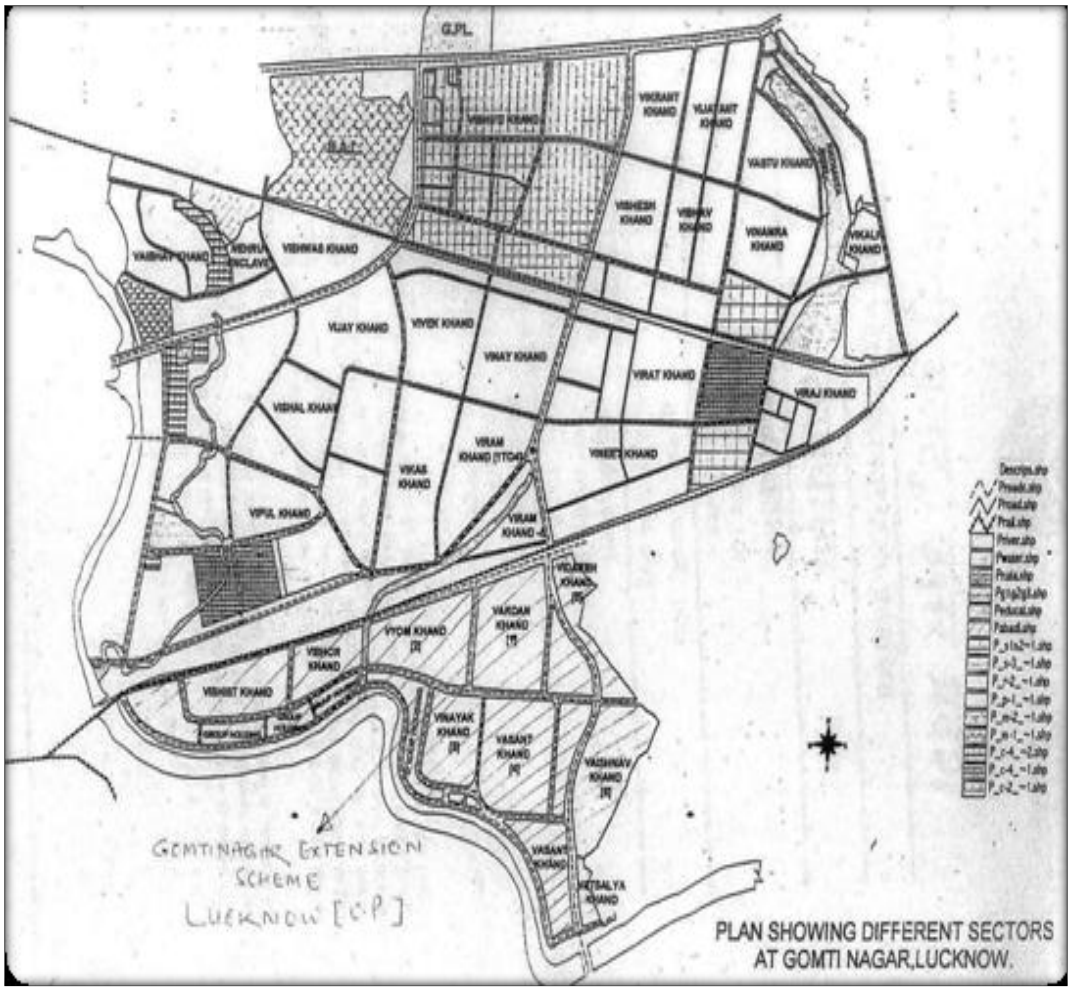


Figure 3.7: Site map of LDA Gomti Nagar Extension Scheme

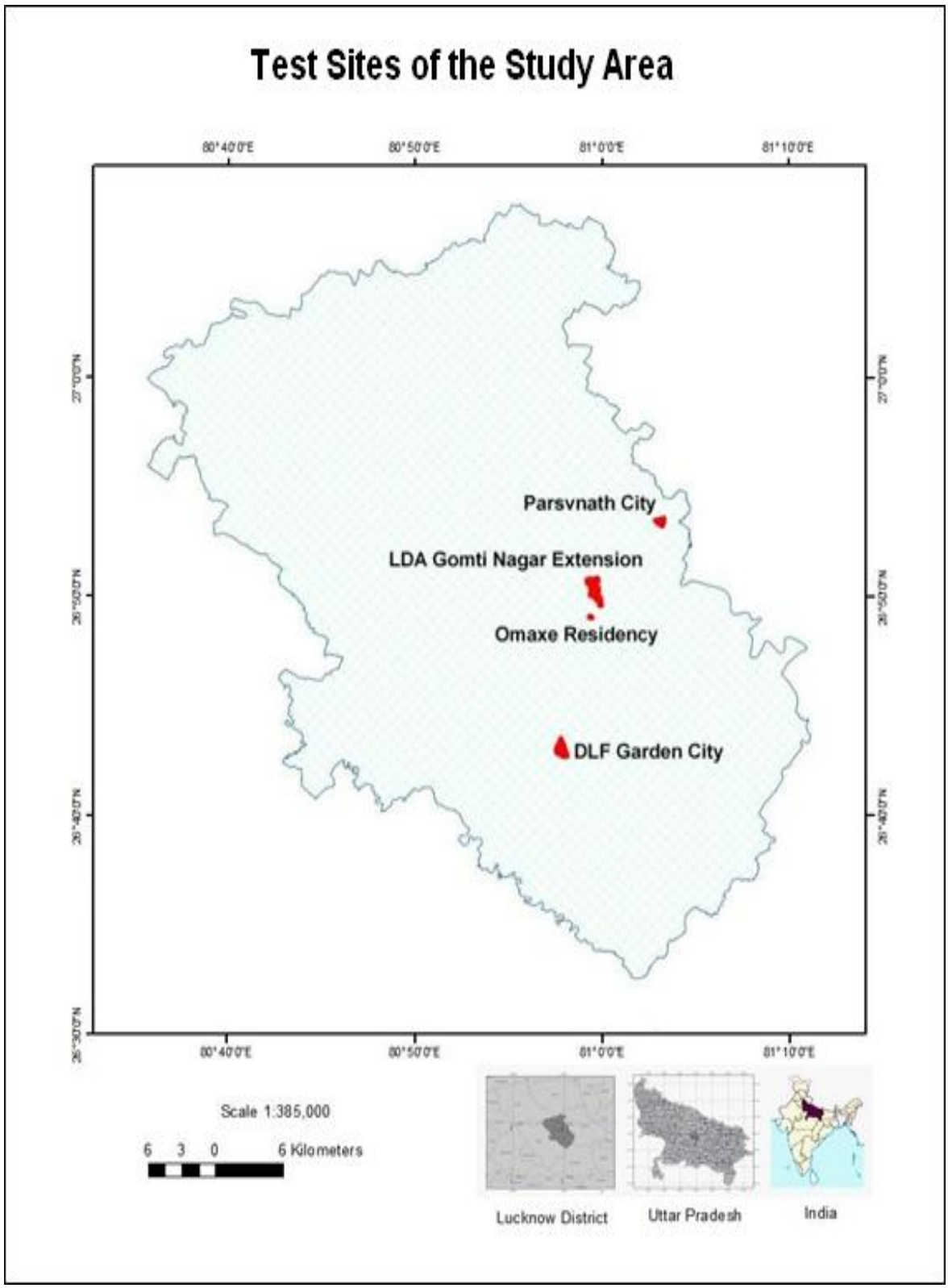


Figure.3.8: Test Sites of the study area of housing projects in Lucknow

Table 3.6 Common silent features of housing projects in Lucknow City, Uttar Pradesh

Sl. No.	Parameters	DLF garden city	Omaxe Residency	Parsvnath city	LDA Gomti Nagar Extension Scheme
1.	Location	Village- Pursaini Tehsil- Mohanlalganj District- Lucknow Raibarelly Road	Village-Sarsawan Tehsil-Lucknow District-Lucknow Amarshaheed path sultanpur road	Gram- Uttardhanua Faizabad Road	Village-Ugarion, LDA Gomtinagar Amarshaheed path sultanpur road
2.	Nearest railway station	MohanlalGanj (20.4 km)	Gomtinagar Railway Station (9.9km)	Gomtinagar Railway Station (9.5km)	Gomti Nagar Railway Station (5.1km)
3.	Project costs	706.28 crore	98.66 crore	150.31 crore	68.45 crore
4.	Power requirement	0.132 MVA	3 MVA	3.245MVA	57.8 MVA
5.	Size of area	445.76 acre (180.3927 hectare)	13.88 acre (5.62 hectare)	34.8 acre (14.0831 hectare)	1174 acre 475 (hectare)
6.	Green Area (%)	37.899 acre (8.5%)	1.98 acre (14.26%)	20.88 acre (60%)	376.0944 acre (32.035%)
7.	Parking facilities	Provided	Provided	Provided	Provided
8.	Water requirement	4.04 MLD	0.568 MLD	0.976 MLD	32.77 MLD
9.	Solid waste generation	28.34 MT/day	2.45 MT/day	3.9 MT/day	150 MT/day
10.	Source of supply water	Ground water	Ground water	Ground water	Ground water
11.	Quantity of sewage generated (MLD)	2.19 MLD	0. 403 MLD	0.805 MLD	57.638 MLD
12.	STP Facility	Provided	Provided	Provided	Provided

13.	Rainwater harvesting system	Ground based	Ground based	Ground based	Ground based
14.	Basement system	Basement not provided	Basement not provided	Basement not provided	Basement not provided
15.	Distance from the city centre (Hazratganj)	17.5km	16km	16km	5km
16.	Nearest city/town	SGPGI	AnsalSushant Golf City	BBD Green City	Omaxe City
17.	Water depth (mbgl)	25 feet (7.62 meter)	20 feet (6.096 metre)	20 feet (6.096 meter)	25 feet (7.62 meter)
18.	Nearest village	Pursaini	Chiraiyamau, Arjunganj	Uttardhanua	Ugarion
19.	Nearest water bodies.	Irrigation canal	Gomti River	Indra Canal	Gomti River
20.	Nearest highway	Raebareli Road	Amar Shaheed Path Sultanpur Road	Faizabad Road	Amar Shaheed Path Sultanpur Road
21.	Nearest sensitive zone	SGPGI (12.8 km)	AnsalSushant Golf City (10.9 km)	BBD College, BBD Green City (1.8 km)	KendriyaVidyalaya , (3.7 km)
22.	Nearest forest	None	None	Kukrail Reserve Forest	None
23.	Nearest airport	Amausi (13.8km)	Amausi (17.6km)	Amausi (28.2km)	Amausi (16.5km)

4 METHODOLOGY

4.1 Material used

4.1.1 Survey of India (SOI) Map: The SOI topographical maps at 1:50,000 scale, sheet numbers: 63B/13 were used for generating the maps.

4.1.2 Ancillary Data: Environmental clearance reports, compliance reports, analytical monitoring reports of baseline and current year (2014) of different housing projects in luck now city are used. Information regarding the Noise quality, STP, Soil quality, Energy Conservation, Flora, Fauna, Solid Waste and their Management was obtained from various departments of Lucknow city.

Certain other important ancillary data was collected from various distinct sources and converted to GIS format wherever possible. Base maps of the study area e.g. District Map, Block Map, Road Map, Railway Map, Canal Network Map, Drainage Map and Village Map were obtained from NIC (Uttar Pradesh). Groundwater level data was obtained from Central Groundwater Board (CGWB) located at Lucknow. The proposed interventions against and supporting the existing infrastructure in form of Master Plan 2021 were also assimilated in the analysis .e.g. the existing and proposed road/transport network in city.

The study uses following data as reference for visual interpretation:

(1) Land use map prepared by UP Remote Sensing Application Centre (NRIS Standards, 1999).

(2) Field survey data including GPS data, photographs and farmer interviews on land use history.

All of these prepared, converted and collected GIS (vector) layers were brought to a standard Universal Transverse Mercator projection (UTM) with Datum WGS 84 in Zone 44 (Table 4.1).

Table. 4.1: Data type and their sources

S.No	**Data Type**	**Scale / resolution**	**Source**
1	Panchromatic image (Yr 1997)	5.8 m	NDC (National Data Centre), NRSC
2	LISS III image (Yr 1997)	23.5 m	NDC (National Data Centre), NRSC
3	Land use/land cover Map : Yr 2002, Yr 2001	Mapping Scale 1: 50,000 Source LISS III (23.5 m)	UPRSAC (UP Remote Sensing Application Centre)
4	Multispectral satellite data : GeoEye Image 2009	1m Mapping Scale 1: 25,000	Google Earth Browser (Open Source)
5	*Base/Infrastructure/Biophysical Maps* : District,Block,Road,Railway, Canal, Drainage, Village Map, Soil group texture, Geomorphology		*Adapted from* UP;NIC (National Informatics Centre)
6	*City Development Maps*		Town Planning Department, Lucknow
7	*Master Plan Maps:* Existing and Proposed Road Network, City landuse		Town Planning Department, Lucknow
8	*Groundwater level data*		CGWB
9	*Digital elevation Model*		SRTM data

4.1.3 Field Survey Information: Field survey data was used and this survey would normally be administered via questionnaires and checklists. These was done from door to door interview with the help of pre-prepared questionnaire and discussed with the experts. The survey provides information regarding population, Energy, Water, Drainage Facility, Parking Area, Rain Water Harvesting System, Near educational sites, Near hospitality, Nearest solid waste disposal site, air quality, noise quality, soil quality, energy conservation etc.

4.1.4 Satellite data-sets used in the study: The satellite data-sets used for the study are given in table 4.2

Table 4.2: Satellite data-sets used in the study

S. No	Image Acquisition date	Satellite Sensor used
1	Feb 2010	Geoeye-1 from Geoeye
2	April 2003	Quickbird from Digital Globe
3	May 2003	
4	Dec 2003	
5	March, 2005	Google Earth(High Resolution)
6	Feb, 2014	Google Earth(High Resolution)

Google Earth High resolution satellite Image (2005 and 2014)

The satellite images were obtained from the Google Earth of year 2005 and 2014. Google Earth is a virtual globe, map and geographical information program that was originally called Earth Viewer 3D created by Keyhole. Google Earth displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle. The degree of resolution available is based somewhat on the points of interest and popularity, but most land (except for some islands) is covered in at least 15 meters of resolution. Google Earth allows users to search for addresses for some countries, enter coordinates, or simply use the mouse to browse to a location. For large parts of the surface of the Earth only 2D images are available, from almost vertical photography. Viewing this from an oblique angle, there is perspective in the sense that objects which are horizontally far away are seen smaller, like viewing a large photograph, not quite like a 3D view. For other parts of the surface of the Earth, 3D images of terrain and buildings are available. Google Earth is able to show all kinds of images overlaid on the surface of the earth and is also a Web Map Service client. Google Earth supports managing three dimensional Geospatial data through Keyhole Markup Language.

The images of different housing projects (study area) taken from the Google earth is shown below:

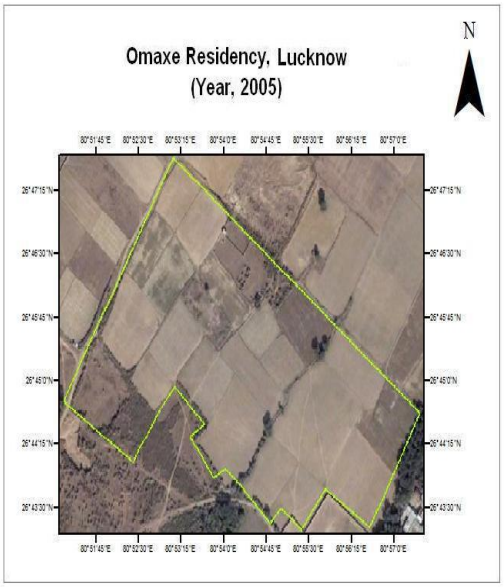


Figure 4.1 Omaxe residency 2005

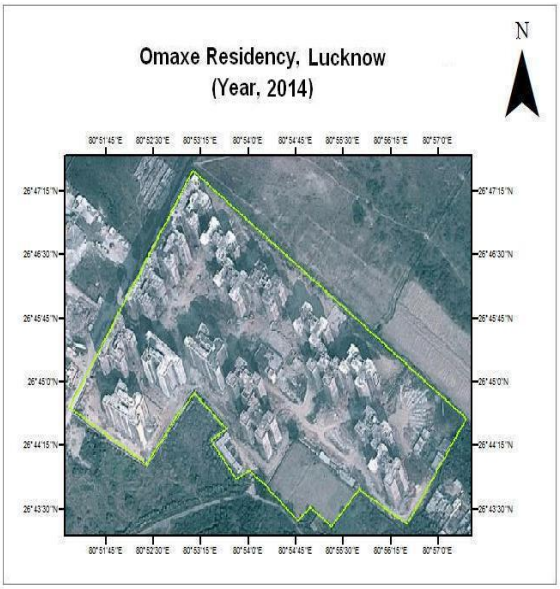


Figure 4.2 Omaxe residency 2014

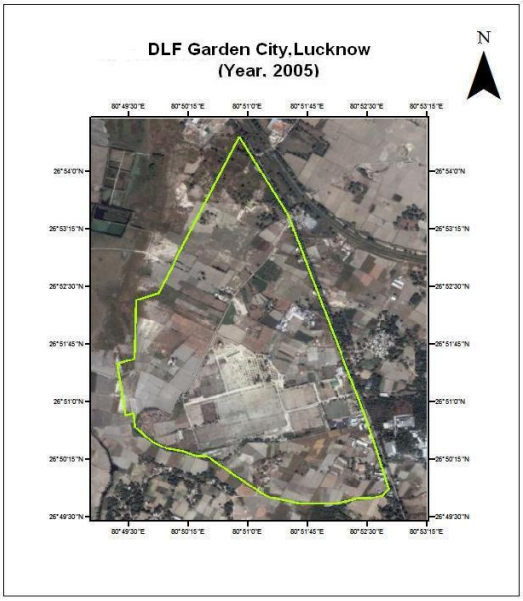


Figure 4.3 DLF Garden City 2005

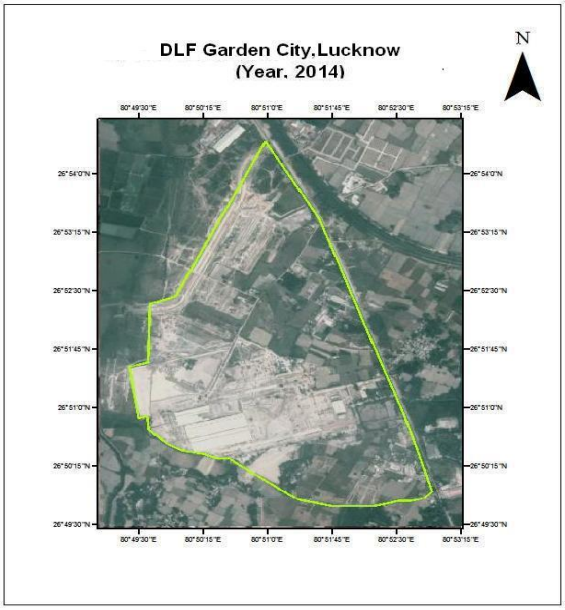


Figure 4.4 DLF Garden City 2014

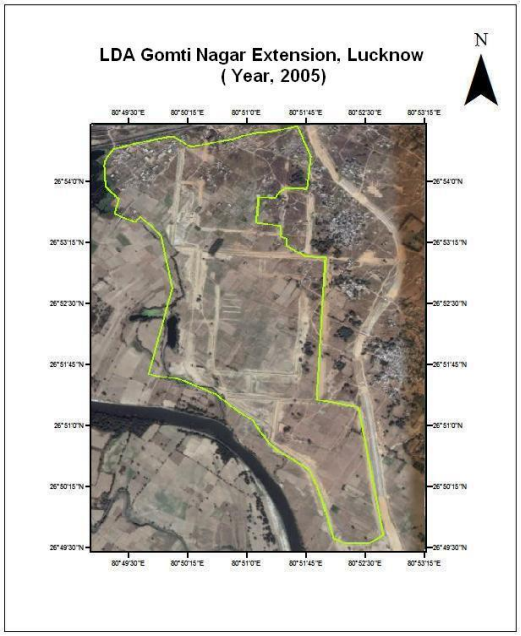
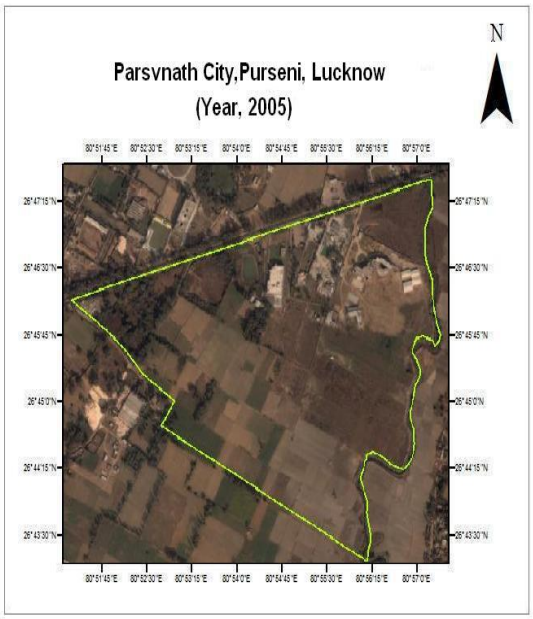


Figure 4.5 LDA Gomti Nagar Ext. 2005 **Figure 4.6 LDA Gomti Nagar Ext.2014**



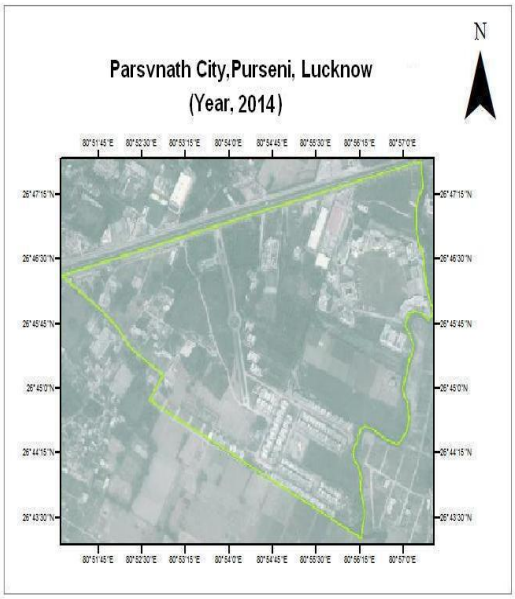


Figure 4.7 Parsvnath 2005 **Figure 4.8 Parsvnath 2014**

4.1.5 Software Used

Following software's were used in this study viz;
(a) Google Earth: Web browser for interpretation and mapping of year 2009 landuse of study area
(b) Map Window GIS: For basic GIS work
(c) ArcGIS 10: Advanced GIS analysis
(d) Erdas Imagine 9: DIP analysis during study
(e) MS Office: For all desktop processing

4.2 Study Area: The methodology was used to observe the Effectiveness of EIA for housing projects in Lucknow by studying and reviewing the government of India EIA notification with the help of spatial and non spatial data, use of Fuzzy – AHP modelling techniques, Leopold interaction matrix, land use/cover change detection, and conflict analysis.

4.2.1 Land use/Land cover (LULC) mapping for three time periods: 1997, 2002 and 2009

Study was initiated by a temporal Land use/Land cover mapping for the three time periods wherein the process of visual interpretation is used due to its high level of accuracy keeping in mind the sporadic and patchy nature of land uses prevalent in an urban and peri-urban landscape developed along the continuum.

Before interpreting the images, a land-use ground reconnaissance was carried out for developing a general understanding of the land-use situation in the area. A field check was carried out in March and June, 2010 for pre-classification survey and a further field survey was undertaken in the month December to validate the accuracy of a land-use map.

For the purpose of present study, an NNRMS adapted scheme of land-use/land-cover classification was ascertained after being modified as per the requirement of project objective. The 12 major LULC categories were identified, delineated and classified using the adapted classification scheme (Committee report on NNRMS standards, 2005). The table below gives a definition to each of the classes (Table 4.3), generalizations have been done wherever it is not possible to separate two types of land uses with insignificant differences.

Table 4.3: Land use/land cover classes (adapted from NNRMS classification Scheme)

S. No.	**Class name**	**Detail / Definition**
1	Area_Under_Construction	Area currently under land use transition into urban
2	Agriculture (Double Crop)	Area cropped during both rabi* and kharif* seasons
3	Dense Forest	Forest area with canopy cover range greater than 40%
4	Open Forest	Forest area with canopy cover range 10-40%
5	Horticulture Plantations	Area with cultivation of fruits, mostly under irrigated conditions, associated with cropland and built-up areas.
6	Water bodies	Area with surface water, either impounded in form of ponds, lakes or flowing as streams, rivers etc.
7	Abandoned fallow	Cropland area left uncropped for many consecutive agriculture seasons.
8	Wasteland	Degraded land which can be brought under vegetative cover with effort but is currently unutilized/deteriorating for lack of water, soil management or other natural causes
9	Scrubland	Land generally prone to deterioration due to erosion. Possess sparse shrub vegetation.
10	Rural-Built-up	Smaller built-up area associated with agriculture and non-commercial activities with population size less than 5000.
11	Urban-Built-up	Notified town area of intensive use with much of land covered by structures with min. population of 5000, at least 75% of which is non-agricultural
12	Urban-Vegetated	Area dominated by vegetation cover midst urban areas.
*Rabi : Cropping season extending between November/December – February/March *Kharif : Cropping season extending between June/July – September/October		

For Analysis, the Panchromatic data (5.8m res) and LISS III data (23.5) of year 1997 for the study area obtained from NDC, NRSA were merged to produce multispectral satellite data (MSS) of 5.8 m spatial resolution. The output image was visually interpreted on computer screen at 1:25,000 (so as to keep a standard mapping scale) mapping scale for the decided 12 landuse classes.

The land use/land cover map (vector) of the study area for year 2002, obtained from UPRSAC (Prepared under NRIS project) had an original mapping scale of 1:50,000 scale. For the purpose of present study, the LULC layer (2002) was modified using reclassification, so as to merge the related classes as one and ungroup certain broad classes as per the decided landuse scheme.

Visual interpretation on Google earth was done at a viewing scale of 1: 25,000 for the decided classes to prepare 2009 LULC map.

After interactive visual interpretation of the images on computer screen, the land-use maps of three time period, produced at a comparable scale were stored in GIS format for further analysis. The ancillary maps related to the study collected from various organisations were scanned and geographically registered with the help of set of GCP's collected for the purpose using a GPS set. The referenced maps were digitized using GIS software, given appropriate attributes and the prepared vector layers transformed to standard UTM WGS84 projection set for the LULC maps.

The land use mapping for years 1997 and 2002 was done on high resolution remote sensing images. Land-use of the study area for year 2009 and for peri-urban test sites of the case study for year 2003 and 2010 were delineated by experienced image analyst using very high resolution satellite data provided by the open source Google Earth web browser. Mapping of Land Use Land Cover (LULC) for recent time period (2009) was attempted using Google Earth primarily due to budget constraints and partially due to the interest of project team in exploring open source alternatives for research.

Google Earth is an open source geographical browser, which presents geographic data to users by providing a fast and simple interface to interact with massive geospatial datasets. It allows preparation of and import/export of geographically referenced vector datasets which can be further analysed with any GIS software. Google Earth uses KML (Keyhole Markup Language) file format to display geographic data, which is a tag-based structure with nested elements / attributes and is based on the XML standard. The KML vector layers prepared in Google Earth can be exported as shape files (standard GIS format) and vice versa.

4.2.1.1 Land-use Change Detection/ Landuse Transformation Analysis

Temporal mapping of LULC was followed by post-classification method of change detection, using comparison of two independent land cover classifications (Mas, 1999) to detect bi-temporal urban land use change.

Post-classification comparison is a comparative analysis of images obtained at different moments after previous independent classifications. It is the most obvious method of change detection, which uses a comparative analysis of spectral classifications for time periods t1 and t2 produced independently (Singh, 1989) with area changed being extracted through direct comparison of classification results (Jensen, 1983). Post classification approach provides "from-to" change information as the end result which can be used to derive the kind of land use transformations that have occurred in study area (Bauer *et al.*, 2005).

A simplistic interpretation of the land use transformation via change detection method may persuade scientists to focus only on the largest transitions e.g. from cropland to urban which account for major part of landscape change, but a glance into the detail reveals other understated transitions which though not as large, are equally significant for sustainable urban planning. When aggregated, LULC changes significantly convey insightful data on the natural resources degradation. A case study attempted under the present work proposes employing the initial "from-to" information derived from change-detection to obtain a comprehensive natural resources status information by aggregation and reclassification of "from-to" change statistics into transformation categories. This process reveals the configuration of present landscape and captures the trends in land use dynamics, from which a future scenario can be perceived. The case study has been attempted for four test sites located in the peri-urban interface of study area, where the LULC change pattern was extensively investigated for examining the extent and distribution of land-use/cover change between years 2002 to 2009.

4.2.1.2 Overall Landuse Change detection for the study area from 1997 - 2009

After the preparation of Land use/Land cover maps for all three time periods .i.e 1997, 2002 and 2009, a multi-date comparison was performed using the change detection algorithm to determine changes in land cover in two intervals, 1997–2002 and 2002 – 2009.

At a time two land-use maps were overlaid to create a composite map. The attribute tables were joined, to produce a transition matrix for detection of the land-use change during the study period. For compilation of the quantitative statistics of the overall land-use changes between the two intervals (1997-2002 and 2002 -2009), the area of land (in hectares) converted from each land cover into each of the remaining categories and the total proportion (%) of each individual land category converted into other categories was calculated. A change detection map was derived for representing two time intervals and well as for a collective 1997-2009 time period analysed.

4.2.2 Land Capability Assessment

Land capability is the ability of land to support a particular type of use without causing permanent damage (Austin and Cocks, 1978). Land capability refers to the evaluation of biophysical factors of land for a particular use. The essence of land capability assessment

is a comparison of the physical requirements for a particular land use with the qualities of land. Land qualities are attributes of land which influence its capability for that use .e.g soil absorption ability and flood hazard. In this study the soil and landform characteristics of the urban and peri-urban area around the city of Lucknow, capital of state Uttar Pradesh in India, has been considered in relation to agricultural capability.

The requirements of a particular land use can be expressed in terms of a list of essential and desirable land qualities. The degree to which the natural land conditions meet these requirements determines the land capability class assigned to a particular parcel of land (land unit). In assessing land capability two aspects need to be considered:

- Effect of land on the proposed use and
- Effect of that use on the land.

The first aspect relates directly to productivity or development costs while the second relates to conservation requirements.

A five class system is generally employed to express land capability (refer Table 4.4). Land rated class I will have qualities which meet the requirements of a proposed land use without any resultant on or off-site land degradation. Land rated from class II to IV becomes progressively less capable of meeting those requirements with the risk of land degradation increasing accordingly. Land rated class V is regarded as prohibitive in terms of the risk of land degradation, or in terms of development costs.

Table 4.4: Class definitions used for describing general land capability

Capability class	Degree of limitation	General description
I	None to very slight	Very high capability for the proposed activity or use. Very few physical imitations present which are easily overcome. Risk of land degradation is negligible.
II	Slight High capability	Some physical limitations affecting either productive land use or risk of land degradation. Limitations overcome by careful planning.
III	Moderate Fair capability	Moderate physical limitations significantly affecting productive land use or risk of land degradation. Careful planning and conservation measures required.
IV	High Low capability	High degree of physical limitations not easily overcome by standard development techniques and/or resulting in a high risk of land degradation. Extensive conservation requirements.
V	Severe Very poor capability	Severity of physical limitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

4.2.2.1 Land Capability Modelling for Prime farmlands

Ascertaining the critical factors for land capability modelling should be based on acknowledged bibliography and agreed upon by the experts. In the process of establishing a practical land capability classification, it is necessary to emphasize the relevant aspects of soil and environment. The focus in this study is on finding fertile well irrigated soils in flat, undegraded areas not very near to rivers prone to flooding or areas prone to soil erosion. In the present study thus, assessment of the ability of land to support agriculture involves consideration of five land qualities, which are: Soil Fertility, Slope, Ground water level, Irrigation Network and Flood Hazard Zone.

1. The fertility of soil to support profitable agriculture;
2. The relative ease of access to ground water for agriculture
3. The relative ease of access to irrigation facilities for crops
4. Gentle slopes to avoid soil erosion
5. Absence of flood hazard.

4.2.2.2 Quantitative land capability assessment

A digital GIS database consisting of all the factor layers was developed, standardized and transformed before combination. Linear scaling method was used to scale the individual classes of criterion layers. The ranked classes were as depicted in Table 4.5 below:

Table 4.5: Ranked classes of the criteria layers

S.No	Criterion Layer	Classes
1	Canal Network	Outside
		Inside
2	Altitudinal Gradient	Almost Flat
		Slightly Elevated
		Low lying
		Very Low Lying
3	Ground Water Level	>10 m from surface
		8-10 m
		5-8 m
		3-5 m
4	Soil	Fine Loamy
		Loamy
		Coarse Loamy
		Fine Silty

Land Capability Analysis can be done by classical GIS overlay method also (reference in LCA) but in order to strengthen the output, in the present study, individual criterion layers (GIS) formed by factors data were weighted using the Geometric Mean method (reference in LCA) and proceeded for WLC procedure. To set the relative importance of individual criterion in the decision making process, each criterion was assigned a weight derived as per the decision maker's preferences in a pair-wise comparison method (Worked example Table 4.6). The selected criteria for Land capability Analysis were evaluated to derive the weights, which need to be summed up to 1. Geometric mean method for calculation of weights is most appropriate here to be used on a pair-wise comparison matrix prepared using expert advice.

Table 4.6: Pair wise comparison matrix for agricultural land capability (worked example)

Agricultural Land Capability					
LCA	Soil Group Texture	Altitudinal Gradient	Ground Water Level	Irrigation Network	Normalised W
Cri1	1	5	3	4	0.539426
Cri2	0.2	1	0.33	0.5	0.082608
Cri3	0.33	3	1	3	0.254439
Cri4	0.25	2	0.33	1	0.123528

Geometric Mean method (worked example)

A =

1	1/4	3
4	1	6
1/3	1/6	1

Normalise (divide each element by determinant of matrix) .i.e. Sum each column, divide each element in the column by its sum.

Sum of column 1 = 5.2 ; Sum of column 2 = 1.416; Sum of column 3 = 10

Normalised matrix =

1/5.2	1/4/1.416	3/10
4/5.2	1/1.416	6/10
1/3/5.2	1/6/1.416	1/10

=

0.192	0.1765	0.3
0.7692	0.7062	0.6
0.2171	0.1177	0.1

Weight of column1 = (0.192 * 0.1765 * 0.3) * power 1/3 = **0.2167**

Weight of column 2 = (0.7692 * 0.7062 * 0.6) power 1/3 = **0.6910**

Weight of column 3 = (0.2171 * 0.1177 * 0.1) power 1/3 = **0.0914**

The expert advice in form of LCA criteria weights is used for Weighted Linear Combination henceforth wherein an average of the weights provided by the experts (12 in number) are multiplied with standardised criteria maps. The weights are used as percentage value (.i.e. 0.47 = 47 %) for the respective criterion layer in the Weighted Overlay operation in Arc GIS 10 software.

In the assessment of land capability for the study area, the diagnostic land characteristics were quantified relative to agriculture and four land capability classes were distinguished according to the degree of the limitations and their effect on productivity.

4.2.3 Land Suitability Analysis (LSA)

Determining suitable land for a particular use is a complex process involving multiple decisions that may relate to biophysical, socio-economic and institutional/organizational aspects. A structured and consistent approach to Land Suitability Analysis (LSA) is therefore essential. Overall land suitability of a land area for a certain land use is evaluated from a set of more-or-less independent land qualities, which may limit the land-use potential. These evaluations often classify map units of natural resource inventories.

Based on the scale of measurement of the suitability, there can be two types of classifications

Qualitative: the classes are evaluated on the basis of physical production potential of land. It is used to evaluate environmental, social and economical criteria.

Quantitative: the classes are defined in common numerical terms; where comparison between the objectives is possible.

Quantified evaluation (Beek et al. 1987) made an evolution in land suitability evaluation by introducing quantification of the indicators of land suitability over an entire area. In such land suitability analysis, GIS and geo-statistical techniques are widely used.

Land-use suitability analysis aims at providing a scientific basis for land-use planning, so as to achieve maximum socio-economic benefits at minimum environmental cost and for further identifying areas to be used for construction or for conservation purpose. Site suitability should take into consideration both site conditions and infrastructures as different land-use categories have different physical requirements. LSA can be preceded by Land capability analysis, which determines the land suitable for agriculture or non-agriculture based on general soil characteristics, slope etc. LSA can follow using a parametric model taking into consideration the existing landuse, terrain characteristics, Soil conditions, infrastructure support, natural hazard zoning etc.

4.2.3.1 Land Suitability Analysis (LSA) for Urban Development

Purpose of the analysis is identification of areas suitable for urban development that do not adversely impact the environment. The procedure is essentially the identification of potential sites for urban development. Evaluation of potential locations involves consideration of the following criteria:

- *Spatial framework of the region :* considers the site's ability to provide services for sustenance of habitation, measured in terms of proximity to existing service centres and service networks .i.e. Road network, Railway Stations, Developed land (existing city) etc.

- *Environmental and historical sustainability:* considers the effect of urbanisation on environment. Involves identification of environmentally sensitive zones and ensures their restriction/protection by using them as constraints in the analysis e.g. forested areas, urban greenery, water bodies, heritage sites and sites with health hazards.

- *Physical characteristics:* considers the physical and socio-economic suitability of sites in terms of urban development: Involves evaluation of soil and landscape parameters e.g. thematic data for Soil, ground water, Agricultural capability, population density, Altitudinal gradient and existing landuse.

On the basis of above observation, project team defined criteria for the Land Suitability Analysis according to available datasets. The criteria of suitability for development (high, medium, low, and least suitable) were identified after dividing them into factors .i.e. criteria supporting urbanization and constraints i.e. criteria restricting urbanization. These parameters were then used in the parametric model for LSA. This selection was done using expert opinion (Table 4.7 and Table 4.8). In order to account for proximity to existing infrastructure, the GIS datasets of settlement, roads and Bus Stations/Railway stations were buffered at multiple distances where each distance ring was weighted varyingly as per its importance to any further urban settlement. Similarly, to account for physical and socioeconomic characteristics of the area, the GIS datasets of Slope gradient, Soil Texture, Agricultural Suitability, Groundwater Levels and Population Density were weighted individually as per their importance to any further urban settlement.

Table 4.7: Factors for determining the suitability of land parcels

Criterion	Factors	Classes
Proximity to existing infrastructure	Settlement	Buffer for 1,3,5 km
	Roads	Buffer for 1,3,6 km
	Bus Stations/Stops and Railway Stations	Buffer for 5,10,15 km
Physical and socioeconomic Characteristics	Slope gradient	Very Low Lying, Low lying, Almost Flat, Slightly Elevated
	Geomorphology	Older Alluvial Plain, Younger Alluvial Plain and Paleo channels
	Soil Texture	Loamy, Coarse Loamy, Fine loamy and Fine Silt
	Agricultural Suitability	Class 1, 2, 3,4 and Degraded land
	Groundwater Levels	3-5m, 5-8m, 8-10m, >10m
	Population Density	Very Highly Populated, Highly Populated, Moderately populated, Sparsely populated

Table 4.8: Constraints influencing suitability of land parcels

Constraints:
Heritage or Protected/Conserved Areas
Substantial non-coastal wetlands
Flood Plain
Solid-waste dumps
Solid-waste Treatment Plant
Slums
Toxic Industrial waste

For residential development, less distance from transport infrastructure, water supply sources and existing developed land is essential to ensure accessibility of resources to the population.

A primary issue in site suitability is to assign weights to each factor separately. For each land-use category, a set of relative weights for influential factors should be developed in advance so that it can be used as input for suitability evaluation in the next step. Thus, defining of criteria was followed by multi-criteria evaluation procedure in LSA, wherein this study uses a methodology based on advanced techniques .i.e. the already established technique of analytic hierarchy process (AHP) (Saaty, 1977) and Fuzzy logic infused AHP , which are appropriate methods for deriving the weights assigned to each factor. Results from both methods will be compared in terms of their accuracies.

As LSA is essentially a multi-criteria decision making problem, a GIS based multi criteria evaluation method like Weighted (L)linear (C)combination (WLC) or Boolean overlay can be considered for their straightforward approach. WLC or simple additive weighting and its variants require summation of weighted criteria.

WLC is based on the concept of a weighted average in which continuous criteria are standardized to a common numeric range, and then combined by means of a weighted average. The decision maker assigns the weights of relative importance directly to each attribute map layer. The total score for each alternative is obtained by multiplying the importance weight assigned to each attribute by the scaled value given for that attribute to the alternative and then summing the products over all attributes. The scores are calculated for all of the alternatives and that with the highest overall score is chosen (Drobne, 2009). The method can be executed using any GIS system with overlay capabilities, and allows the evaluation criterion map layers to be combined in order to determine the composite map layer which is output. With the weighted linear combination, factors are combined by applying a weight to each followed by a summation of the results to yield a suitability map:

$$S = \sum w_i x_i$$

where S is suitability, w_i is weight of factor i , and x_i is the criterion score of factor i . In cases, where Boolean constraints also apply, the procedure can be modified by multiplying the suitability calculated from the factors by the product of the constraints:

$$S = \sum w_i x_i \, . \, \Pi c_j$$

where c_j is the criterion score of the constraint j . All GIS software systems provide the basic tools for evaluation of such a model (Eastman J.R. 2006).

The first step in this process is digital GIS database development. Because criteria are measured on different scales, it is necessary that factors be standardized before combination, and that they be transformed, if necessary, so that all factor maps are positively correlated with suitability. Voogd (Voogd H, 1983) reviewed a variety of procedures for standardization, typically using the minimum and maximum values as scaling points. The simplest is a linear scaling such as:

$$x_i = [(R_i - R_{min}) / (R_{max} - R_{min})\ ].SR$$

where R_i is the raw score of factor i, R_{min} is the minimum score, R_{max} the maximum score, and SR is the standardized range.

Blind use of linear scaling (or indeed any other scaling) between the minimum and maximum values of the image is ill advised. In setting these critical points for the set membership function, it is important to consider their inherent meaning.

Multi Criteria decision problems involve criteria of varying importance to decision makers and information about the relative importance of the criteria is required. This is usually obtained by assigning a weight to each criterion. The derivation of weights is a central step in defining the decision maker's preferences. A weight can be defined as a value assigned to an evaluation criterion indicative of its importance relative to other criteria under consideration. The larger the weight, the more important is the criterion in the overall utility (Malczewski j. 1999). A variety of techniques exist for the development of weights. In very simple cases, assignment of criteria weights may be accomplished by dividing 1.0 among the criteria. When more than a few criteria are involved and many considerations apply, it becomes difficult to make weight evaluations on the set as a whole. The weights are then usually normalized so that they sum to 1. In the case of n criteria, a set of weights is defined as follows:

$$w = (w_1, w_2 \ldots, w_j \ldots .w_n) \text{ and } \sum w_j = 1$$

There are four main groups of techniques for the development of weights (Malczewski j. 1999): 1.Ranking methods, which are the simplest methods for assessing the importance of weights, every criterion under consideration is ranked in the order of the decision maker's preferences;

2. Rating methods, which require the estimation of weights on the basis of predetermined scale; 3. Pairwise comparison methods, which involve pairwise comparison to create a ratio matrix;

4. Trade-off analysis methods, which make use of direct trade-off assessments between pairs of alternatives.

It needs to be emphasized that the reliability of the assessment results depends on a multitude of factors ranging from the quality of the database to the introduction of potential errors associated with data entry, manipulation, and analysis within the GIS. Another problem is that the weighting method employed depends entirely on the perceptions and priorities of the evaluators, so knowledge of the local conditions is critical to the rationality of the weights applied. The modeling results are highly sensitive to the weights applied, and altering the weights assigned to the various factors will have significant effects on the results.

4.2.3.2 Adopted WLC in form of Analytical Hierarchy Process (AHP)

Standardization of individual criteria maps is basic for Land Suitability Assessment, as any map/GIS layer should represent each evaluation criterion with ordinal values (like S1, S2, S3, N1, N2 etc.) indicating the degree of suitability with respect to a criterion, based on suitability objective. These classes have to be rated, as to how important is the class S1 with respect to a particular criteria to contribute for the final objective. Pair-wise comparison technique can be used for the purpose of rating or standardization of these ordinal values (Malczewski *et al*., 2003).

AHP is a multi-objective, multi-criteria decision-making approach that employs a pair-wise comparison procedure to arrive at a scale of preference among a set of alternatives. The process of AHP can be used in two distinctive ways within the GIS environment: first, it can be used in derive the weights associated with the criteria map layers and second the AHP principle can be used to aggregate the priority for all hierarchical levels including the level representing alternative (Drobne, 2009). To apply this approach, it is necessary to break down a complex unstructured problem into its component factors; arrange these factors in a hierarchic order; assign numerical values to subjective judgments on the basis of relative importance of each factor; and synthesize the judgments to determine the priorities to be assigned to these factors (Saaty and Vargas, 1991).

The fundamental input for AHP procedure is the pair-wise comparison matrix, which establishes the preference scores for classes on different criteria and weights of criteria by comparisons measured on a ratio scale. The process requires a decision maker to make qualitative comparison between each element under evaluation .e.g. weak preference, moderate preference etc. (called pair-wise comparisons), which is later converted to quantitative values using Saaty's Scale (Table 4.9). For the construction of a pair-wise comparison matrix, each factor is rated against every other factor by assigning a relative dominant value between 1 and 9 to the intersecting cell. When the factor on the vertical axis is more important than the factor on the horizontal axis, this value varies between 1 and 9. Conversely, the value varies between the reciprocals 1/2 and 1/9 and the main diagonal is always equal to unity.

Table 4.9: Scale for comparisons and description (Saaty 1977)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate prevalence of one over another	Experience and judgement slightly favour one activity over another
5	Strong prevalence	Experience and judgement strongly favour one activity over another
7	Very strong and demonstrated prevalence	An activity is strongly favoured and its dominance is demonstrated in practise
9	Extremely high prevalence	The evidence favouring one activity over another is of highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is required
Reciprocals	For inverse comparison	

The selected elements in the pair wise comparison matrix can be evaluated using several methods to derive the relative importance from the matrix of paired comparisons. A very popular solution of AHP problem was proposed by Saaty (1980), which consists of taking as weights of the components of the (right) eigenvector of the matrix. A number of authors have suggested alternatives to this approach. A number of authors have provided arguments against using the eigenvector as a solution of the AHP problem. The eigenvector can lead to a wrong solution because it violates basic sense of consistency. Generalization of the eigenvector method can lead to non-uniqueness, which produces different solutions depending on whether one uses the right or left eigenvector (Chobot M. and Škrovánková L, 2006). The alternative solution obtained by the geometric mean eliminates these shortages. In Geometric Mean method all the elements in the row are multiplied, the nth root is calculated and divided by their sum to get the normalized

$$g(A) = w, \quad w_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}} .$$

Where w_i is the weight for i= 1,…..n and n is the total number of elements being compared

The derived weights are then used in multi-criteria decision making by employing the Weighted Linear Combination method.

4.2.3.3 Adopted WLC in form of Fuzzy Analytical Hierarchy Process (FAHP)

In FAHP-LSA triangular fuzzy numbers are used for the fuzzification of the crisp pair wise comparison matrix (PCM) being used in traditional AHP. The basic concept of fuzzy extent analysis is to obtain the criteria importance and alternative performances by solving these fuzzified reciprocal PCM's. After obtaining the fuzzy performances, the ultimate aim is to get the final results in crisp form. Therefore the fuzzy performance matrices are transformed into interval performance matrices using the α-cut concept. Then to obtain the crisp output, the concept of optimism index, λ is introduced. The process of FAHP can be explained in following steps (Jie et.al., 2006)

4.2.3.3.1 Acquisition of Crisp PCM and Fuzzifying the Crisp PCM to Fuzzy PCM

In the fuzzy AHP, the triangular fuzzy number is used for the fuzzification of the crisp PCM. Given a crisp PCM A, having the values raging from 1/9 to 9, the crisp PCM is fuzzified using the triangular fuzzy number f = (l,m,u), which fuzzified the original PCM using the conversion number as indicated in the table below (Table 4.10). The l (lower bound) and u (upper bound) represents the uncertain range that might exist in the preferences expressed by the decision maker or experts.

Table 4.10: Fuzzified values of PCM

Crisp PCM Value	**Corresponding Fuzzy PCM value**	**Crisp PCM Value**	**Corresponding Fuzzy PCM value**
1	(1,1,1) if diagonal; (1,1,3) if otherwise	1/1	(1,1,1) if diagonal; (1,1,3) if otherwise
2	(1,2,4)	1/2	(1/4,1/2,1)
3	(1,3,5)	1/3	(1/5,1/3,1)
4	(2,4,6)	1/4	(1/6,1/4,1/2)
5	(3,5,7)	1/5	(1/7,1/5,1/3)
6	(4,6,8)	1/6	(1/8,1/6,1/4)
7	(5,7,9)	1/7	(1/9,1/7,1/5)
8	(6,8,10)	1/8	(1/10,1/8,1/6)
9	(7,9,11)	1/9	(1/11,1/9,1/7)

4.2.3.3.2 Fuzzy Extent Analysis for Calculation of Performance Ratings, Weight Multiplication and Summation

The fuzzy extent analysis is applied on the above fuzzy PCM to obtain the fuzzy performance matrix. The purpose of fuzzy extent analysis is to obtain the criteria importance and alternative performance by solving these fuzzified reciprocal PCMs.

$$\tilde{X}_i \text{ or } \tilde{W}_j = \frac{\sum_{j=1}^{k} \tilde{a}_j}{\sum_{i=1}^{k} \sum_{j=1}^{k} \tilde{a}_{ij}}$$

where i= 1,2,3…… p , j= 1,2,3……q and k=p, or k=q, depending upon the element under operation, whether it is an alternative or criteria (the number of rows and columns in the PCM)

Fuzzy extent analysis is applied to get the fuzzy decision or performance matrix ($\tilde{X}_i$) and fuzzy weights ($\tilde{W}$). After that, a fuzzy weighted performance matrix ($\tilde{P}$) can thus be obtained by multiplying the weight vector with the decision matrix.

$$\tilde{P} = \tilde{X}_i * \tilde{W}$$

The next step is weight summation where the weighted performance matrix (P~) for each alternative under each criteria context is summed up to obtain a total weighted performance matrix for each alternative.

4.2.3.3.3 Check Fuzzy Ranking with Alpha-Cuts-Based Method

According to Wang (1997), in order to make a crisp choice among the alternatives, alpha-cuts-based method is needed for checking and comparing fuzzy number. The alpha-cuts-based method states that if A and B be fuzzy numbers with α-cuts, then Aα = [aα - , aα +] and Bα = [bα - , bα +]. It says A is smaller than B, denoted by A ≤ B, if aα - < bα - and aα + < bα + for all α (0.1)]. The advantage of this method is that the conclusion is less controversial. Here, alpha cut analysis is applied to the total weighted performance matrices for each alternative, checked for the ranking consistency for each alternative under different alpha level circumstances.

4.2.3.3.4 Alpha Cut Analysis for Confidence Level Representation

The alpha cut analysis is applied to transform the total weighted performance matrices into interval performance matrices. The alpha cut is to account for the uncertainty in the fuzzy range chosen. In this case, the decision maker expressed personal confidence about this range. The confidence value ranges between 0 and 1, from the least confidence to the most confidence.

$$\alpha\text{Left} = [\alpha * (\text{Middle\_fuzzy} - \text{Left\_fuzzy})] + \text{Left\_fuzzy}$$

$$\alpha\text{Right} = \text{Right\_fuzzy} - [[\alpha * (\text{Right\_fuzzy} - \text{Middle\_fuzzy})$$

4.2.3.3.5 Lambda Function and Crisp Values Normalization

Through the alpha cut analysis, it will get two values are obtained, namely Alpha_Right (maximum range) and Alpha_Left (minimum range) which need to be converted into a crisp value. It is done by applying the Lambda function which represents the attitude of the decision maker. The attitude of the decision maker is maybe optimistic, moderate or pessimistic. Decision maker with optimistic attitude will take the maximum values of the range; the moderate person will take the medium value and the pessimistic person will take the minimum value of the range. Here, the concept of optimism index, λ, is introduced to obtain the crisp output.

Crisp_value = λ * αRight + [(1– λ) * αLeft]

$$C_\lambda = \lambda * p_{r\alpha} + (1-\lambda) * P_{l\alpha}$$

Where λ = [0,1]

Finally, the crisp values need to be normalized, because the elements of the PCM do not have the same scale. It is important to note that elements can be compared if they have the uniform scale.

$$C_{i\lambda} = \frac{C_{i\lambda}}{\sum C_{i\lambda}}$$

The normalised weights thus derived are used in multi-criteria decision making by employing the Weighted Linear Combination method.

4.2.4 Conflict Analysis (Restricted areas viz. a viz. Master Plan 2021)

Investment in infrastructure is needlessly wasted if urban managers do not adequately plan the place, sequence and time of construction. A small expenditure on good planning can bring benefits that are so much greater as to make the failure to plan a ridiculous oversight. Improvements to development management have rarely attempted to dramatically change the dominant urban planning practice, even though it has most often proved unable to guide public investment to greater efficiency and effectiveness. In the case of urban areas, it is thought that spatial planning will, among other things (Keeble, 1964; Chapin, 1979):

- Coordinate location in time and place of both supply and demand for service infrastructure and facilities;
- Establish uses for land which will increase efficiency and effectiveness of services, including transport, compared to piecemeal land development.

These effects can reduce the cost of constructing, operating and maintaining basic infrastructure like road, sewerage, water piping, and telephone and electricity. A chief reason for this is that conventional urban spatial planning methods have proved to be too slow to inform decisions in today's world, especially in urban areas where rates of economic, political, and population change are great (Dowall and Clarke, 1991 and Farvacque and McAuslan, 1992).

Conflict analysis is an essential yet tremendously challenging solution to the above problem. Conflict analysis should inform decision-making with the aim of improving the effectiveness of planning and management interventions, including the effectiveness of development and humanitarian assistance. It is important to emphasise that conflict analysis is an ongoing process and not a static, one-off exercise.

Conflict analysis for urban development planning can be achieved using basic GIS overlay techniques on the authentic future development plans like City Master plans or City Development plans and a detail urban suitability assessment of the area. Such an analysis seeks to address the problem of ensuring sustainable development to forever increasing urban dwellers.

Constraints i.e. criteria restricting urbanisation were buffered for varying diameters individually and combined into a single restricted areas layer.

Areas that are covered with natural land covers like forest and water bodies (e.g. ponds and rivers), buffered for a defined area were considered unsuitable or conflicting for urban development. Not only are these areas sensitive to anthropogenic disturbance, but also under building bylaws, these land covers with a defined buffer are considered conserved/protected and cannot be accessible to human interference. These forest areas were buffered for 500 mts around them and water bodies were buffered for 1000 mts around them.

Buildings, structures and monuments declared as heritage sites buffered for a defined area were considered unsuitable or conflicting for urban development, as any approaching construction would eventually result in either engulfing the site for upcoming real estate or rendering the site ruined by congested construction all around it, marring its glorious legacy. These restricted areas were buffered for 500 mts around them.

Slums, Toxic industries and sewage dumps buffered for a defined area were considered unsuitable or conflicting for urban development as these unhygienic/unaesthetic sites have long been associated with various public health issues and considered as source or support to diseases often leading to epidemics threatening the living populations surrounding them. These restricted areas were buffered for 500 mts around them.

All these buffered layers were combined together into a single constraint layer which was overlayed on Master Plan 2021 digital layer to extract areas of conflict. Through an inspection of spatial layers (unsuitable zones viz a viz master plan2021) and simultaneous GIS overlay analysis, there appeared to be a number of proposed urban zones and infrastructures in the observed unsuitable area. Potential zoning conflicts included planned residential areas and supporting infrastructures (roads, streets etc.; proposed plantation and agricultural areas.

4.3 Site Selection: On the basis of land use changes and urban growth in urban and peri urban limits of Lucknow four site (one governmental and other three non governmental) was selected.

4.4 Data Collection: Ancillary data (for baseline and current environmental status) and Google Earth high resolution satellite data of 2005 and 2014 was obtained.

4.4.1 Baseline environmental status: Baseline data before the start of the project was studied from the reports obtained from SPCB, Lucknow. The brief descriptions are given as below:

(A) Ambient Air Quality: This assessment was accomplished by reviewing historical ambient air quality data, examining source of air emission within 10 km radius of proposed site. The air quality was monitored for 24 hour continuous of SPM/RSPM and 8 hourly for gaseous parameters for 12 weeks from march 2006 to may 2006 at 5 different locations in case of LDA Gomti Nagar Extension (core zone, dalukhera,

chinhat, ardaunamau, dilkhush garden), 5 different location in case of DLF Garden City (on site, purseni, DDU park, canal coloney,houses on highway) for 24 hours of RSPM, SPM, NO_x, SO_x and CO for 8 hour twice a week. Similarly with respect to Parsvnath City due to on site traffic load the ground level RSPM, SPM, NO_x, SO_x was observed for 24 hours averaged except CO (for 8 hours) at 5 different locations and with respect to Omaxe Residency monitoring frequency, period, and locations are not mentioned in the compliance reports.

(B) Ambient Noise Quality: the noise monitoring was conducted at 5 different locations in case of LDA Gomti Nagar Extension (core zone, dalukhera, chinhat, ardaunamau, dilkhush garden), 4 different locations in DLF Garden City (on site, purseni, DDU park, canal coloney) .With respect to the Parsvnath City and Omaxe Residency the noise level monitoring locations are not mentioned in the compliance report obtained from the different governmental departments. The sound pressure level (SPL) measurements were automatically recorded to give the noise level for every hour continuously for 24 hours in a day (i.e; 6.00 am to 10.00 pm and from 10.00 pm to 6.00 am).

(C) Water Quality: The ground water samples were collected from 5 different location in the pre monsoon 2006 with respect to LDA Gomti Nagar Extension (core zone, Dalukhera, Chinhat, Ardaunamau, Dilkhush Garden), 4 different location with respect to DLF Garden City (on site, purseni, DDU park, canal coloney), 8 different location with respect to Omaxe residency (Arjunganj, Nizampur, Gosaiganj, Ahmamau, Baghiamau, Devamau, Muzzafer nagar, Gluswal, Hariharpur while the ground water was collected from the site.

(D) Soil quality: The soil samples were collected from the 5 different location with respect to LDA Gomti Nagar Extension (core zone, Dalukhera, Chinhat, Ardaunamau, Dilkhush Garden), 3 different location with respect to DLF Garden City (on site, purseni, DDU park), 1 location (on site) with respect to Parsvnath City while soil monitoring locations are not mentioned in the compliance reports. The soil samples were collected at the 15 cm depth after removing the upper crust. The samples from each spot were were well mixed with hand on a clean polythene sheet. This sample was kept for some time for air drying at room temperature, stored in polythene bag with label at the top. After that samples were analysed. In this way baseline data of **socio economic status, flora, fauna, and land use / land cover** (from Google earth 2005) were collected.

4.4.2 Current environmental status: The current environmental status was collected by self preparation of environmental monitoring plan by hiring a consultancy named prakriti (MOEF certified laboratory) from the core zone (within 10 km radius of the site).

(A) Ambient Air Quality: The assessment of air quality of the 3 study area (LDA Gomti Nagar Extension, DLF Garden City, and Omaxe Residency) except parsvnath city (because permission from the project authority was not granted) was done near the main gate (on site) within 10 km radius of proposed site. The air quality was monitored for 24

hour continuous of SPM/RSPM and 8 hourly for gaseous parameters for 12 weeks after monsoon 2014.

(B) Ambient Noise Quality: The noise monitoring for the study area (LDA Gomti Nagar Extension, DLF Garden City, Omaxe Residency, and parsvnath city) was conducted near the main gate (on site) after monsoon period in 2014. The sound pressure level (SPL) measurements were automatically recorded to give the noise level for every hour continuously for 24 hours in a day (i.e; 6.00 am to 10.00 pm and from 10.00 pm to 6.00 am).

(C) Water Quality: The ground water samples of the study area (LDA Gomti Nagar Extension, DLF Garden City, Omaxe Residency, and Parsvnath City) were collected from the main gate (on site) after monsoon period in 2014.

(D) Soil Quality: The soil samples of the study area (LDA Gomti Nagar Extension, DLF Garden City, Omaxe Residency, and Parsvnath City) were collected from the from the main gate (on site) after monsoon period in 2014 .The soil samples were collected at the 15 cm depth after removing the upper crust. The samples from each spot were were well mixed with hand on a clean polythene sheet. This sample was kept for some time for air drying at room temperature, stored in polythene bag with label at the top after that samples were analysed.

4.5 Comparative Assessment of baseline and current environmental status:

A comparative study of housing projects was done by the assessment between the pre to pre projects (baseline data) and post to post projects (current environmental status) for the change detection.

4.6 Effectiveness of EIA System implemented in Housing Project of Lucknow

Effectiveness is commonly defined as the ability to produce a desired effect. So, the effectiveness of EIA system implemented in the housing projects was determined, i.e. whether EIA is effective or not, when it is implemented in the housing projects, and how it can be made more effective? The overall evaluation of the effectiveness of EIA system implemented in the housing projects were based on *Leopold interaction matrices* and *land use and land cover change detection analysis of housing projects.*

4.6.1 Leopold interaction matrix:

The Leopold matrix method was developed by Dr. Luna Leopold and others of the United States Geological Survey (Leopold *et al.*, 1971)**.** Leopold interaction matrices was applied to determine the effectiveness of EIA on a ranking (scaling) between 0 to 10 which was again scaled/ranked on the basis of result obtained between 0 to 1 (where 0 to 0.50 indicates for neutral effective, 0.51 to 0.70 indicates for 'high effectiveness, and 0.71 to 0.80 indicates for 'medium/moderate effectiveness' 0.81 to 1.0 indicates for 'low

effectiveness'). The matrix is designed for the assessment of impacts linked with almost any type of construction project. It not only gives the qualitative information on cause-and-effect relationships, but it is also useful for communicating results. When an action or activity is expected to have an environmental impact, it is noticed by the intersection cell and is further described in terms of magnitude and importance.

4.6.2 Land use/cover change detection:

Satellite data of the recent year 2014 from the Google earth were collected for the land use and land cover change detection. Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land use and land cover changes than the information obtained from continuous change (Ramachandra and Kumar 2004). Detecting change in urban areas is not only of academic interest, because it serves as the major data source for strategic planning and analysis in urban areas (Donnay et al. 2001).

Land-use and land-cover changes refer to (quantitative) changes in the aerial extent (increases or decreases) of a given type of land use or land cover, respectively. The Land-use and land-cover changes are detected to find out the effectiveness of EIA on the basis of satellite images obtained from the Google earth software (by using parameters like built up area, non built up area, green area, water bodies, and road network) and are classified into effective, non effective, moderate effective. *However, land-cover changes may result either from land conversion (a change from one cover type to another), or land modification (alterations of structure or function without a wholesale change from one type to another), or even maintenance of land in its current condition against agents of change. Similarly, land-use change may involve either conversion from one type of use to another (i.e., changes in the mix and pattern of land uses in an area), or modification of a certain type of land use (i.e., changes in the intensity of use or alterations of its characteristic qualities/attributes).*

5 RESULT AND DISCUSSION

Construction activities in India have been pursued without giving much attention on environmental issues. This has resulted in pressure on its finite natural resources, besides creating impacts on human health and well-being. Unplanned and unsustainable urban development has lead to severe environmental pressures. Modern buildings built in our cities have high levels of energy consumption because of requirements of air- conditioning and lighting. These results of the study are directly and indirectly degrading the quality of environment. These parameter are discussed in this chapter through which impacts on environmental quality are now discussed in detail by comparative study of pre-project and post project environmental status.

The ancillary data layers were digitised to build a GIS database of factor layers required for Landuse change detection, Agricultural Land capability Analysis, Land Suitability Analysis and conflict analysis. The spatial data for drainage, transport network, major settlements and administrative boundaries (Figure 5.1 to Figure 5.3) were generated using georeferenced base layers. The primary input layers of Soil group texture, Geomorphology and Ground water level (Figure 5.4 to Figure 5.6) were also generated using georeferenced spatial data. Further, the Elevation gradient data (Figure 5.7) was generated using georeferenced and density sliced DEM (Digital Elevation Model) from SRTM (Shuttle Radar Topography Mission) satellite data, freely downloaded from internet. A digital layer of Master plan 2021 for Lucknow City (Figure 5.8) was also prepared using georeferenced product of hardcopy provided by Town and Country Planning Dept of Uttar Pradesh.

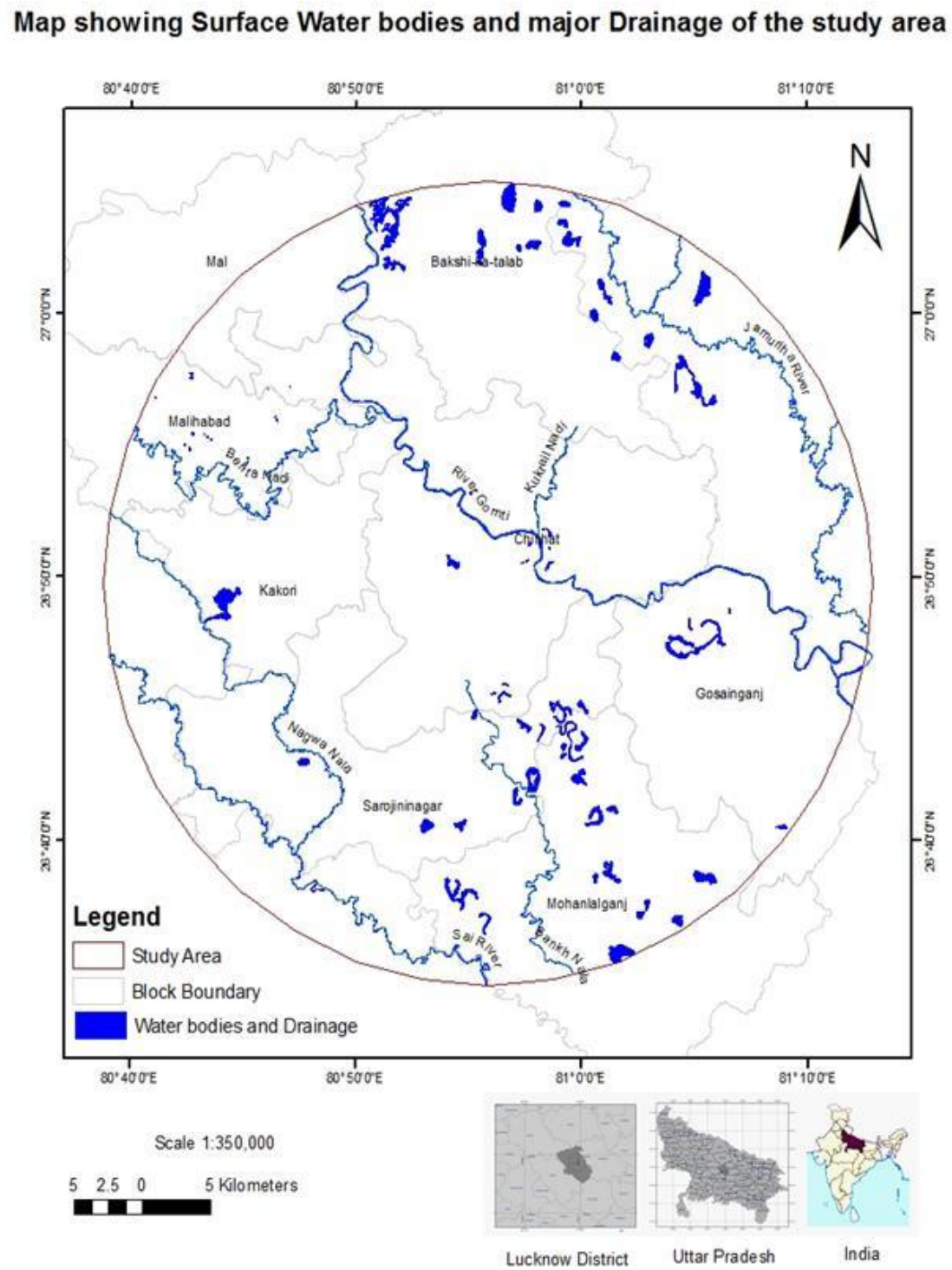

Map showing Surface Water bodies and major Drainage of the study area
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
N
Mal
Bakshi-ka-talab
Malihabad
Jamunth a River
Belra Nadi
River Gomti
Kukrail Nadi
Chinhat
Kakori
Gosainganj
Nagwa Nala
Sarojininagar
Mohanlalganj
Sai River
Bankh N ala
Legend
Study Area
Block Boundary
Water bodies and Drainage
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.1

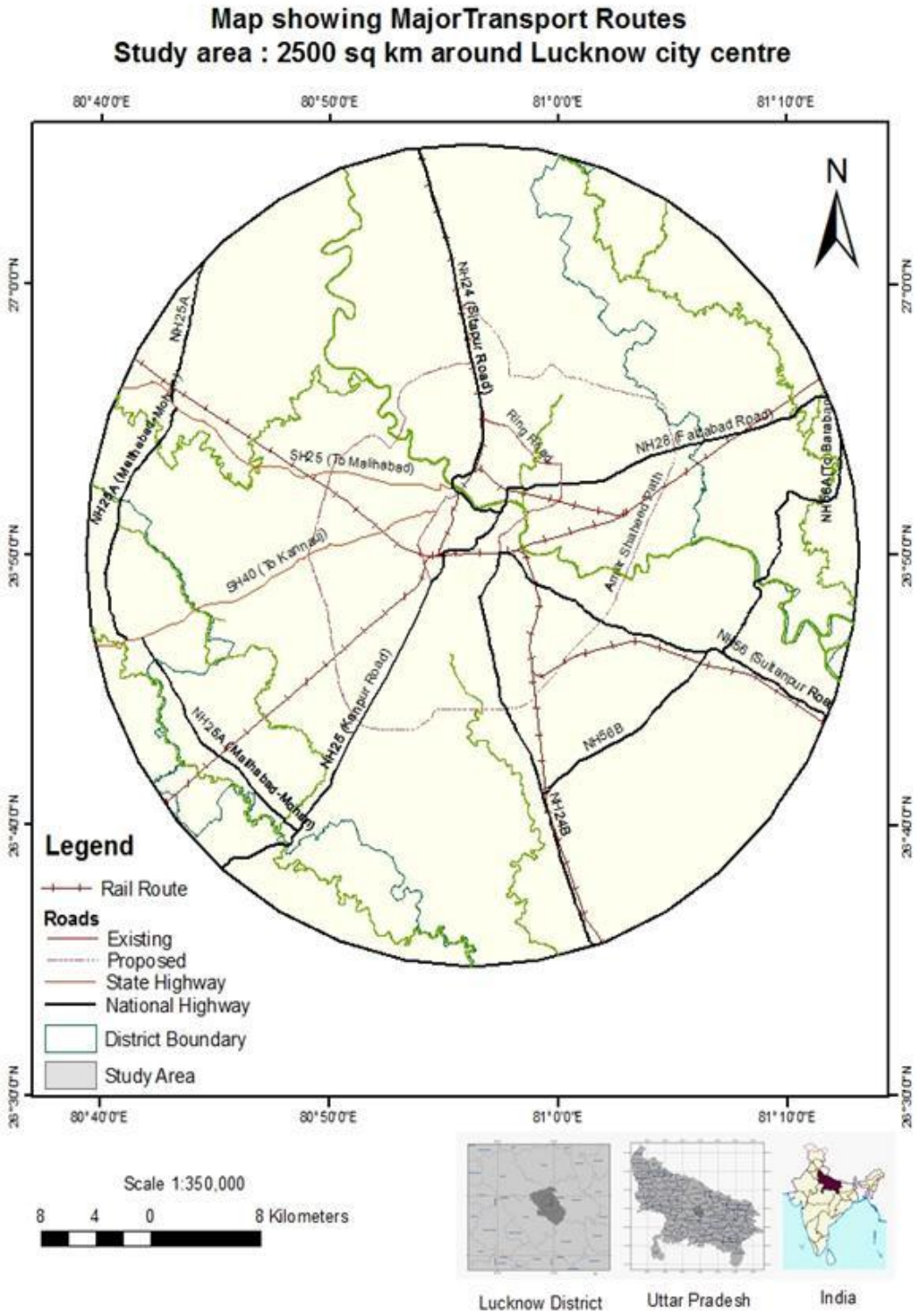

Map showing MajorTransport Routes
Study area : 2500 sq km around Lucknow city centre
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
NH24 (Sitapur Road)
NH25A
SH25 (To Malihabad)
SH40 (To Kamta)
Ring Road
NH28 (Faizabad Road)
NH56 (Sultanpur Road)
NH25 (Kanpur Road)
NH24B
Legend
Rail Route
Roads
Existing
Proposed
State Highway
National Highway
District Boundary
Study Area
Scale 1:350,000
8 4 0 8 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.2

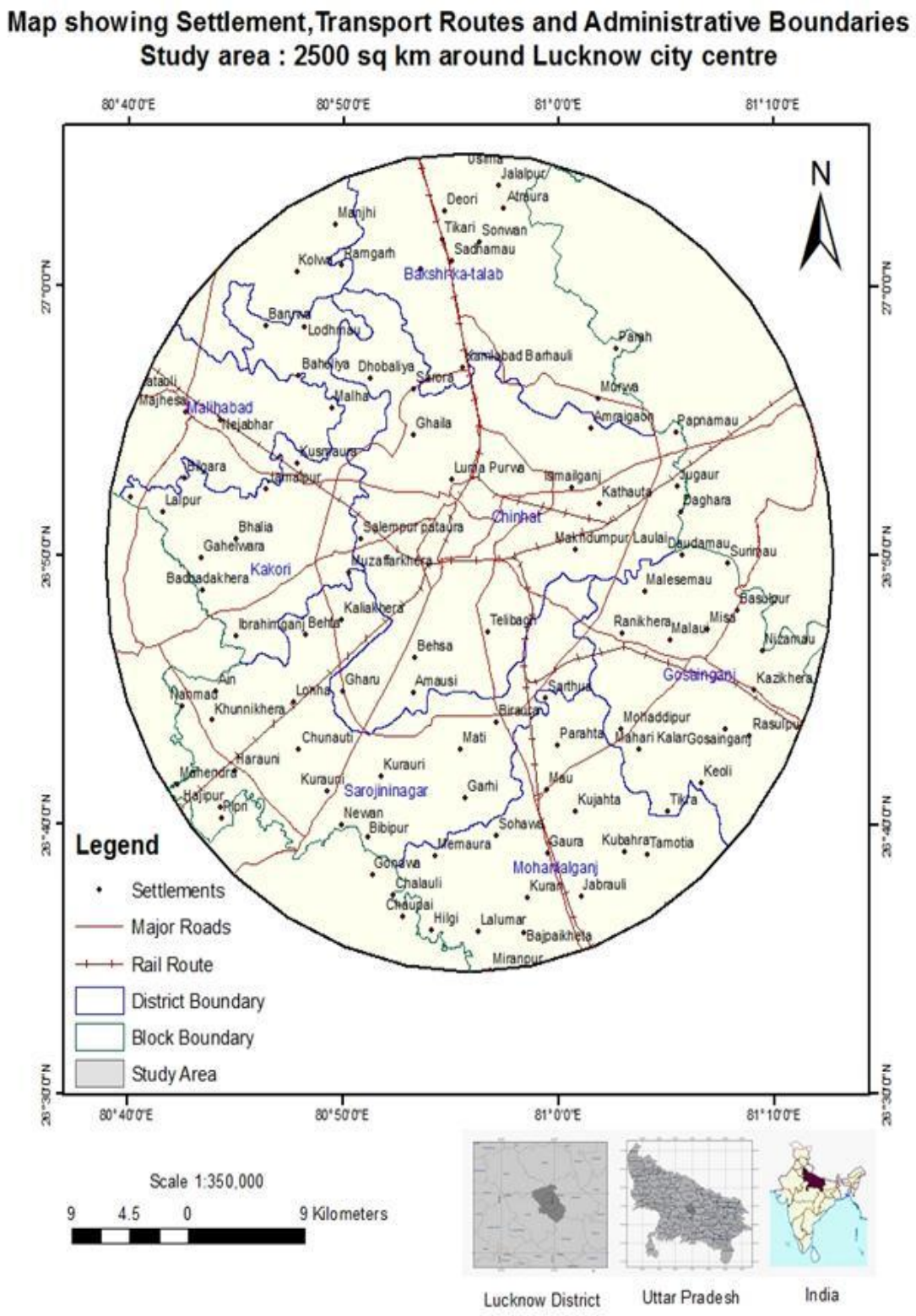

Map showing Settlement, Transport Routes and Administrative Boundaries
Study area : 2500 sq km around Lucknow city centre
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Legend
Settlements
Major Roads
Rail Route
District Boundary
Block Boundary
Study Area
Scale 1:350,000
9 4.5 0 9 Kilometers
Lucknow District
Uttar Pradesh
India
Bakshi-ka-talab
Chinhat
Kakori
Sarojininagar
Gosainganj
Mohanlalganj
Malihabad
Jalalpur
Deori
Atraura
Manjhi
Tikari
Sonwan
Sadhamau
Kolwa
Ramgarh
Barwa
Lodhimau
Panah
Kamlabad Barhauli
Baheliya
Dhobaliya
Sarora
Morwa
Majhesa
Malha
Nejabhar
Ghaila
Amraigaon
Papnamau
Kusmaura
Bijgara
Ramapur
Lunia Purwa
Ismailganj
Kathauta
Jugaur
Lalpur
Daghara
Bhalia
Salempur pataura
Gaheiwara
Makhdumpur Laulai
Daudamau
Surimau
Badsadakhera
Nuzaffarkhera
Malesemau
Basolpur
Kaliakhera
Ibrahimganj
Behta
Telibagh
Ranikhera
Malau
Misa
Nizamau
Behsa
Gharu
Amausi
Sarthua
Kazikhera
Lonha
Khunnikhera
Birauta
Mohaddipur
Rasulpur
Chunauti
Mati
Paraha
Mahari Kalan
Gosainganj
Harauni
Kurauri
Mahendra
Kurauri
Garhi
Mau
Kedli
Hajipur
Pipri
Kujahta
Tikra
Newan
Bibipur
Sohawa
Gaura
Kubahra
Tamotia
Gonawa
Chalauli
Kurar
Jabrauli
Chaupai
Hilgi
Lalumar
Bajpaikhela
Miranpur

Figure 5.3

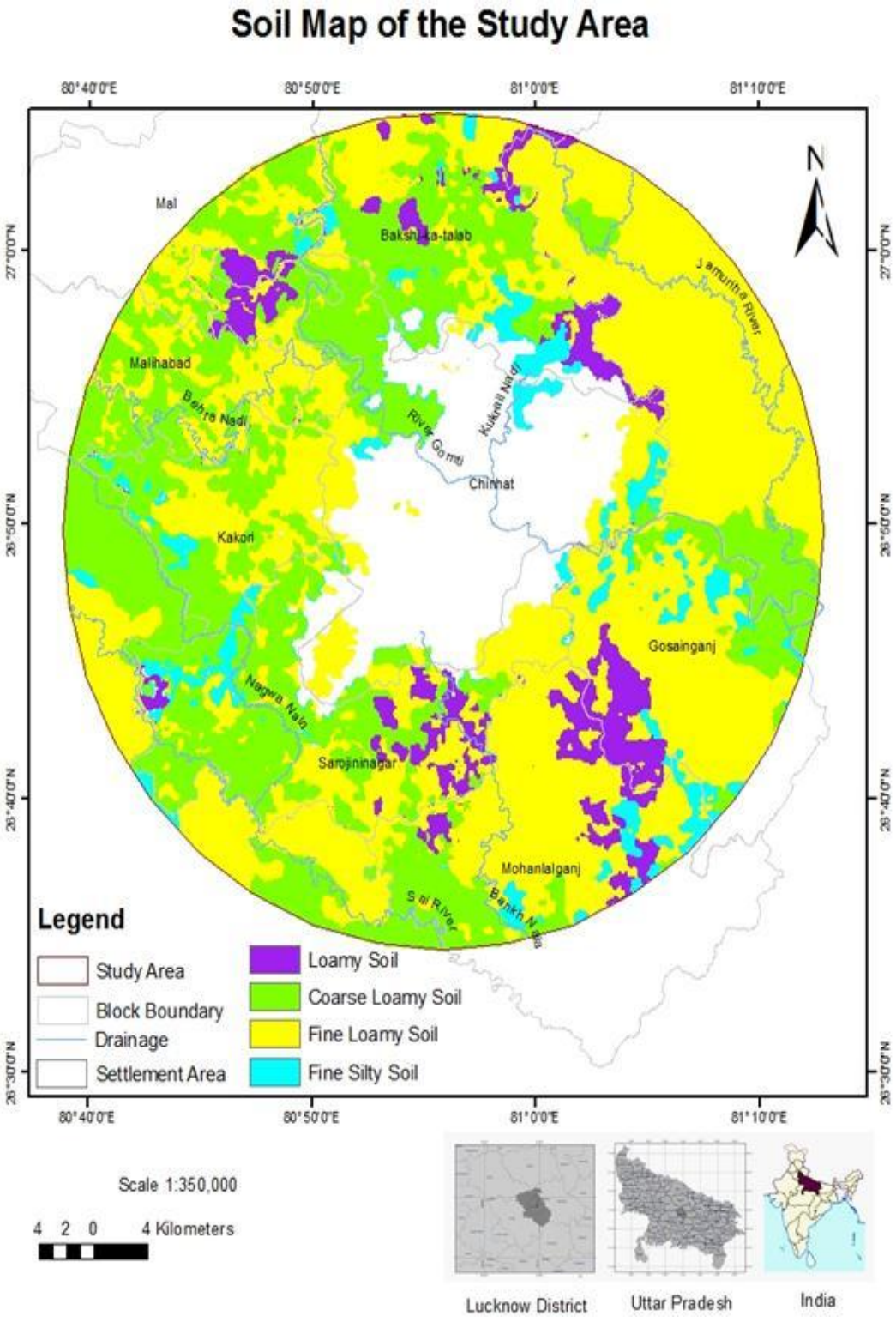

Soil Map of the Study Area
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Mal
Bakshi-ka-talab
Jamunitra River
Malihabad
Behta Nadi
Kukrail Nadi
River Gomti
Chinhat
Kakori
Gosainganj
Nagwa Nala
Sarojininagar
Mohanlalganj
Sai River
Bakhi Nala
Legend
Study Area
Block Boundary
Drainage
Settlement Area
Loamy Soil
Coarse Loamy Soil
Fine Loamy Soil
Fine Silty Soil
Scale 1:350,000
4 2 0 4 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.4

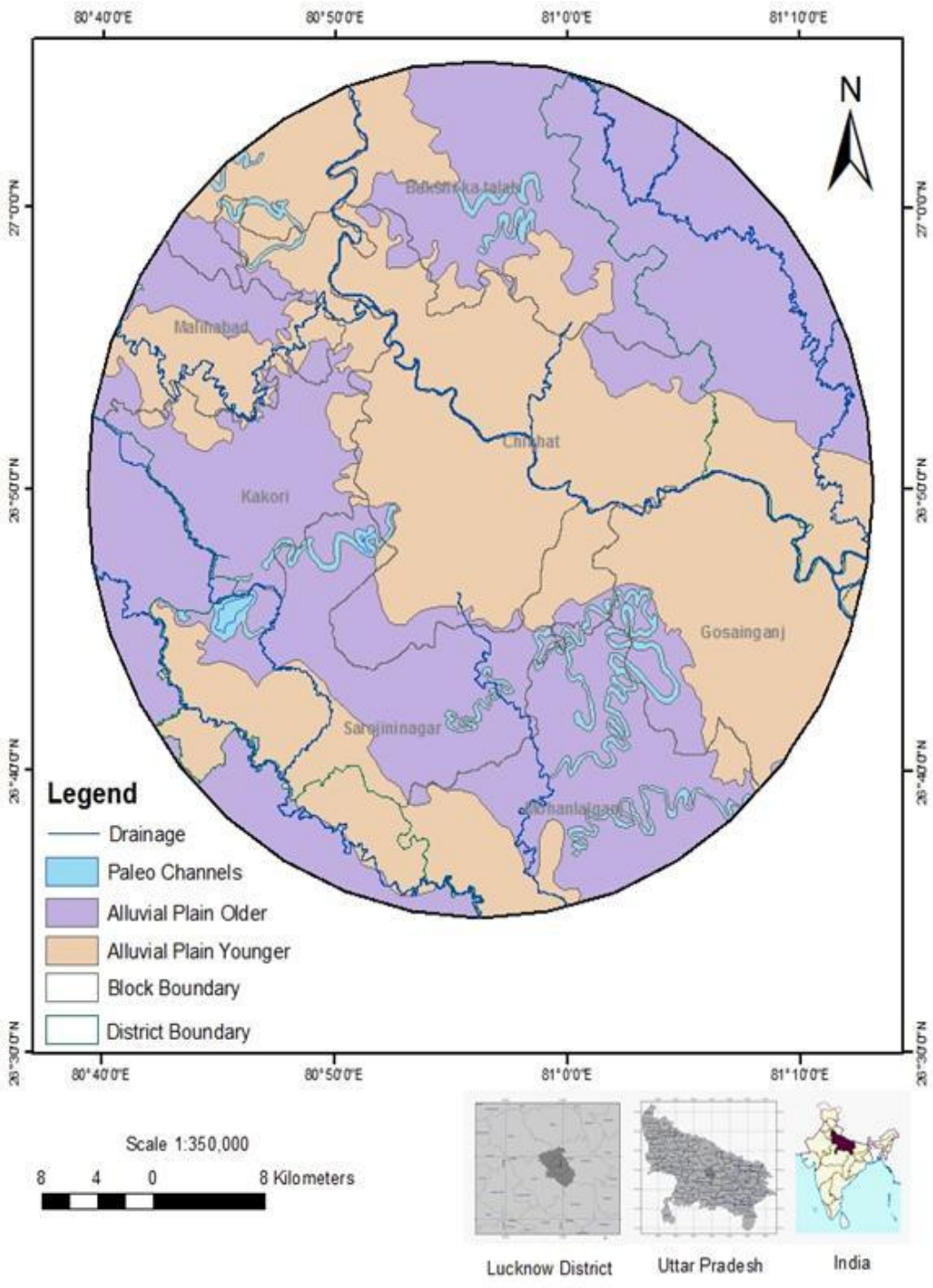

80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Malihabad
Kakori
Gosainganj
Sarojininagar
Legend
Drainage
Paleo Channels
Alluvial Plain Older
Alluvial Plain Younger
Block Boundary
District Boundary
Scale 1:350,000
8 4 0 8 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.5

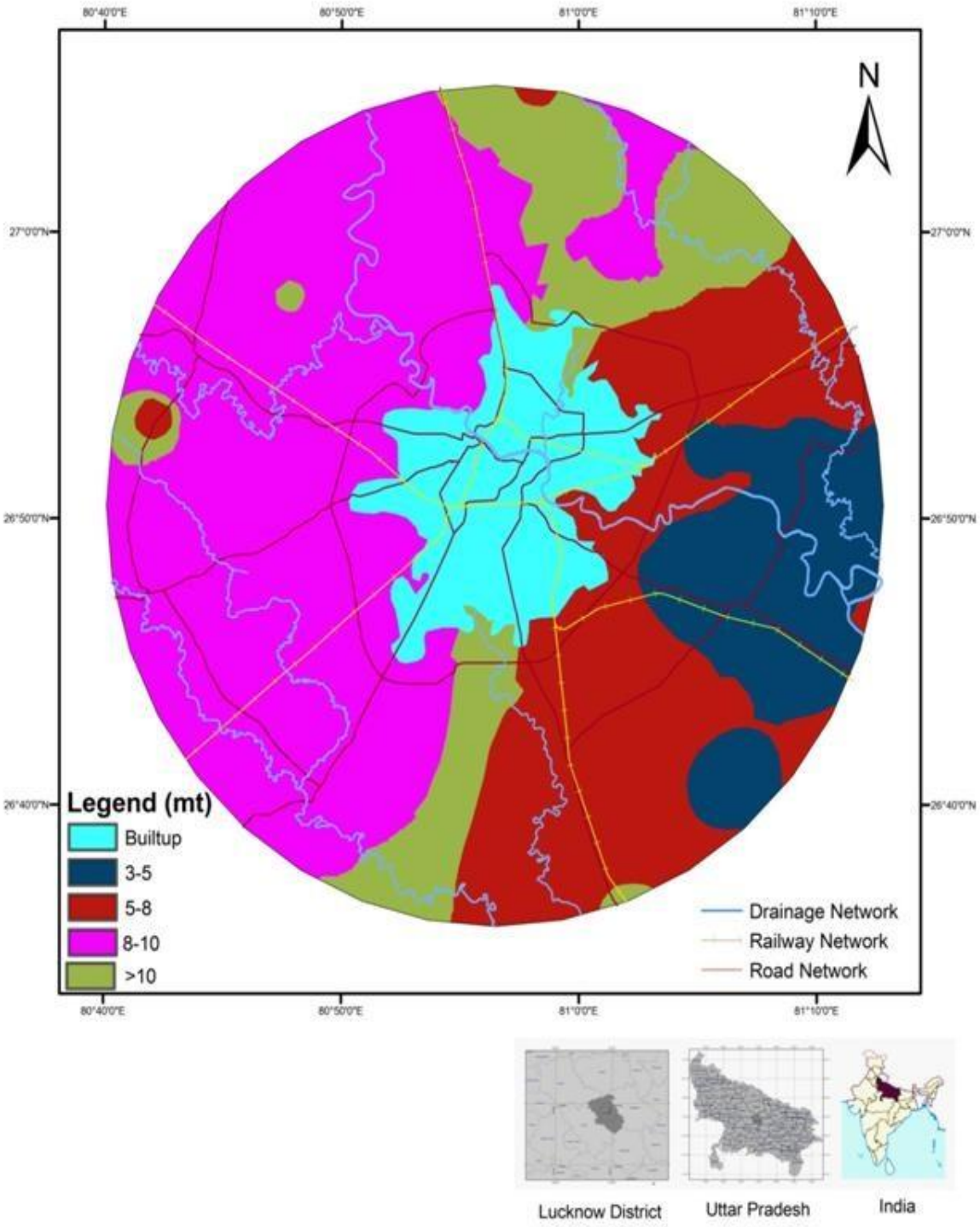

80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
N
27°0'0"N
26°50'0"N
26°40'0"N
Legend (mt)
Builtup
3-5
5-8
8-10
>10
Drainage Network
Railway Network
Road Network
Lucknow District
Uttar Pradesh
India

Figure 5.6

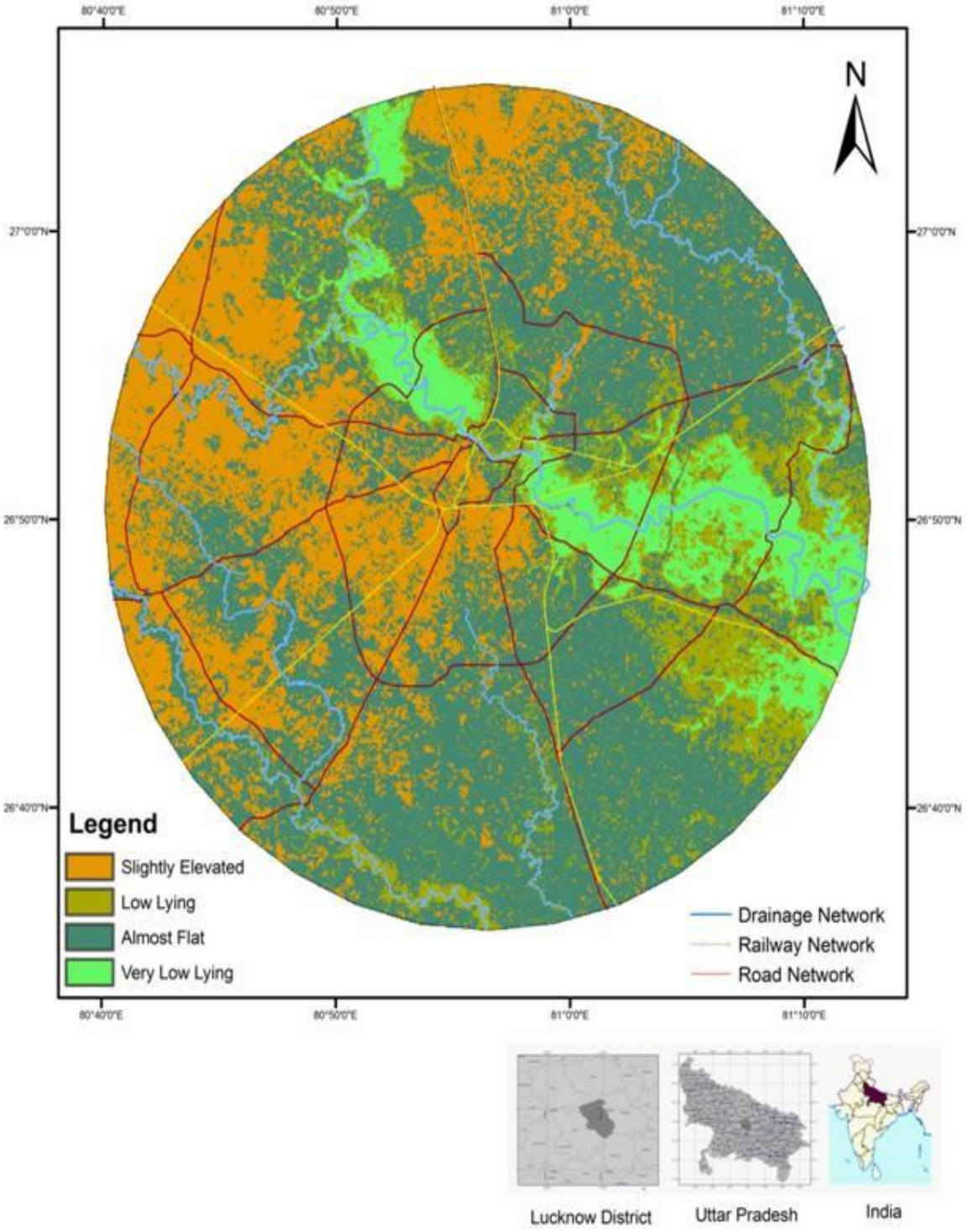

80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
N
27°0'0"N
26°50'0"N
26°40'0"N
Legend
Slightly Elevated
Low Lying
Almost Flat
Very Low Lying
Drainage Network
Railway Network
Road Network
Lucknow District
Uttar Pradesh
India

Figure 5.7

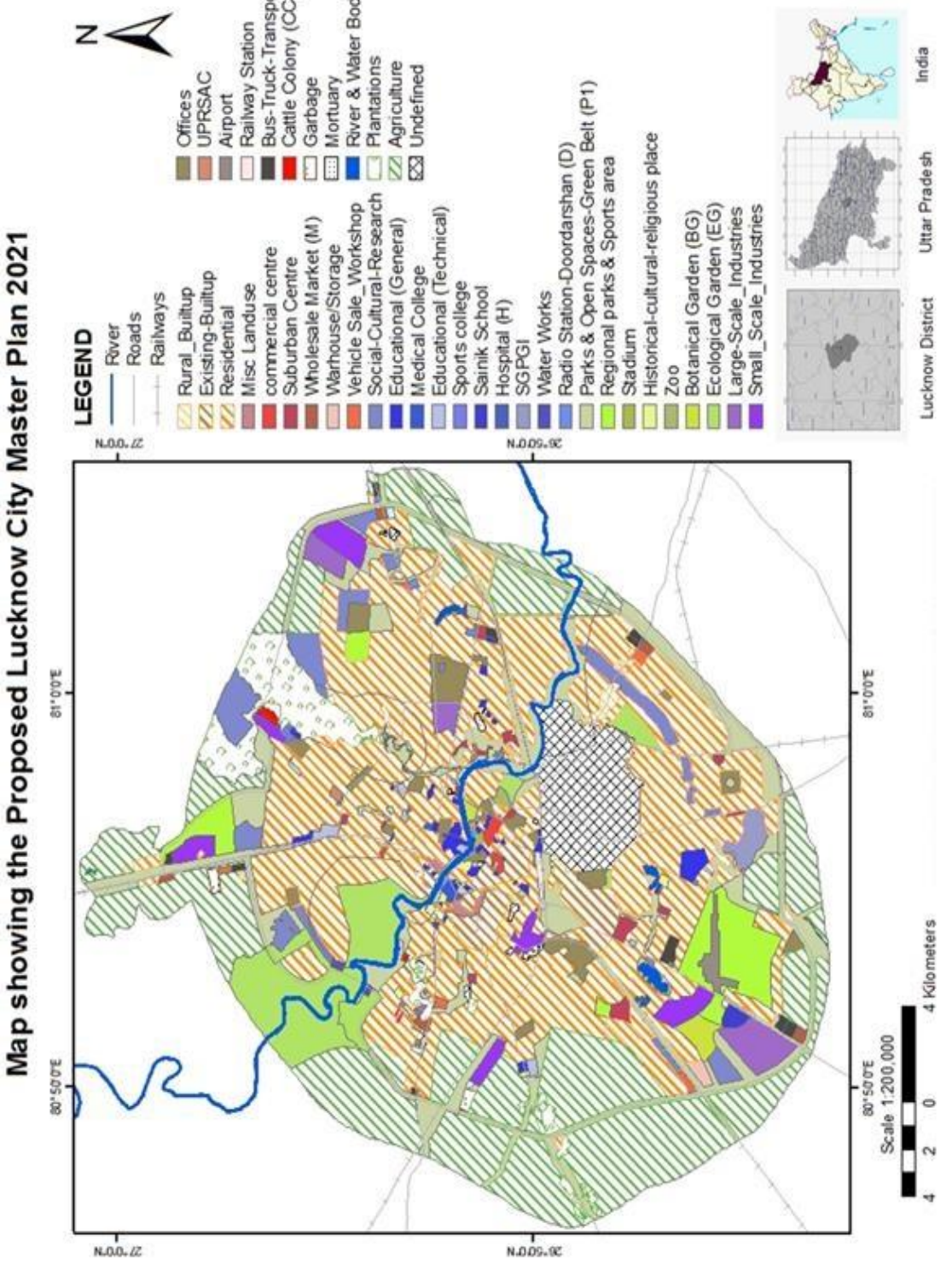

Map showing the Proposed Lucknow City Master Plan 2021
LEGEND
River
Roads
Railways
Rural_Builtup
Existing-Builtup
Residential
Misc Landuse
commercial centre
Suburban Centre
Wholesale Market (M)
Warhouse/Storage
Vehicle Sale_Workshop
Social-Cultural-Research
Educational (General)
Medical College
Educational (Technical)
Sports college
Sainik School
Hospital (H)
SGPGI
Water Works
Radio Station-Doordarshan (D)
Parks & Open Spaces-Green Belt (P1)
Regional parks & Sports area
Stadium
Historical-cultural-religious place
Zoo
Botanical Garden (BG)
Ecological Garden (EG)
Large-Scale_Industries
Small_Scale_Industries
Offices
UPRSAC
Airport
Railway Station
Bus-Truck-Transport
Cattle Colony (CC)
Garbage
Mortuary
River & Water Bodies
Plantations
Agriculture
Undefined
N
Lucknow District
Uttar Pradesh
India
80°50'0"E
81°0'0"E
Scale 1:200,000
4 2 0 4 Kilometers

Figure 5.8

5.1 Multi-temporal Landuse mapping using high resolution satellite data

Multi-temporal land use mapping and simultaneous land use change analysis has been attempted for the study area covering 2500 sq.km, encompassing Lucknow city, its peri-urban interface and beyond. The reference satellite data are high to very high spatial resolution ranging from 5.8 m of Pan sharpened LISS-III to 1.65 m of Geoeye-1 product. The landuse statistics observed for individual time periods .i.e. 1997, 2003 and 2009 have been detailed below (Table 5.1 and Figure 5.9) and their corresponding landuse maps have also been depicted in Figure 5.10 to Figure 5.12.

Table 5.1: Landuse Mapping Statistics

LUSE CLASS	Area (sq. km)	Area % 1997	Area (sq. km)	Area % 2003	Area (sq. km)	Area% 2009
Cropland	1526.58	61.5	1586.22	63.9	1429.22	57.4
Forest	36.23	1.5	28.90	1.2	35.07	1.4
Horticulture	376.25	15.2	215.40	8.7	389.72	15.6
Waterbodies	37.06	1.5	34.66	1.4	40.59	1.6
Wasteland	101.39	4.1	143.61	5.8	127.39	5.1
Scrubland	118.02	4.8	147.26	5.9	123.62	5.0
Area Under Construction	29.40	1.2	40.74	1.6	50.88	2.0
Rural-Builtup	64.63	2.6	65.30	2.6	64.63	2.6
Urban-Builtup	164.62	6.6	179.49	7.2	189.31	7.6
Urban-Vegetated	26.89	1.1	40.32	1.6	40.30	1.6

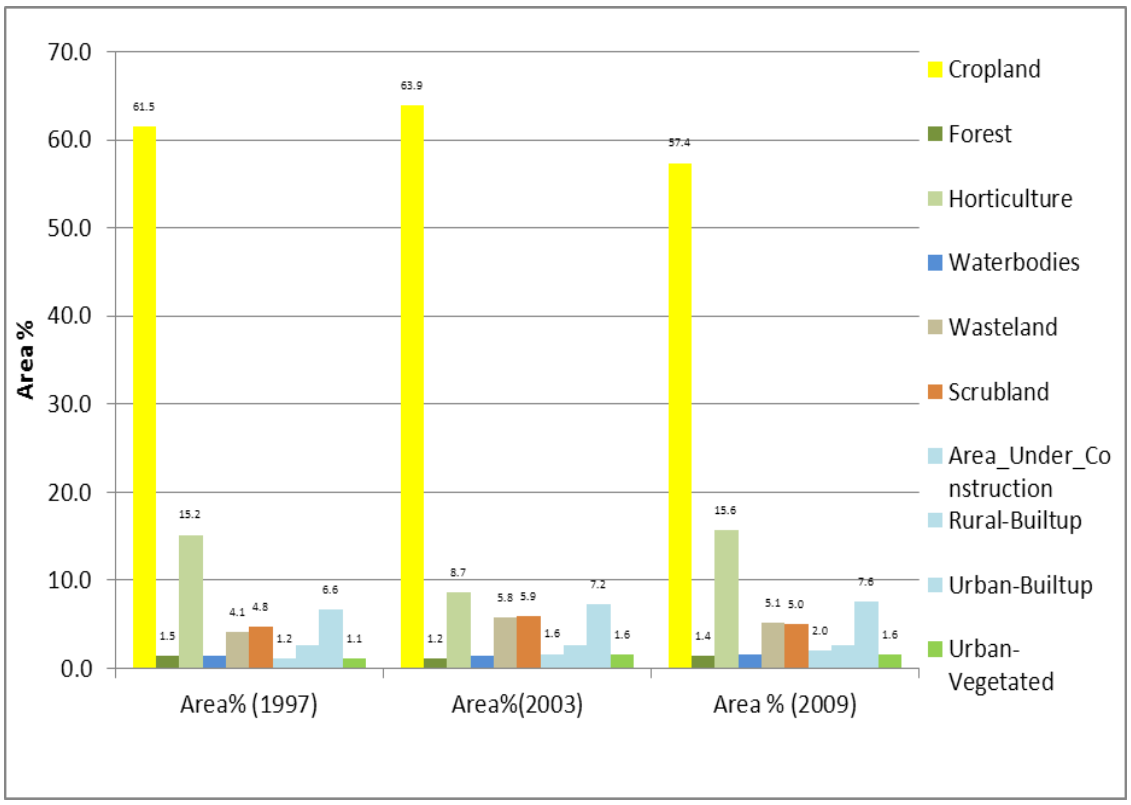


Figure 5.9: Land-use Statistics

The ensuing land-use change analysis using multi-temporal land-use data has highlighted some unique facts which are elaborated below (Table 5.2, figure 5.13):

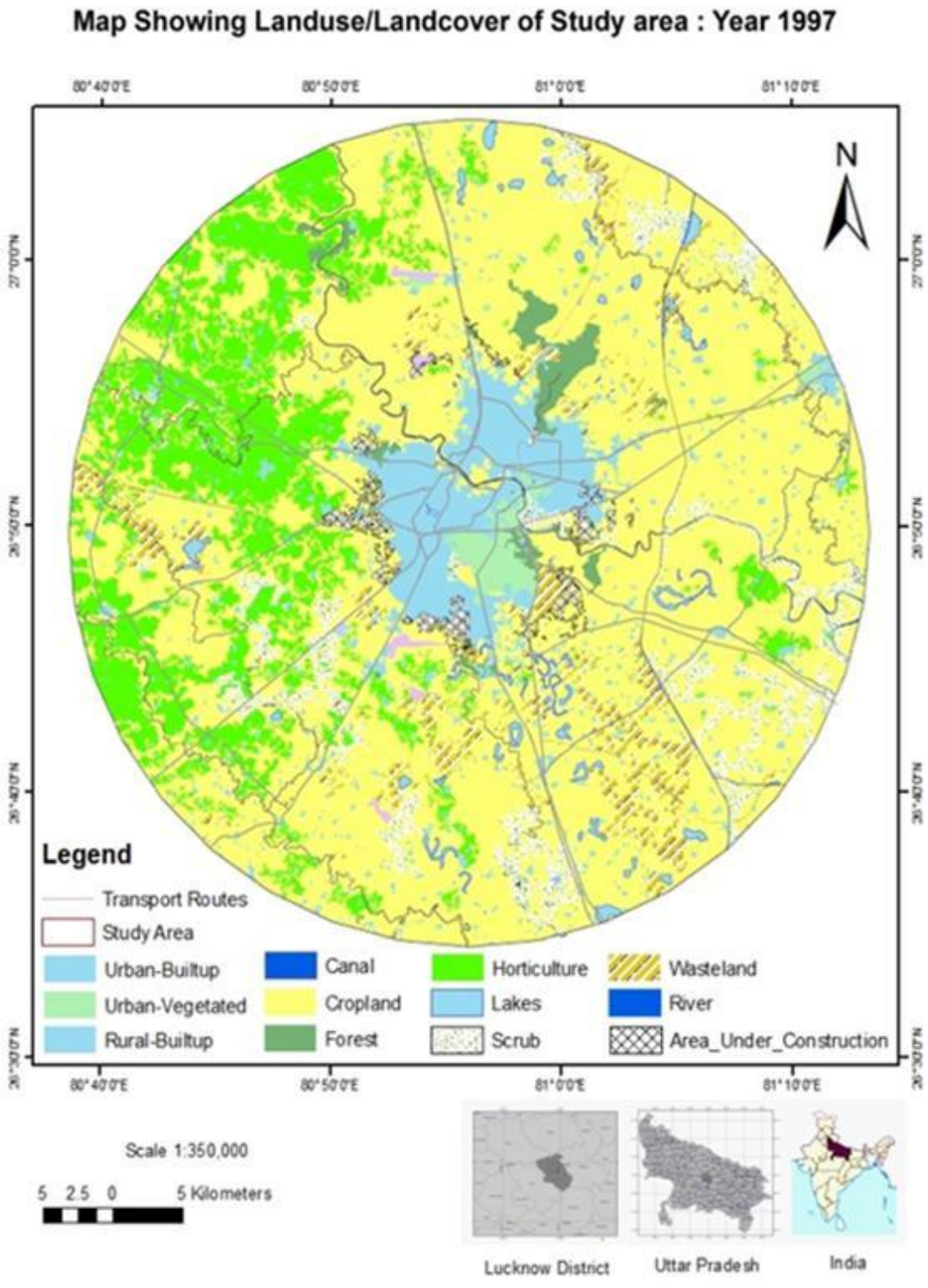

Map Showing Landuse/Landcover of Study area : Year 1997
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Legend
Transport Routes
Study Area
Urban-Builtup
Urban-Vegetated
Rural-Builtup
Canal
Cropland
Forest
Horticulture
Lakes
Scrub
Wasteland
River
Area_Under_Construction
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.10

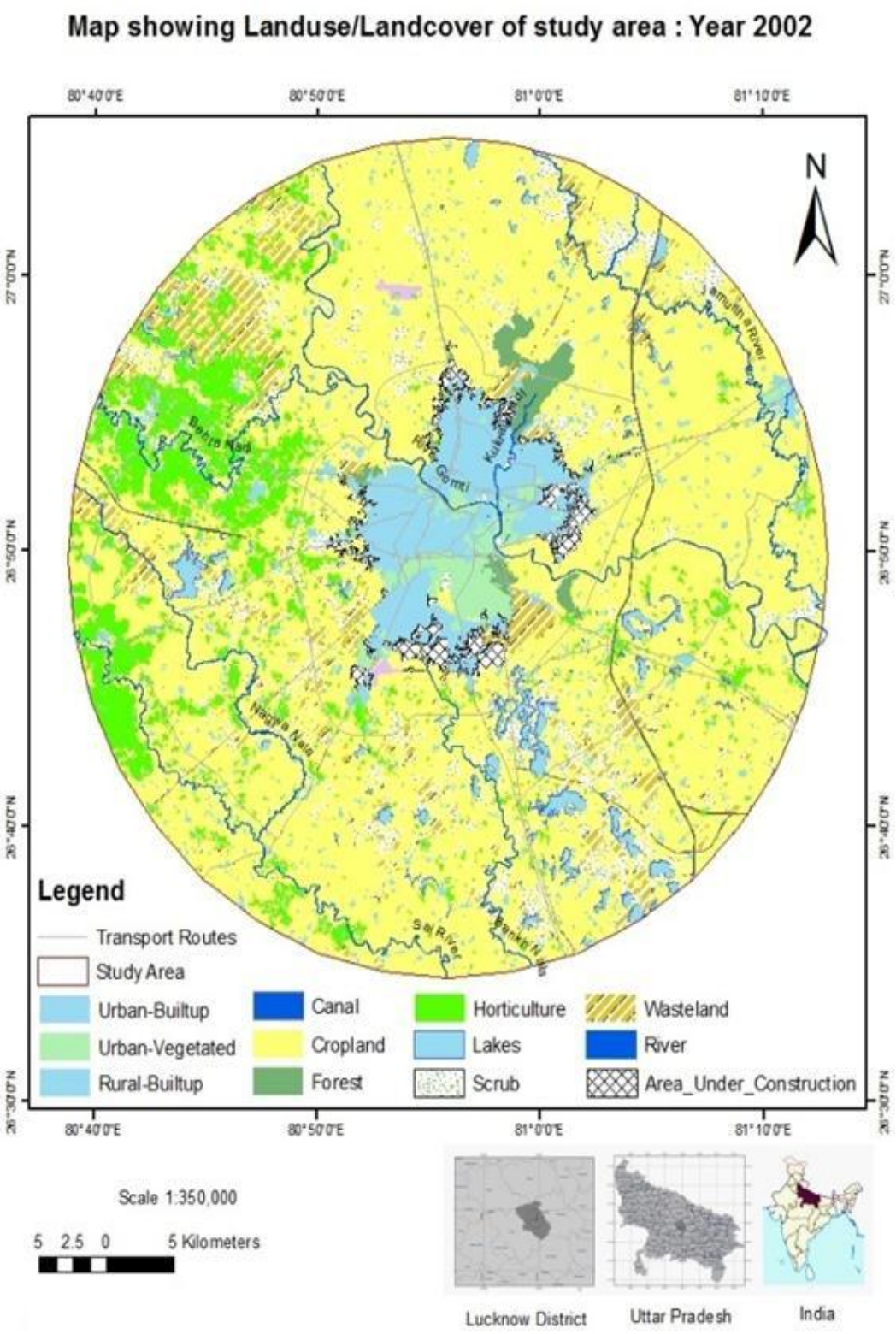

Map showing Landuse/Landcover of study area : Year 2002
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Legend
Transport Routes
Study Area
Urban-Builtup
Urban-Vegetated
Rural-Builtup
Canal
Cropland
Forest
Horticulture
Lakes
Scrub
Wasteland
River
Area_Under_Construction
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.11

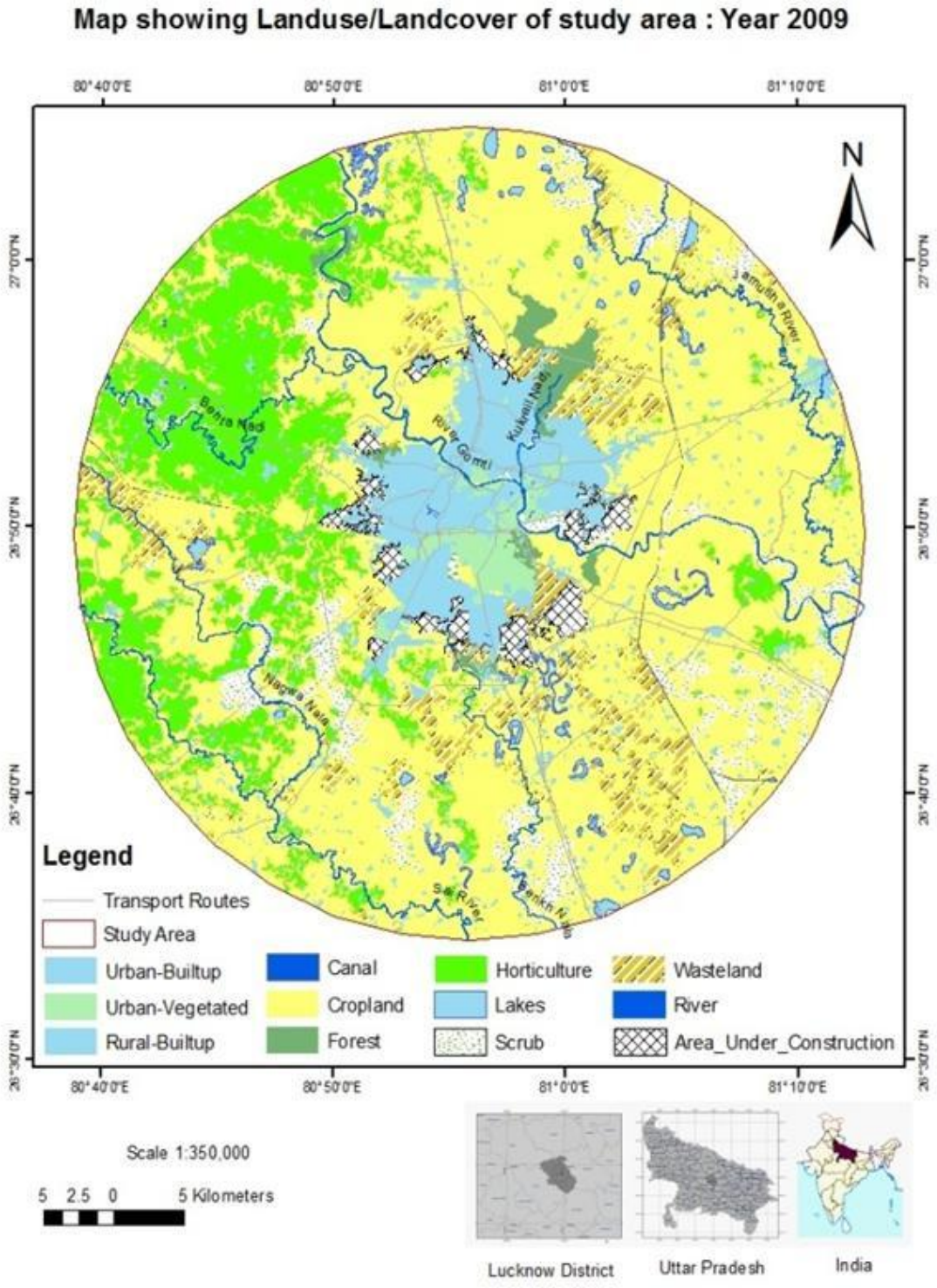

Map showing Landuse/Landcover of study area : Year 2009
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
27°0'0"N
26°50'0"N
26°40'0"N
26°30'0"N
N
Jamuthia River
Kukrail Nala
River Gomti
Sai River
Legend
Transport Routes
Study Area
Urban-Builtup
Urban-Vegetated
Rural-Builtup
Canal
Cropland
Forest
Horticulture
Lakes
Scrub
Wasteland
River
Area_Under_Construction
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.12

Table 5.2: Land-use change analysis

LUSE_CLASS	% Area Change 1997 to 2003	% Area Change 2003 to 2009	Net % Area Change 1997 to 2009
Cropland	2.4	-6.5	-4.1
Forest	-0.3	0.2	-0.1
Horticulture	-6.5	7.0	0.5
Waterbodies	-0.1	0.2	0.1
Wasteland	1.7	-0.7	1.0
Scrubland	1.2	-1.0	0.2
Area_Under_Construction	0.5	0.4	0.9
Rural-Builtup	0.0	0.0	0.0
Urban-Builtup	0.6	0.4	1.0
Urban-Vegetated	0.5	0.0	0.5

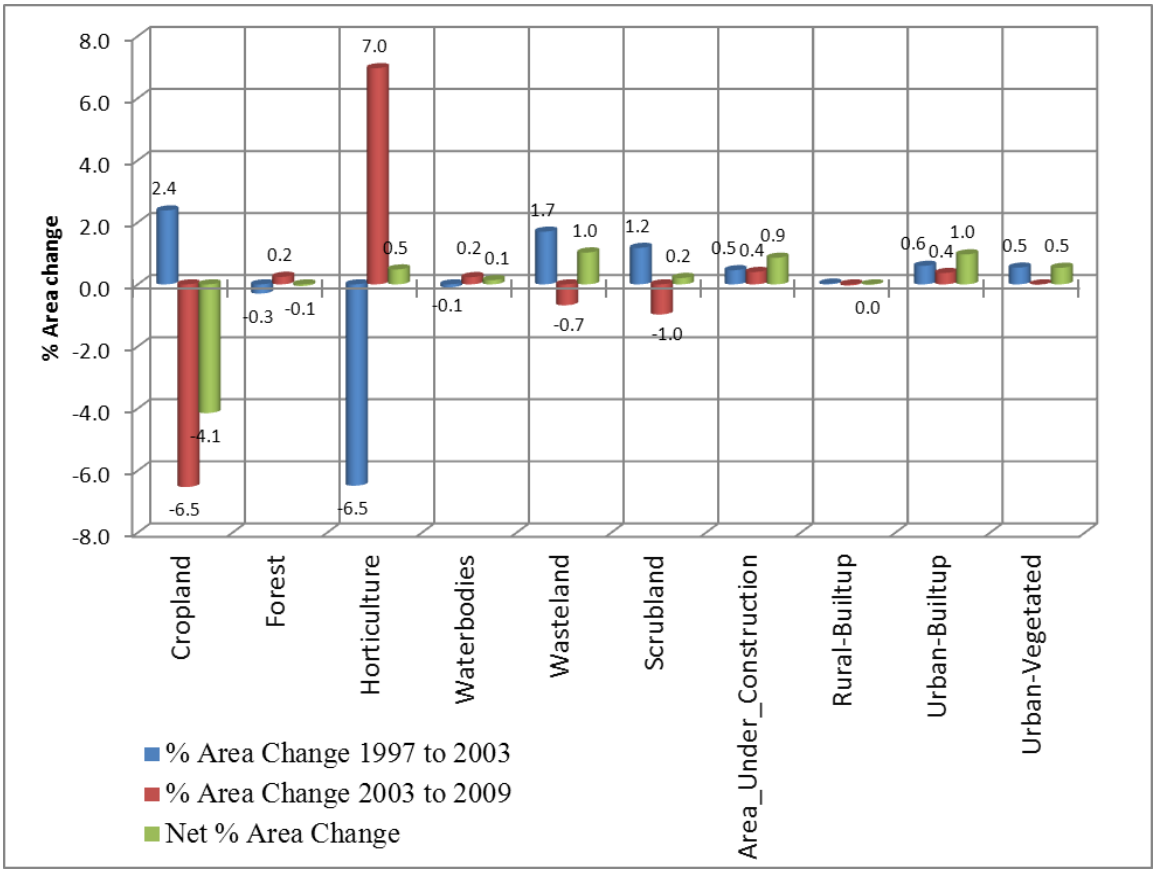


Figure 5.13: Land-use change analysis results

Elaborating on the landuse change statistics, the 5 year duration from year 1997 to 2003, shows a marked increase in cropland area in response to maybe the decrease in area under horticulture, an increase is also observed for wasteland and scrubland. All other landuses show insignificant changes. The simultaneous 6 year duration from year 2003 to 2009 shows a reverse of the earlier observed change, as area under horticulture increases significantly with a considerable decrease in cropland. Wasteland and Scrubland also exhibit significant changes, all other land use changes are marginal. The net land use change in 12 years hence .i.e. year 1997 to 2003 has a considerable loss in cropland and significant increase in urban built-up and wasteland. The collective gradual change in urban area has probably eaten into the cropland which seems to loss some of its resources to degradation also and hence an increase in wasteland. Horticulture apparently has not been affected collectively during the longer duration and the change observed mid duration can be attributed to shifting of occupation as per the economics.

5.2 Case Study: Land Transformation Analysis (Year 2002 – 2009) using very high resolution satellite data

Peri-urban test sites located adjacent to the City development boundary of Lucknow city (Figure 5.14) were visually interpreted on very high scale (1:10,000) for year 2002 and 2009 and observed for detailed landuse changes.

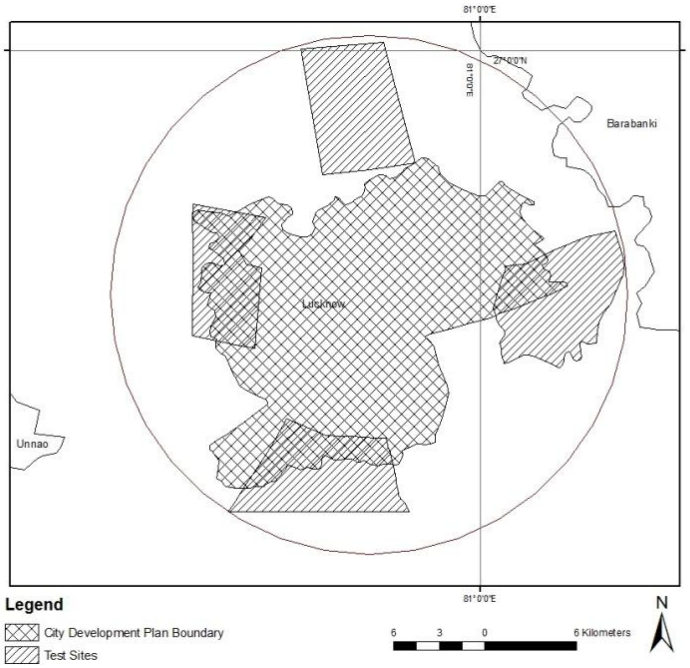


Figure 5.14: Location of Peri-urban test sites

Results from bi-temporal change detection analysis reveal that urban land use has increased over the study period (year 2003 to 2009) with an average annual rate being 13%. This observation is supported by table.3.3 (Rural to Urban is 41.91% of total change), which shows major land use transformations. As indicated by figures in

Table. 5.3, Rural to Urban and Transitional to Urban are main transformations observed, which is quite obvious given rapid urbanization of area.

Of importance to the study are other categories, specifically the Rural to Transitional and Natural to transitional which together contribute a fair 16.84 % to the LULC change and are placed in the transformation category of Critical. This Critical category is generally the result of land cover degradation and is prevalent in peri-urban areas on brink of being urbanized. With existing open areas in city core and a possibility of giving vertical dimension to urbanization (construction of sky scrapers), this category can be saved and reconverted to its original state of sustainable landcover.

Table 5.3: Statistics for major land use transformations

"From" Class	**"To" class**	**Change (2006-2010)**	
		Area	**%**
Natural	Rural	0.22	0.63
	Transitional	1.46	4.24
	Urban	1.43	4.16
Rural	Urban	14.46	41.91
	Transitional	4.36	12.64
	Natural	0.29	0.84
Transitional	Urban	9.47	27.45
	Natural	1.29	3.74
	Rural	1.35	3.90
Urban	Rural	0.02	0.07
	Transitional	0	0
	Natural	0.14	0.42

Also important is the observation of a small but significant amount of change (7.64%) from Transitional to Natural and Transitional to Rural, recorded in the study as conversion of wastelands into croplands, which confirms that above reconversion is possible and takes place naturally also, although at much smaller percentage than required.

Detailed results from the study reveal that urban land use for all four sites has increased over the study period (year 2003 to 2010) with the largest growth of 17.5 % being observed for Northern site and lowest of 10% for Southern site (Fig.5.15).

On an average, more than 70% of the total land use /landcover change has been towards the transformation category of Loss towards urban land use, there has been practically negligible amount of Gain and an insignificant amount of Loss-recoverable. Only the Critical class holds some hope especially for Northern and North Eastern sites where more than 20% of the total land use is in Critical stage.

5.2.1 Spatio-temporal LULC patterns of study sites during urbanization

When considered individually, the land use change statistics of study sites reveal important details about current socioeconomic processes dominating the area and their drivers. As is revealed from the statistics (Fig.5.15), there are four classes displaying significant land transformation; Agricultural cropland shows major decrease, Urban Built-up shows major increase, Wasteland shows moderate decrease and Area under construction shows significant increase; all other land use classes exhibit relatively insignificant change.

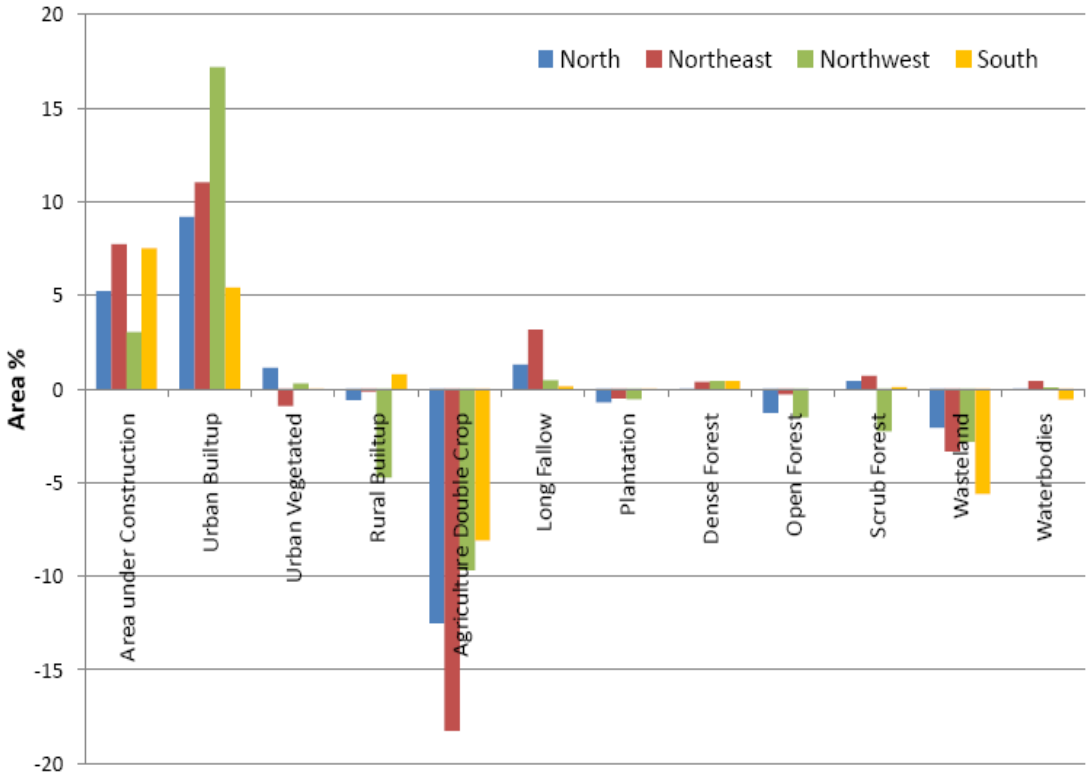


Figure 5.15: Land-use transformation statistics

It is observed that site along the Northwestern direction (enroute to Malihabad town) has experienced maximum amount of relative increase in Urban Built-up (17.18%), with a simultaneous decrease in Rural Built-up (4.71%), wherein the latter seems to have merged with extending urban land use (Fig. 5.15). This finding is unexpected, as

it was anticipated that this area would experience least urban growth due to its location along state highways, as opposed to location of other sites along national highways and absence of adjacent major industrial town as opposed to North east (adjacent to Barabanki) and South (adjacent to Kanpur). The site also shows a significant decrease in cropland (9.68%) and wasteland (2.82%), indicating the conversion from these classes to urban land use. Surprisingly, this site displays minimum Area_under_construction (3.04%) amongst the study sites; indicating a reduction in rate of future urbanization and pointing towards occurrence of a probable land speculation prevalent in recent past which may have spurred the observed urbanization.

Decrease in cropland area (18.25%) is observed to be maximum in North-eastern site, which falls along the Lucknow-Barabanki national highway (Fig. 5.15). The area is intensely industrialized, with increasing number of unplanned factories/industries. Capacity of existing environmental infrastructure in the area for sewage, industrial and solid waste management is inadequate, spelling serious environmental deterioration. The site displays maximum amount of Area_under_construction (7.72%), a significant increase in urban built-up (11.02%) and fair decrease in cropland. The area also shows a significant amount of area under Long fallow (3.15%), indicative of a trend where farmers leave their cultivable land fallow, waiting for urban development opportunities and in event of selling their land towards urban development, gain compensation used to develop farmlands further from city. For these farmers, the uncertainty of when exactly the land might be taken over by urban structures is too great to make it worthwhile continuing with serious, intensive agricultural production. This explains the widespread abandoned fallow or unutilized land found around many expanding cities (Van den berg et al, 2003).

Southern site, falling on Lucknow-Kanpur route, displays a marked decrease in wasteland (5.59%) and cropland (8.08%), with a simultaneous increase in Area_under_Construction (7.51%) indicating an increased rate of future urbanization (Fig. 5.15). A careful observation of initial (2003) and final (2010) images of the site, reveals that most of the defined wastelands are being used for real-estate development. Southern site alone shows a decrease in water bodies, owing to the fact that this area was marked by presence of numerous big and small water bodies in past, which have been transformed to agricultural uses or land filled for real estate development.

Northern test site displays significant decrease in most rural land use classes; Cropland (12.50%), Wasteland (2.07%) and Open Forest (1.28%) with a simultaneous increase in urban built-up (9.17%) which is understandably due to urbanization (Fig. 5.15). The transformation class of Area_under_construction (5.21%) also shows significant increase indicating a continuous urbanization in future.

5.2.2. Relating spatio-temporal patterns to ecological processes

Site specific observation of Critical land transformation category (Fig. 5.16), reveals that at Northern site, Critical category is being formed by conversion of four Rural land use classes, out of which conversion from Cropland is maximum (63%), followed by a substantial 28% being formed by conversion of Forest to Urban-

vegetated. This observation is alarming, making this site fragile, since presence of Forest on a city periphery is already rare and its being lost to urban land use means extensive loss of natural habitation with severe threat to the remaining areas of core natural forest.

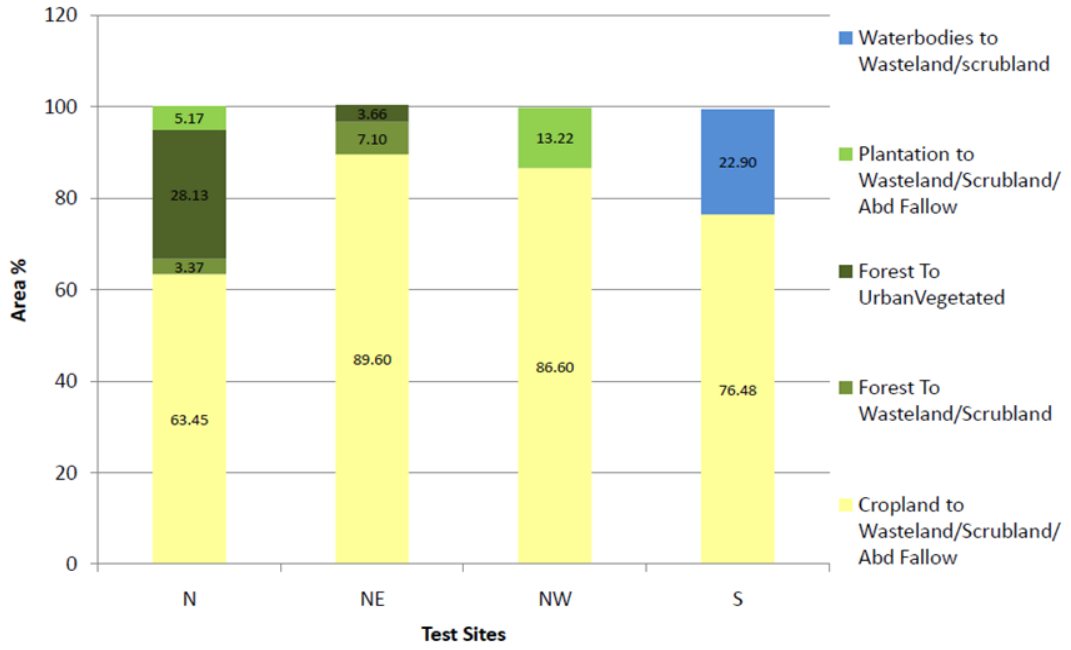


Figure 5.16: Critical Land transformation Category Statistics

Other sites cannot boast of such strong natural landcover class but the presence and hence loss of water bodies in Southern site is also alarming, making it a fragile area as well. Decreasing croplands have their own serious implications as unnecessary loss and degradation of prime agricultural land through urban expansion can be deteriorating. As observed (Fig. 5.16), North Eastern area exhibits the change of maximum amount of Cropland into Transitional category.

5.2.2 Relating urban accessibility, spatiotemporal landuse pattern & developing urban form

In studying interactions between human and ecological processes, considering solely the aggregated interactions cannot help explain the outcomes. A complex set of social, political, economic, and biophysical factors drive urbanization and affects when, where, how, and at what rate urban development proceeds (Alberti et al., 2003).

The environmental and social problems associated with peri-urban sustainability initiates the idea of possible influence of urban accessibility on spatio-temporal land use patterns and the ensuing urban form. Initially, urban accessibility seems to be a consequence of population and employment geographical distribution, whereas in long term, accessibility turns out to be an important factor in determining urban form (Miralles, 1997).

The present study observes that the relationship of urban accessibility with spatio-temporal patterns and ensuing urban form exists but is relative and not the only causal factor. This fact has been explored by relating the statistics of spatio-temporal LULC vs. ecological processes to transport infrastructure of area. The areal extent of the analysis is depicted in figure 5.17 with corresponding spatial occurrence being shown in figure 5.18.

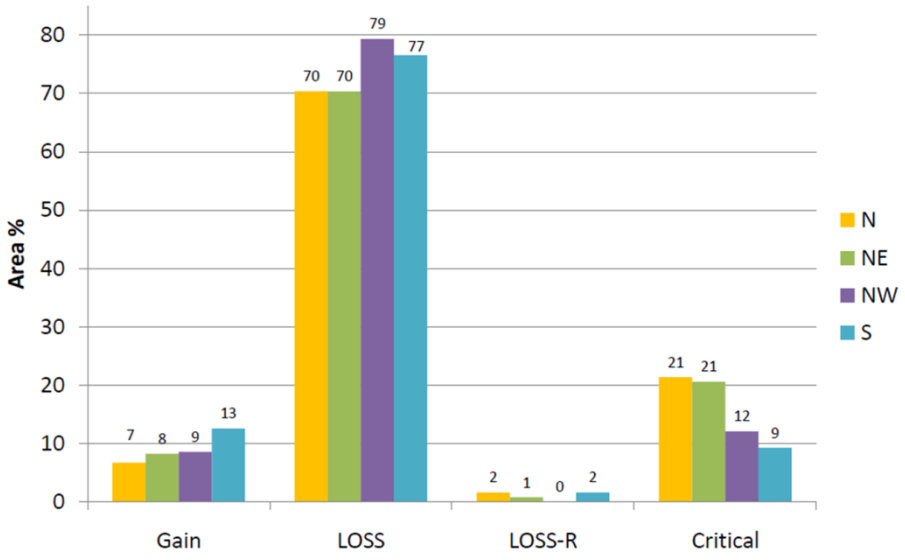


Figure 5.17: Areal extent of the analysis

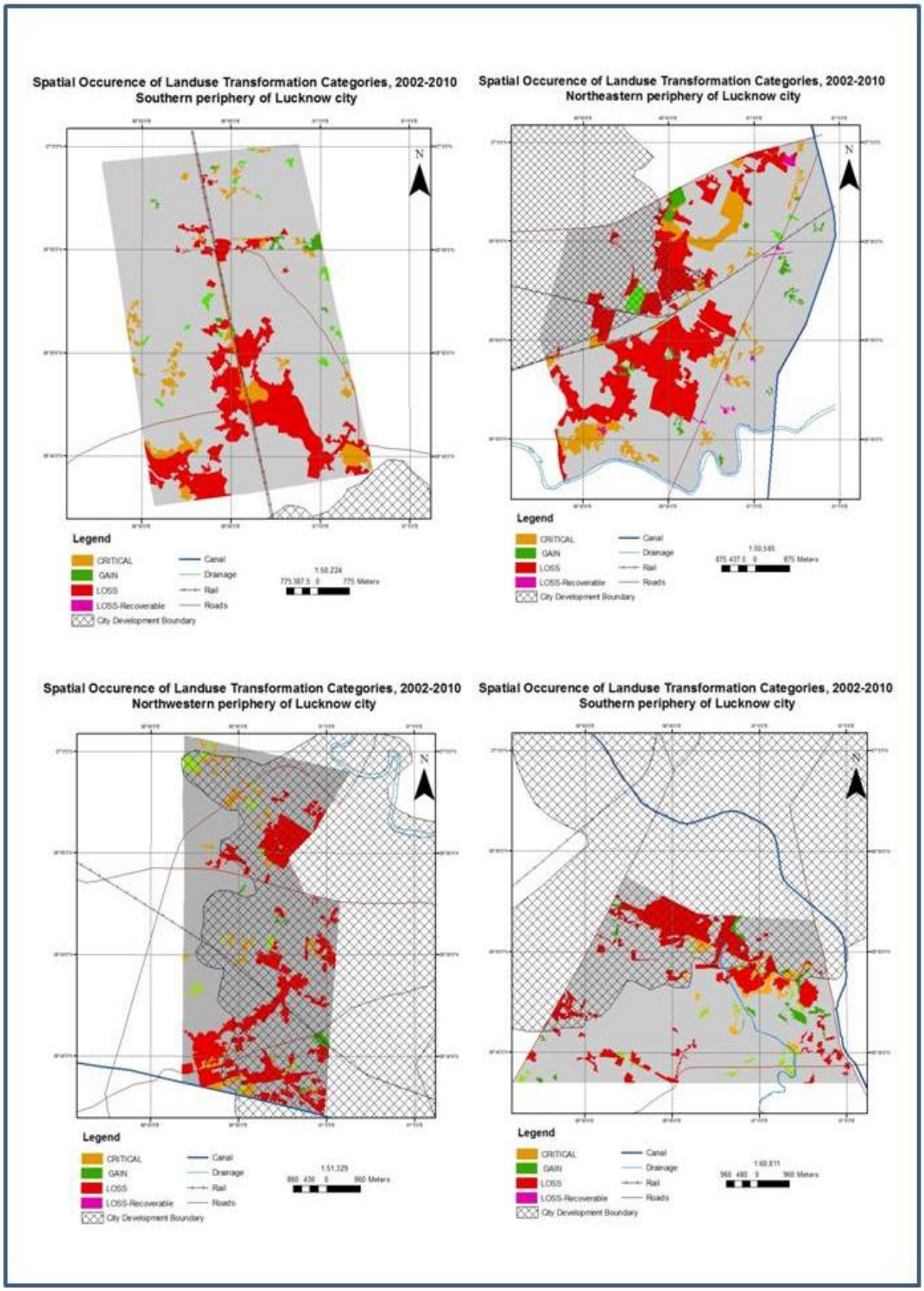

Spatial Occurence of Landuse Transformation Categories, 2002-2010
Southern periphery of Lucknow city
Spatial Occurence of Landuse Transformation Categories, 2002-2010
Northeastern periphery of Lucknow city
Spatial Occurence of Landuse Transformation Categories, 2002-2010
Northwestern periphery of Lucknow city
Spatial Occurence of Landuse Transformation Categories, 2002-2010
Southern periphery of Lucknow city
Legend
CRITICAL
GAIN
LOSS
LOSS-Recoverable
City Development Boundary
Canal
Drainage
Rail
Roads
N

Figure 5.18

From the figures (Fig.5.17 and Fig.5.18), it is evident that LULC change does not follow a general pattern across all the sites. The land use change pattern appears to be very complex, depending upon not one or two but a number of varying factors. In North Eastern site, the change (mostly Loss and Critical) appears to be closer to and along City Development Plan (CDP) boundary, not much dependent on National Highway passing through just middle of the site. In Northern site too, National Highway does not apparently play the only important role as the change (Loss, Critical and Gain) appears to be radially extending outside along the CDP. The influence of transport routes is also absent in the Southern site which is bounded in two sides by important highways. The change (mainly Loss) appears to be along the third boundary collinear to the existing urban zone and extending outwards.

In North Western site, the influence of state highways is visible, as the change (mostly Loss) is concentrated along the two major roads, towards Malihabad and towards Kannauj with more urbanization noticeable along the road to Kannauj. The reason seems to be the presence of lucrative Horticulture-plantations along the Malihabad road, which might stop the marginal farmers who sell their lands to real-estate and other urban developers.

5.3 Agricultural Capability modeling using Weighted Linear Combination of Multiple Criteria

Agricultural Capability Analysis was done to identify prime farmlands in study area using Weighted linear Combination of relevant factors, selected after obtaining expert advice as detailed in Chapter 4. The spatial data of Soil group texture, Altitudnal gradient; Ground water level and Irrigation network were standardized (Figure 5.19 to Figure 5.22), weighted and analysed to produce agricultural capability zones (Table 5.5).

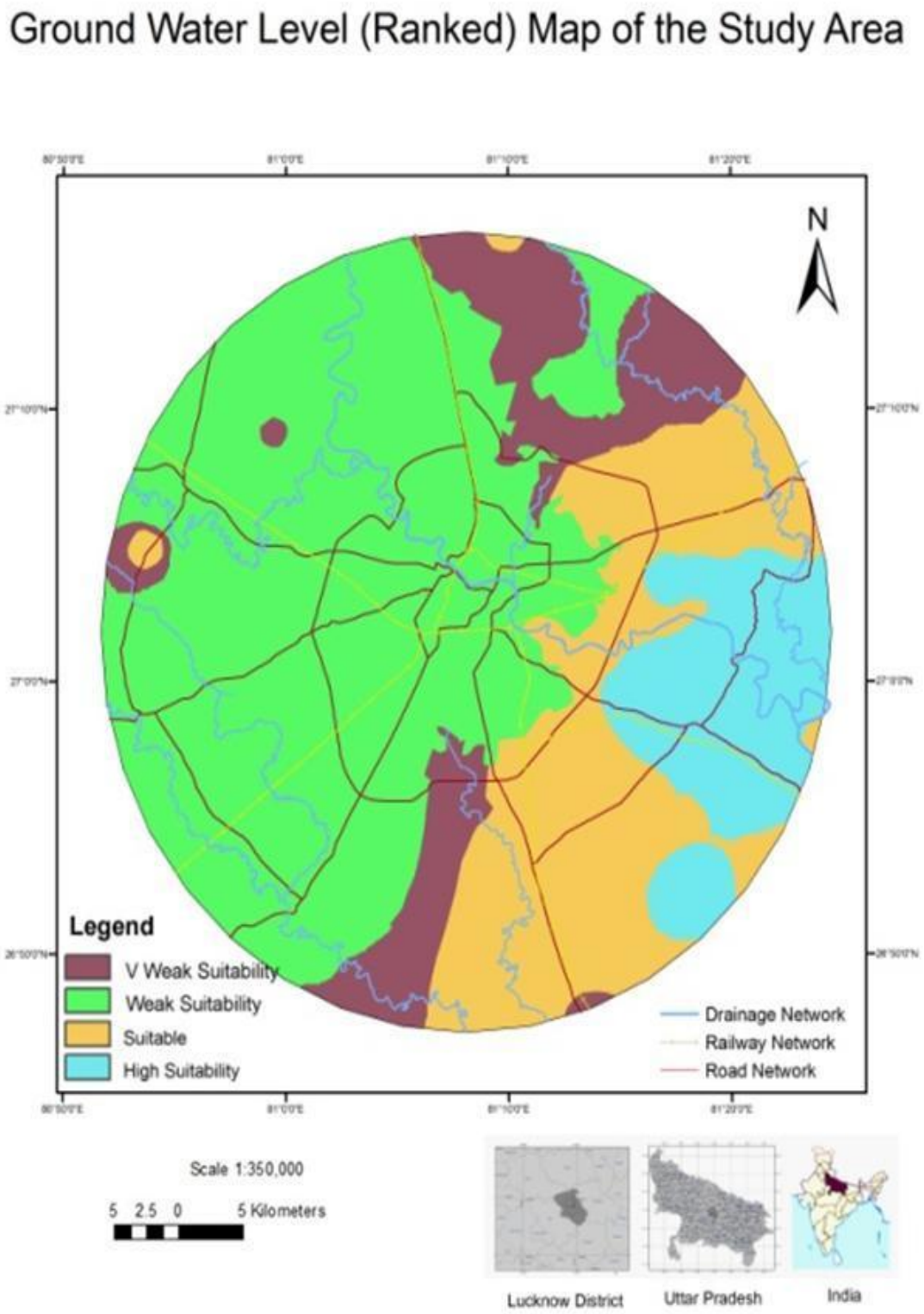

Ground Water Level (Ranked) Map of the Study Area
N
Legend
V Weak Suitability
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.19

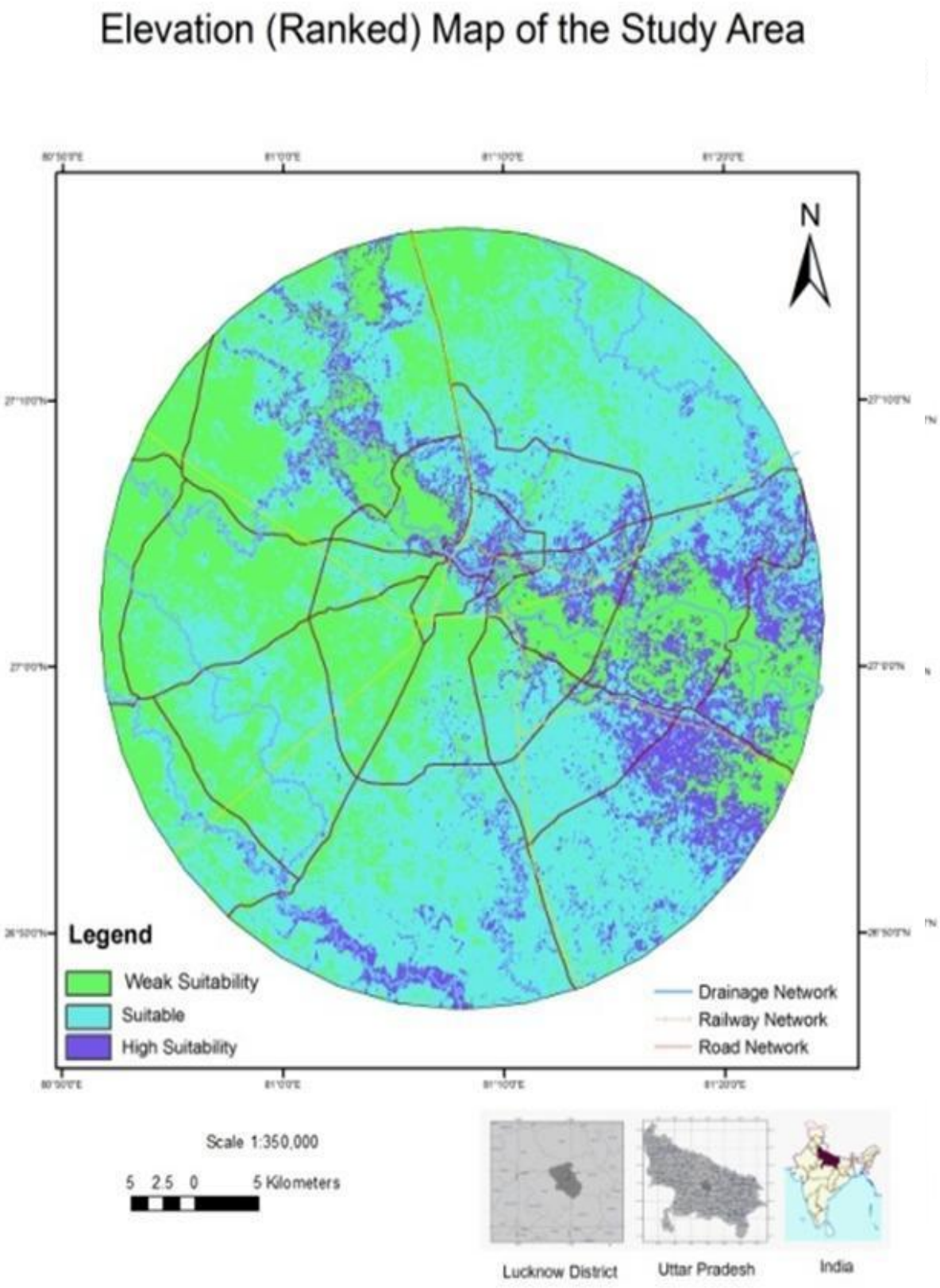

Elevation (Ranked) Map of the Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.20

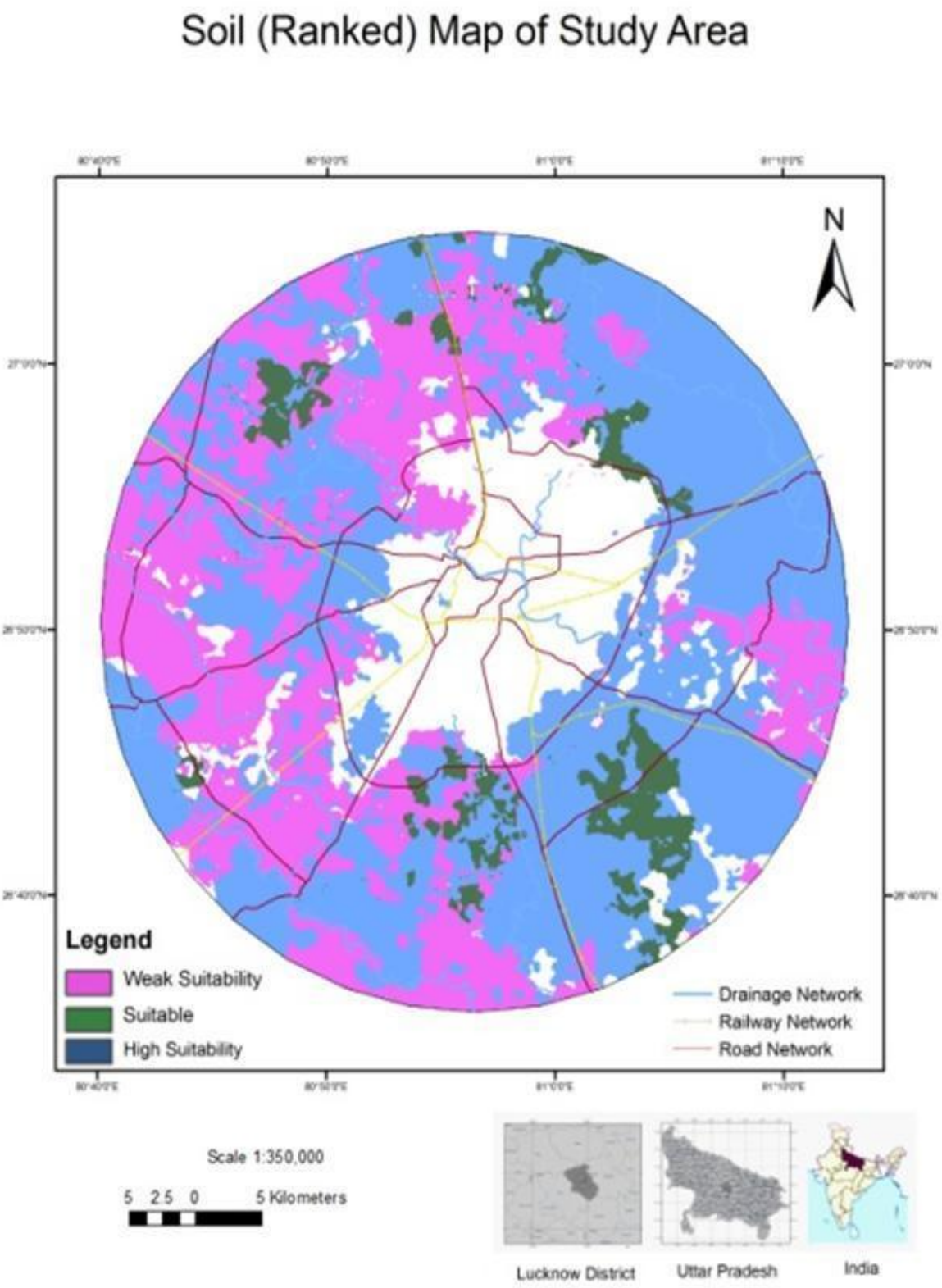

Soil (Ranked) Map of Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.21

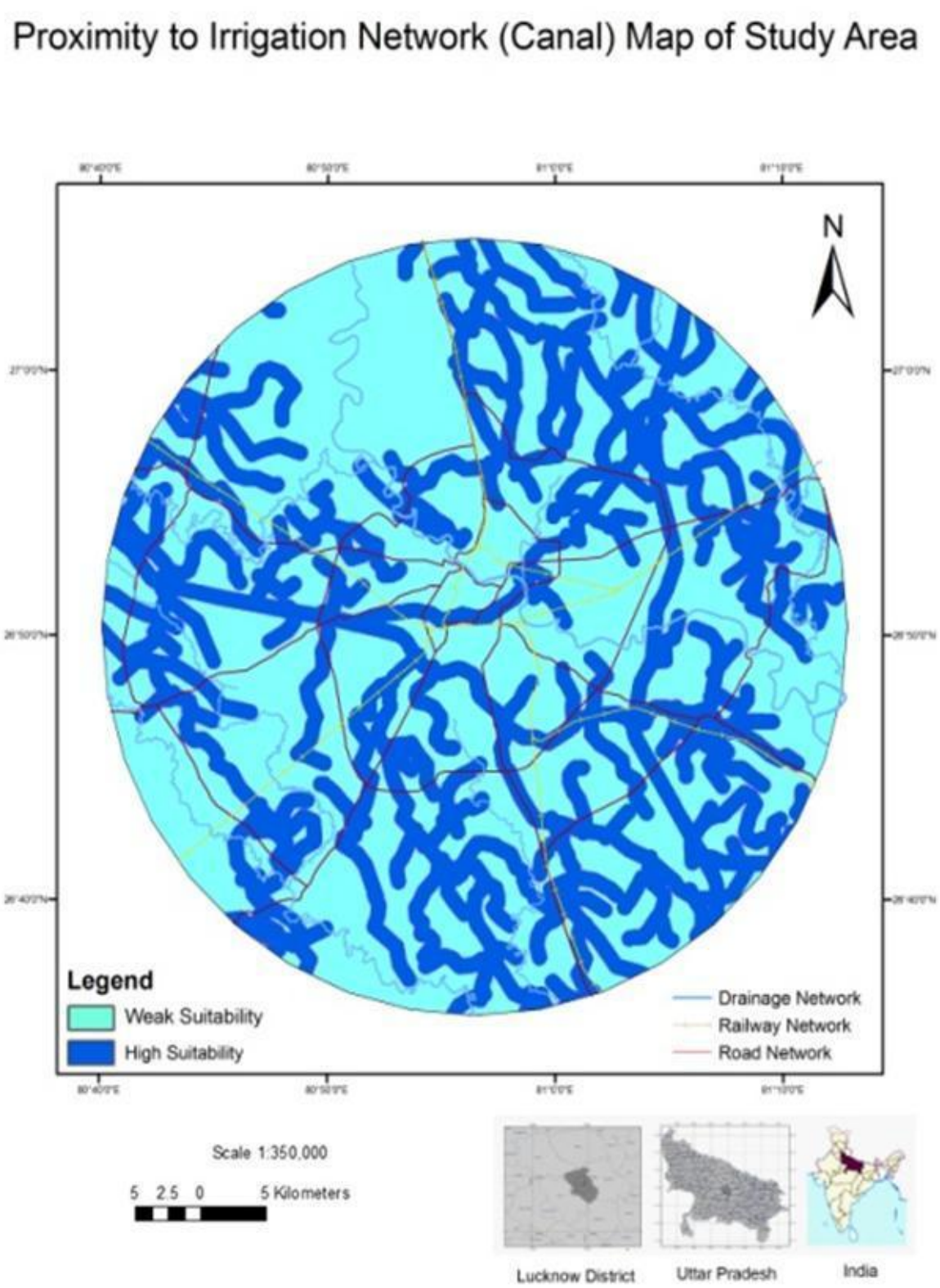

Proximity to Irrigation Network (Canal) Map of Study Area
N
Legend
Weak Suitability
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.22

Table 5.4: Weightage calculation for Agricultural Capability

Land Capability					Normalized Weight
LCA	**Soil Group Texture**	**Altitudinal Gradient**	**Ground Water Level**	**Irrigation Network**	
Cri1	1	5	3	4	0.539426
Cri2	0.2	1	0.33	0.5	0.082608
Cri3	0.33	3	1	3	0.254439
Cri4	0.25	2	0.33	1	0.123528

The weights were calculated using geometric mean method and checked for consistency using random consistency Index provided by Saaty as detailed in Chapter 4. The consistency ratio was obtained as 5.33% which is less that 10% and so the PCM was found consistent. As per the weights calculated, Criteria 1 i.e. Soil group texture has the maximum weight and Criteria 2 .i.e altitudinal gradient has the minimum weight.

It was observed from the calculated statistics of generated agricultural capability map (figure 5.23) that only 9 % of the total area is under prime farmlands category, but as 50% of the area is under Class II agricultural land hence the study area is majorly a fertile cropland area (Table 5.5).

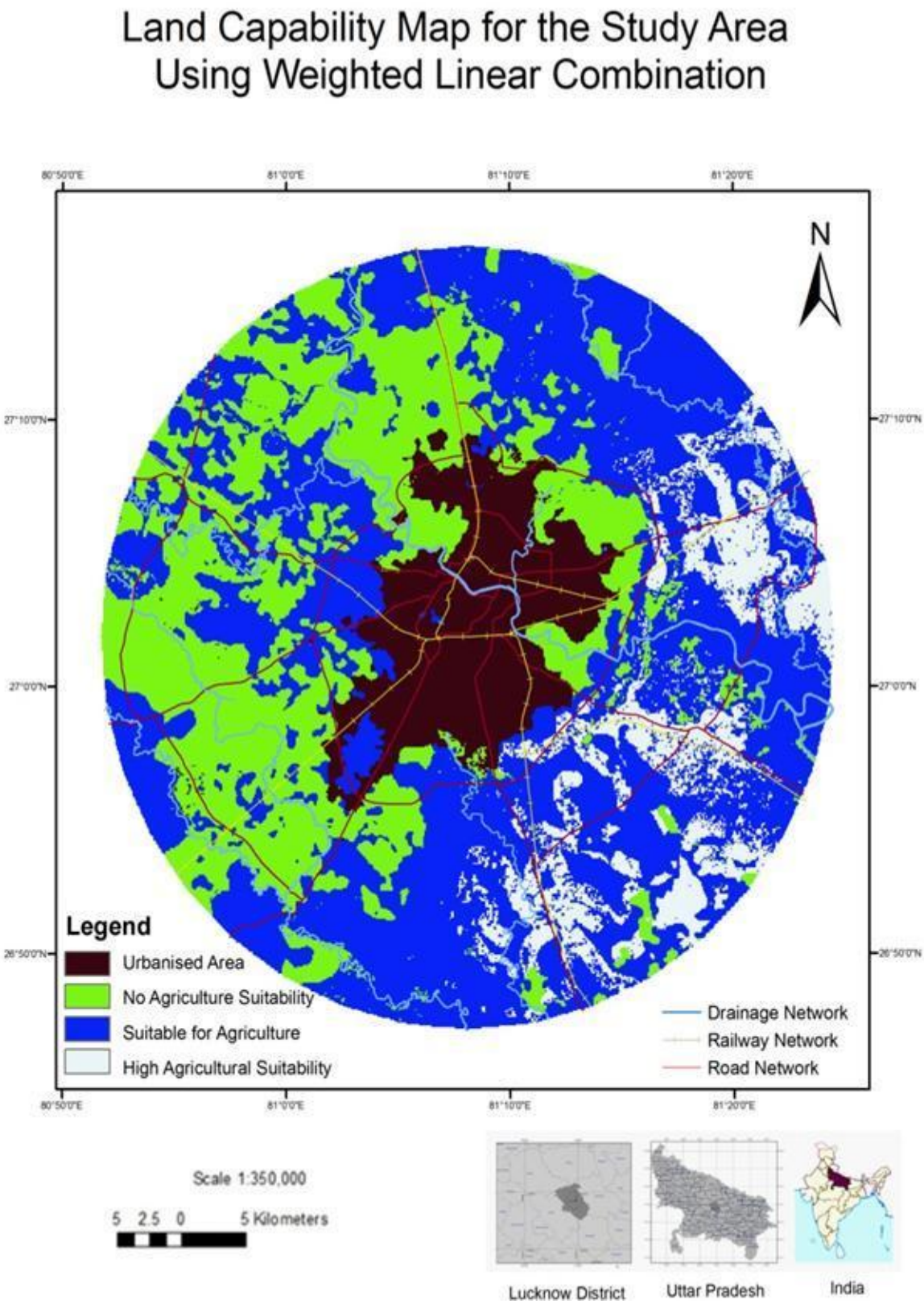

Land Capability Map for the Study Area
Using Weighted Linear Combination
80°50'0"E
81°0'0"E
81°10'0"E
81°20'0"E
27°10'0"N
27°0'0"N
26°50'0"N
N
Legend
Urbanised Area
No Agriculture Suitability
Suitable for Agriculture
High Agricultural Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.23

Table 5.5: Statistics of agricultural capability

Agricultural Capability Class	**Area (hectare)**	**Area %**
Class 4	30872.87775	12.6217
Class 3	68606.395	28.04822
Class 2	122102.3733	49.91887
Class 1	23019.997	9.411219

5.4 Land Suitability Assessment modeling for Urban Development

For assessment of land suitability for urban development, two multi-criteria evaluation techniques were explored, evaluation criteria were framed and organized. Discussions with relevant experts, literature survey and fieldwork were the major tools aided in deciding upon the evaluation criteria. Each criterion was categorized into suitability classes e.g. S1, S2, derived from urban requirements followed by agricultural land capability assessment as detailed in chapter 3 and 4. Various submodels i.e. Infrastructure, landscape and soil were executed (Figure 5.24 to Figure 5.33) and finally the Land Suitability evaluation was evaluated using two techniques as mentioned in chapter 4 and 5. The results of the above mentioned process are presented and interpreted here. The input Pair-wise Comparison Matrices, ratings of the classes of all the criteria and weights of all the criteria are listed in Appendix 1.

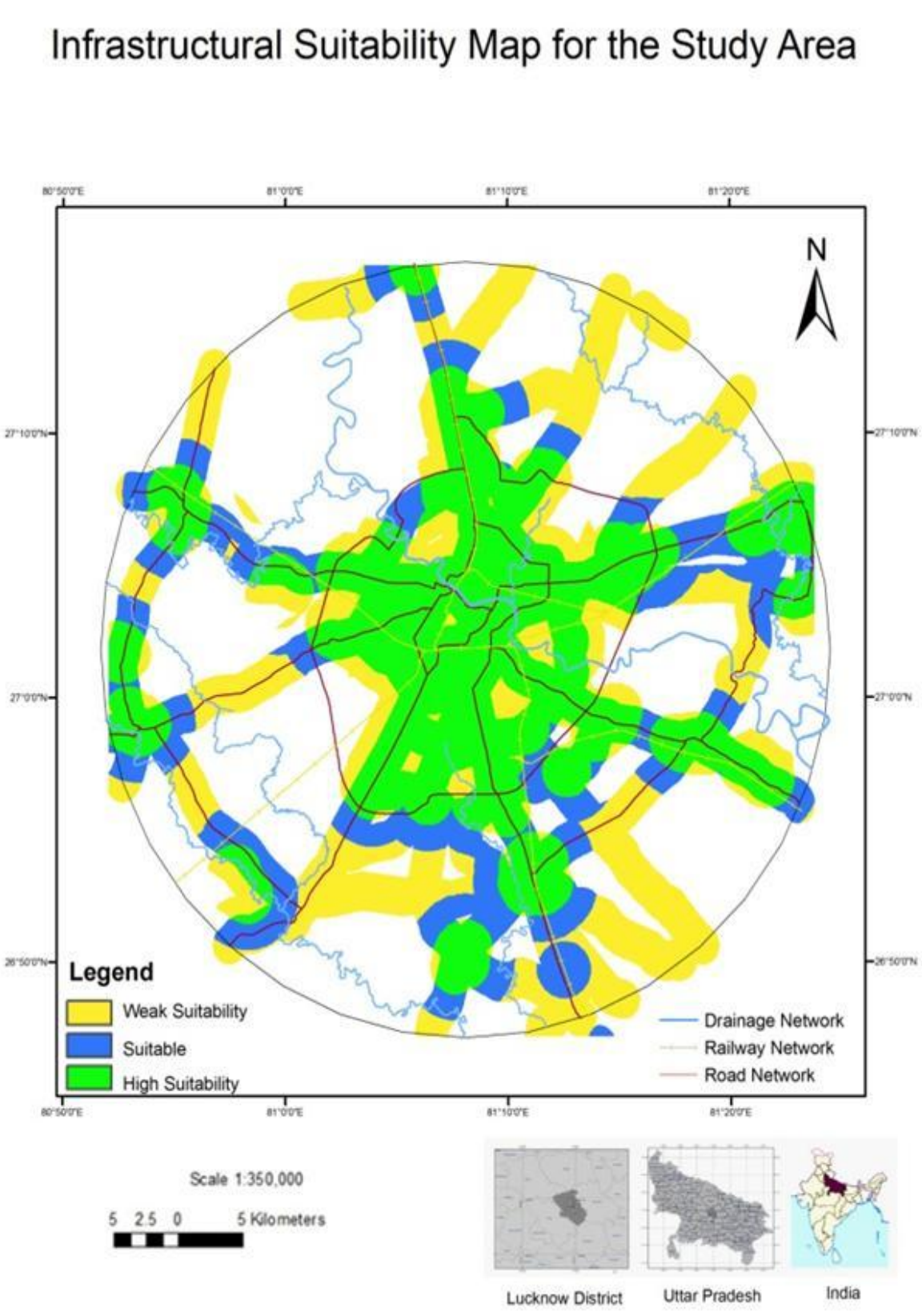

Infrastructural Suitability Map for the Study Area
80°50'0"E
81°0'0"E
81°10'0"E
81°20'0"E
27°10'0"N
27°0'0"N
26°50'0"N
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.24

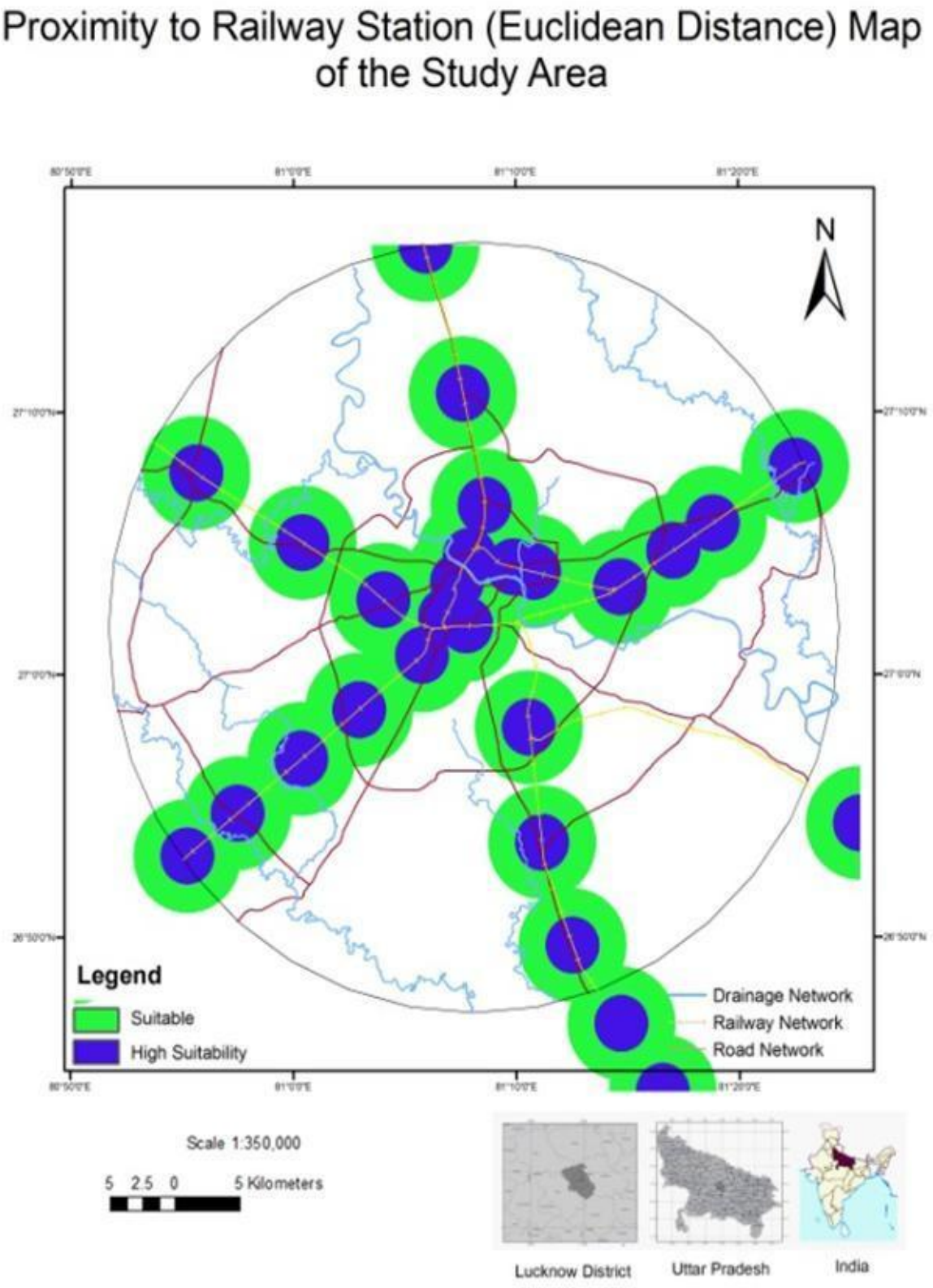

Proximity to Railway Station (Euclidean Distance) Map of the Study Area
N
Legend
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.25

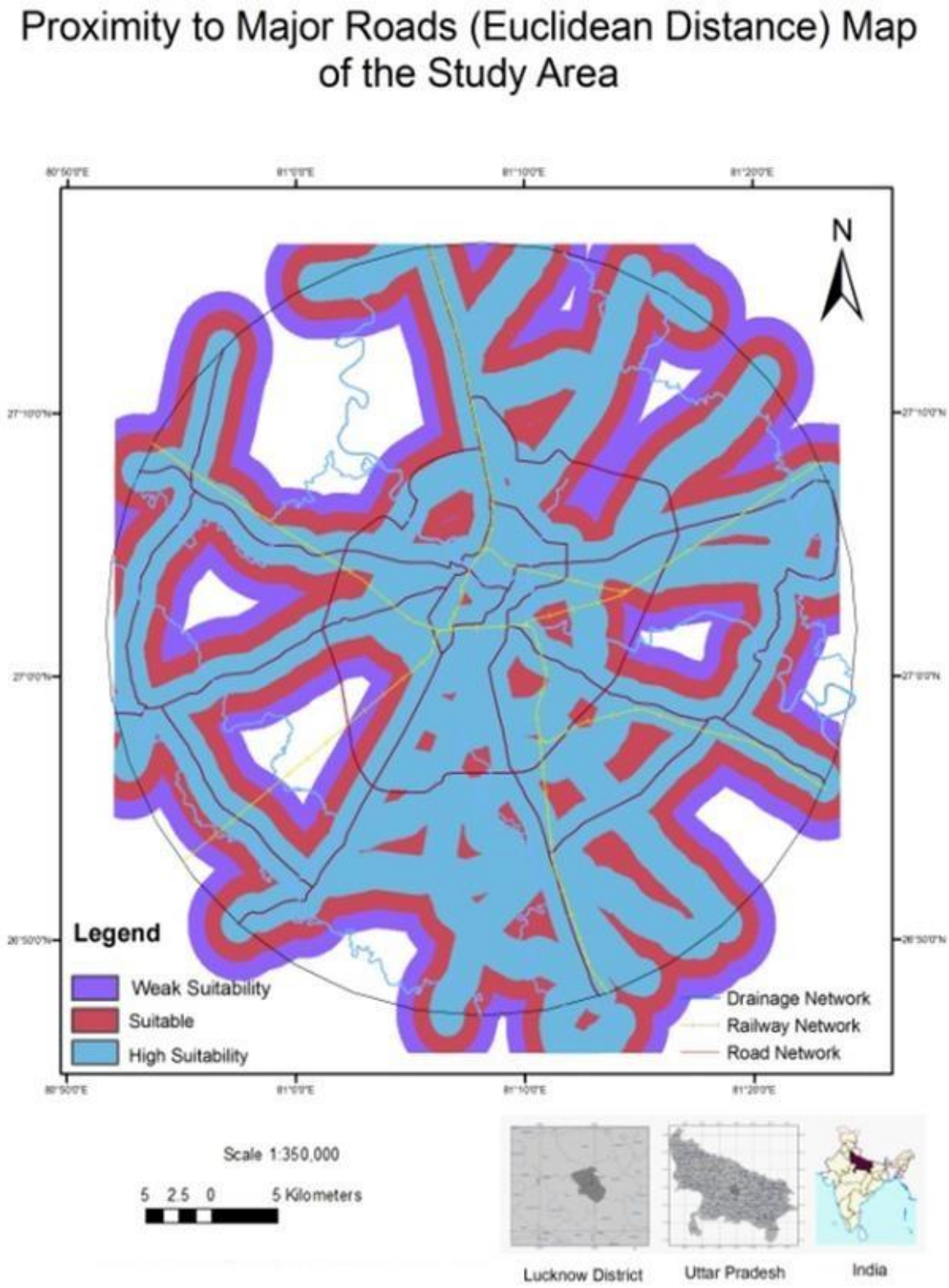

Proximity to Major Roads (Euclidean Distance) Map of the Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.26

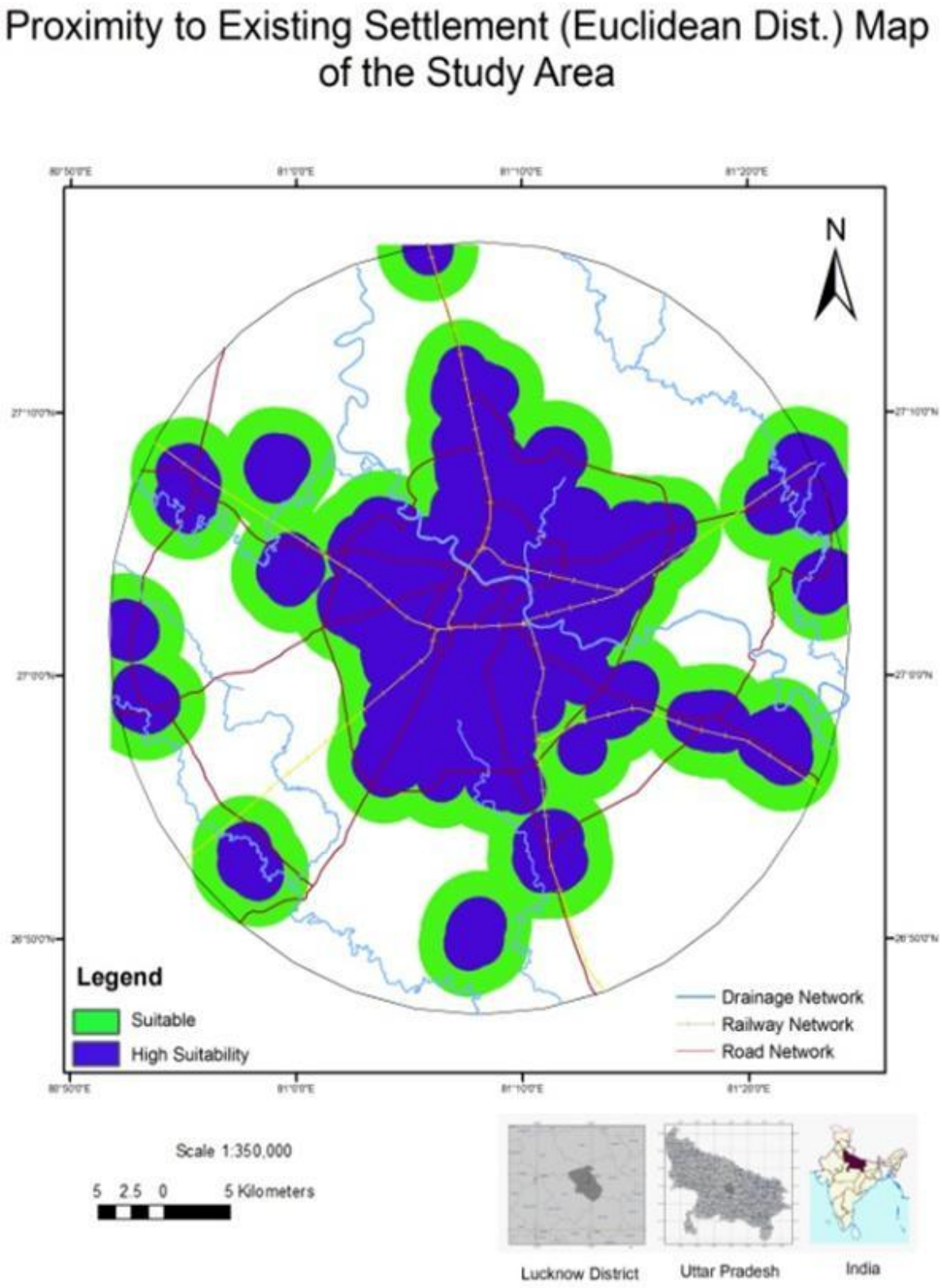

Proximity to Existing Settlement (Euclidean Dist.) Map of the Study Area
N
Legend
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.27

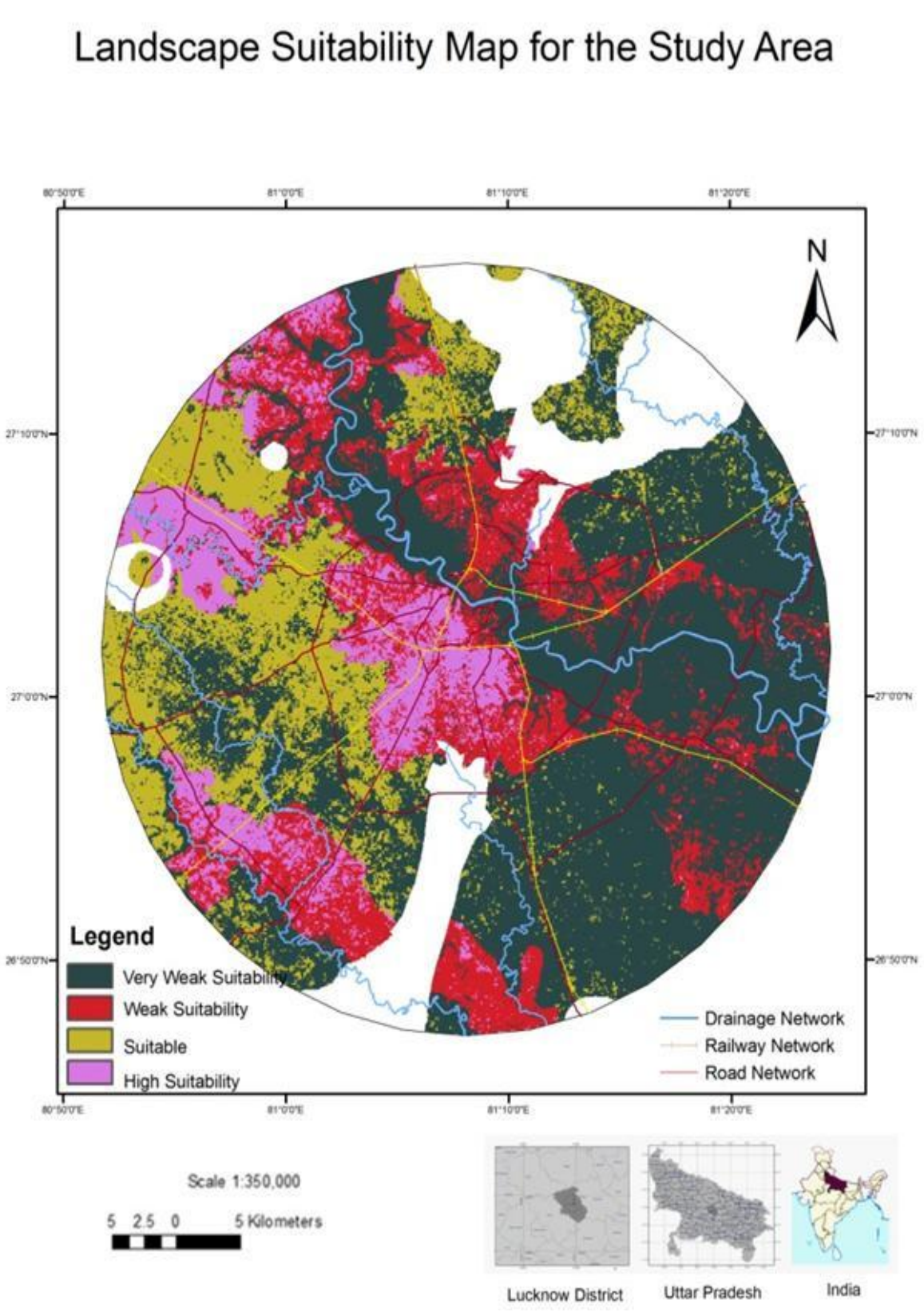

Landscape Suitability Map for the Study Area
80°50'0"E
81°0'0"E
81°10'0"E
81°20'0"E
27°10'0"N
27°0'0"N
26°50'0"N
N
Legend
Very Weak Suitability
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.28

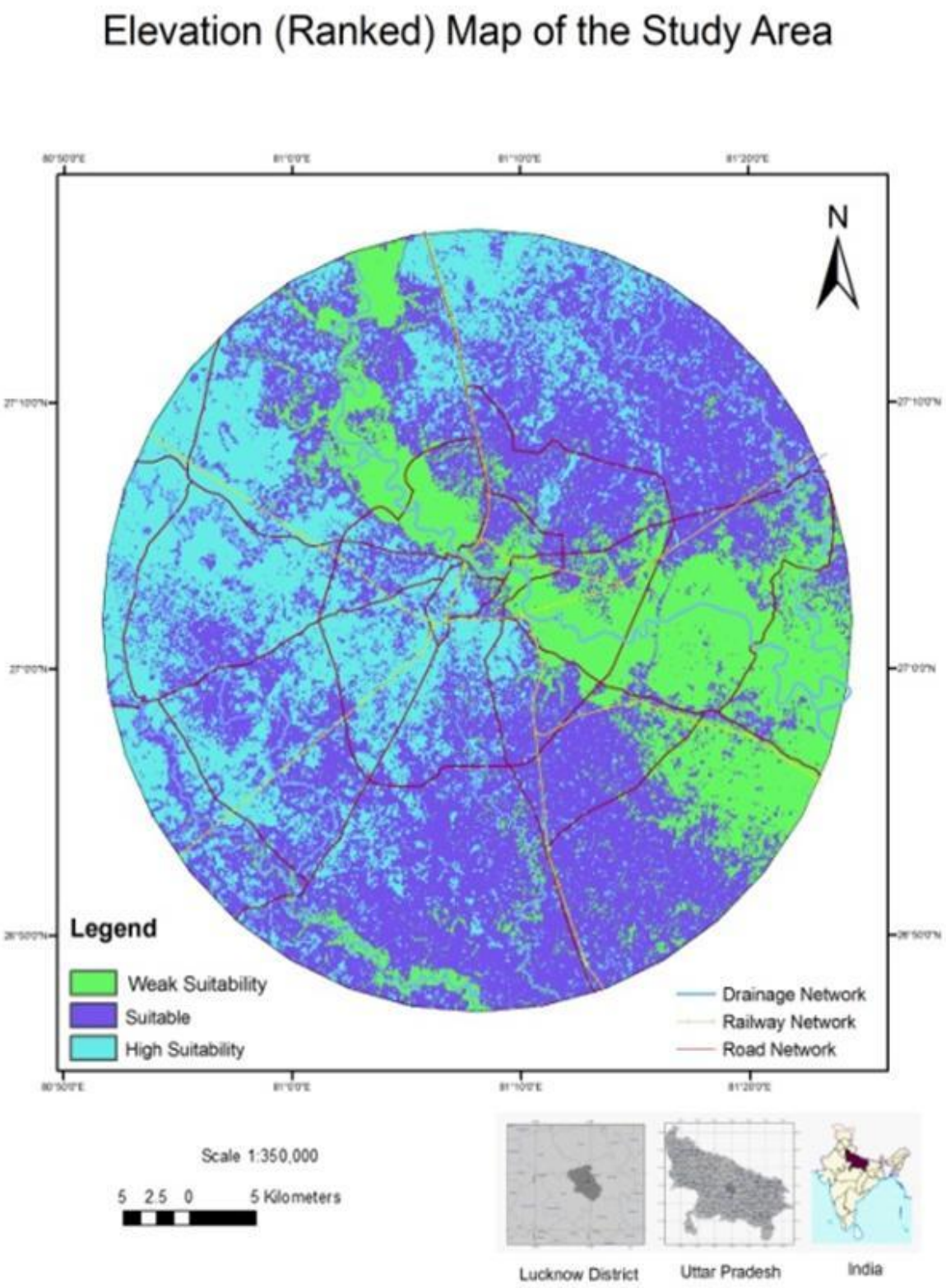

Elevation (Ranked) Map of the Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.29

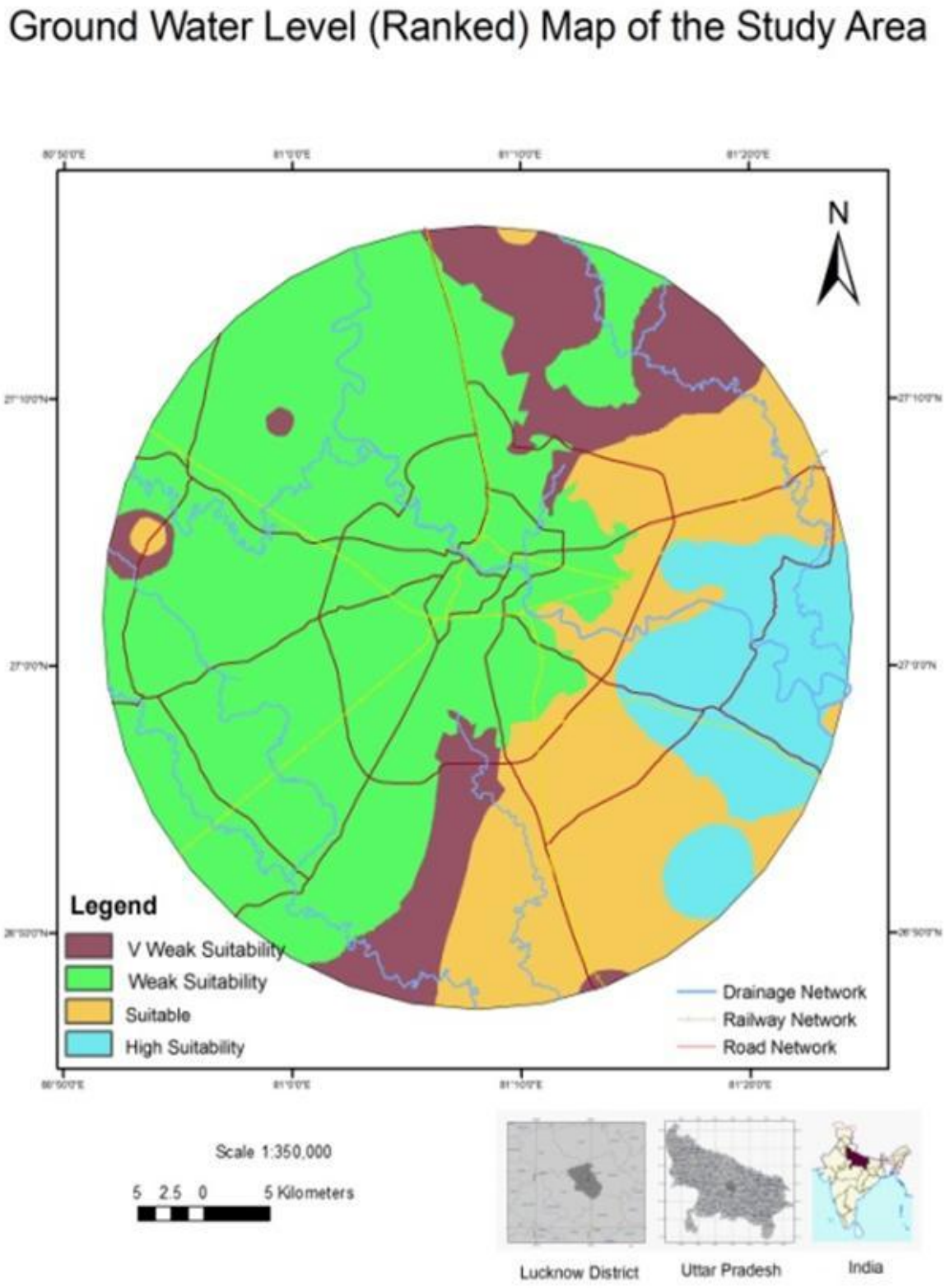

Ground Water Level (Ranked) Map of the Study Area
N
Legend
V Weak Suitability
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.30

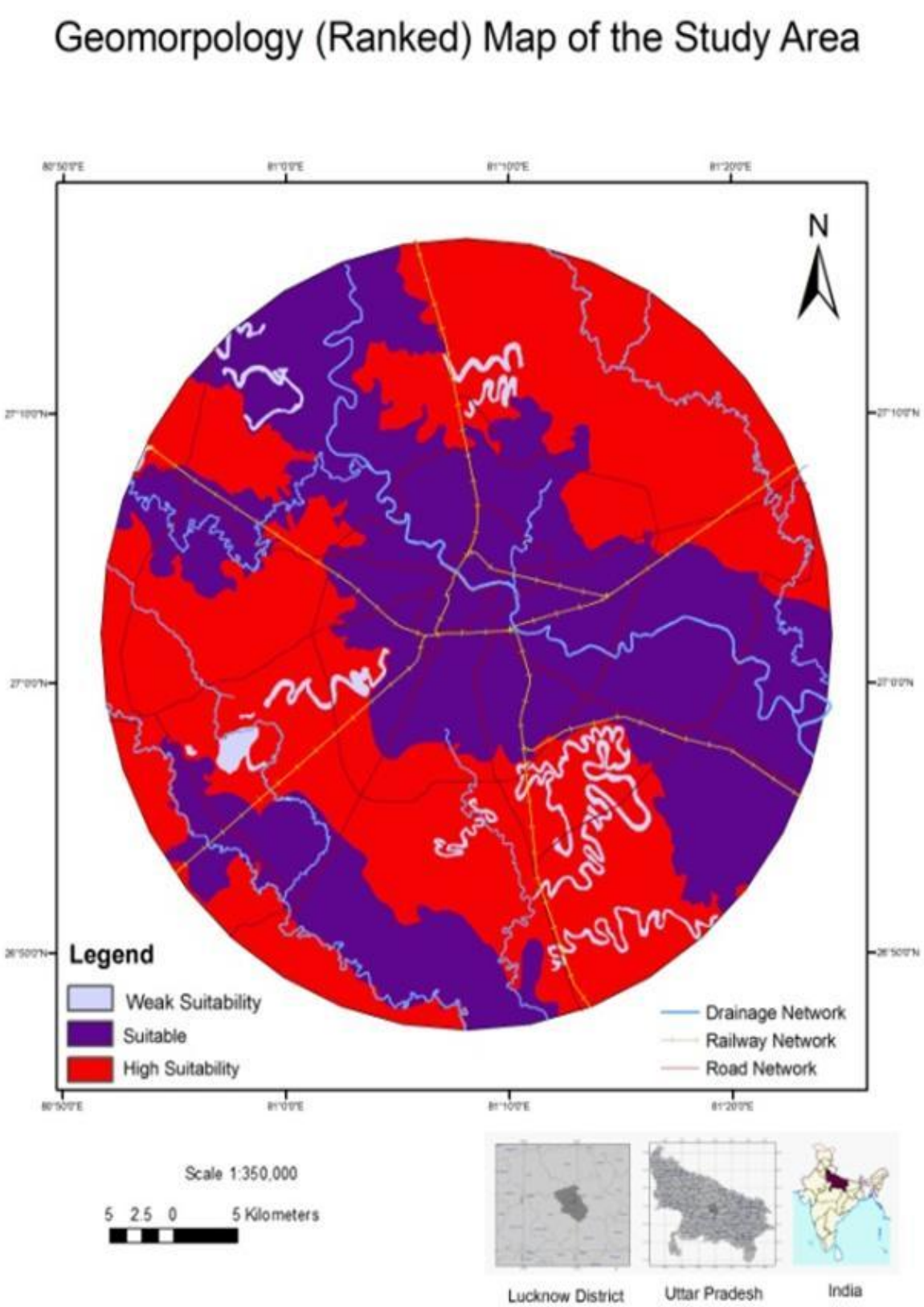

Geomorpology (Ranked) Map of the Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.31

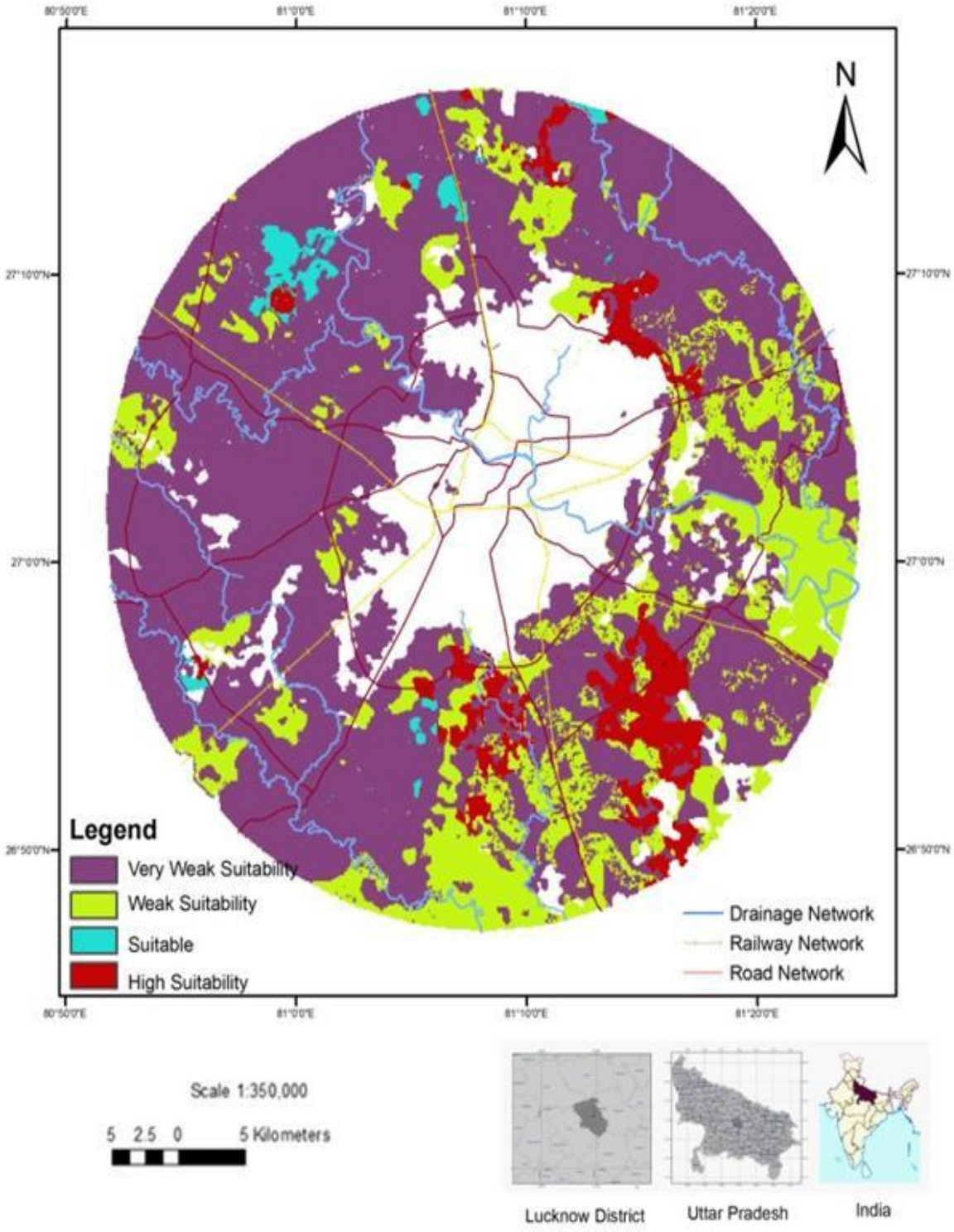

80°50'0"E
81°0'0"E
81°10'0"E
81°20'0"E
N
27°10'0"N
27°0'0"N
26°50'0"N
Legend
Very Weak Suitability
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.32

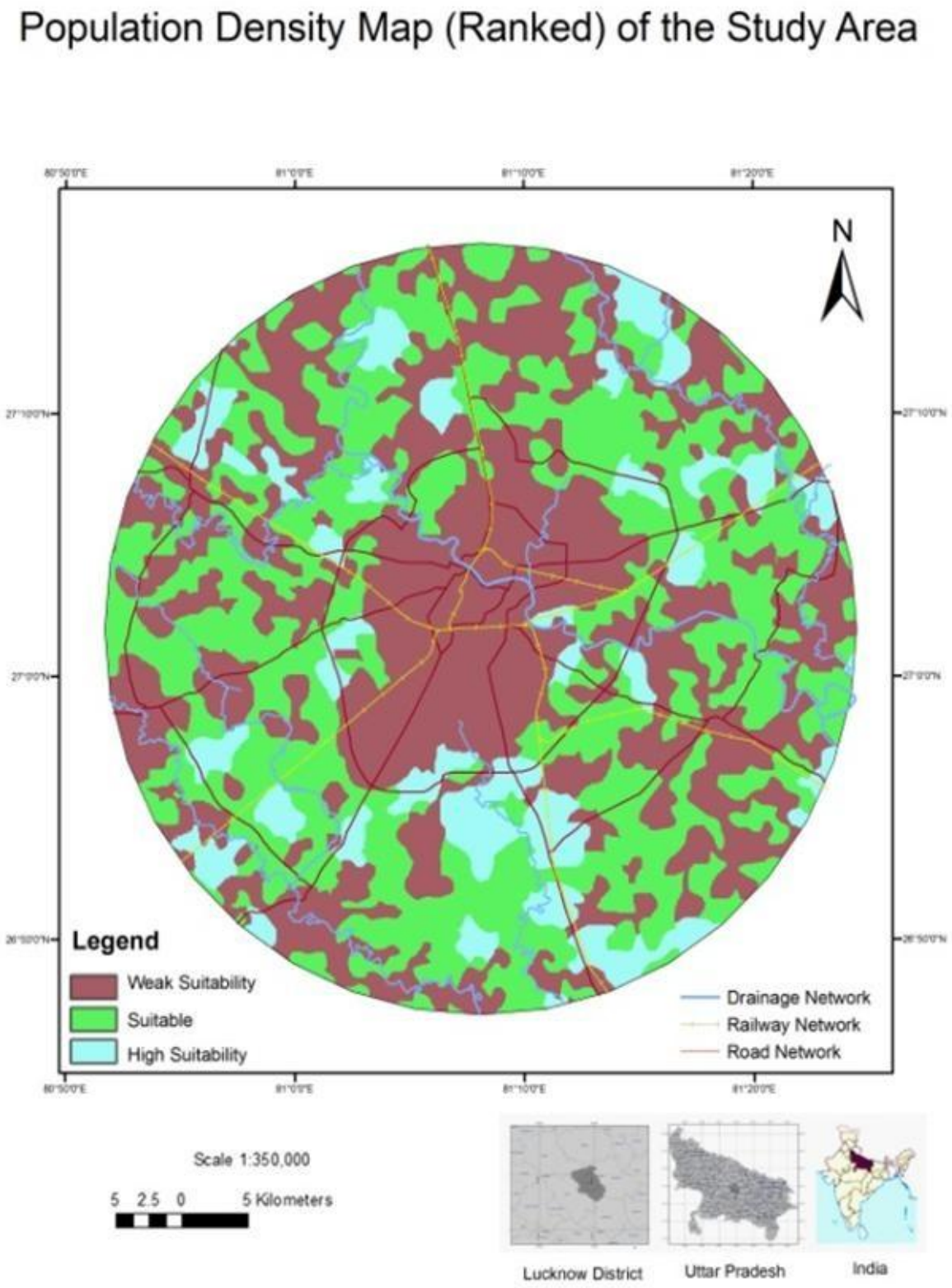

Population Density Map (Ranked) of the Study Area
N
Legend
Weak Suitability
Suitable
High Suitability
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.33

5.4.1 LSA using Analytical Hierarchy Process (AHP)

5.4.1.1 Standardization

Under the AHP process, criteria were standardized, using Pair-wise comparison techniques. The standardization of criteria presented rating ranging from 0 to1. Matrix below shows a worked example of standardization results for Soil Texture (Table 5.6); all other standardized results are given in Appendix 1.

Table 5.6: Standardization of criteria

Soil Group Texture	Loamy	Coarse Loamy	Fine Loamy	Fine Silt	Ranks
Class 1	1	0.33	3	5	1.45
Class 2	0.33	1	4	6	1.63
Class 3	0.2	0.25	1	4	0.63
Class 4	0.16666	0.16666	0.25	1	0.29

The method of maximum Eigen vector was used for standardization of individual classes in a criterion, as this process does not require any further standardizing of performances. As per the weights calculated in above mentioned example (table 5.6), Class 2 i.e. Coarse Loamy has the maximum weight and Class 4 i.e. Fine silt has the minimum weight.

5.4.1.2 Ranking

When the results of standardization were satisfactory, selected criteria were ranked using weights derived from PCM's by Geometric mean method. These weights were multiplied with the standardized criteria maps and aggregated to obtain the suitability map. The result from ranking of the criteria in LSA model is given as worked example below (Table 5.7):

Table 5.7: Ranking of Criteria

LSA	Soil Group Texture	Landscape	Infrastructure	Socio-economic	Normalized Weights
Criteria 1	1	3	4	6	0.551583403
Criteria 2	0.33	1	3	4	0.267117205
Criteria 3	0.25	0.166	1	4	0.120866261
Criteria 4	0.166	0.25	0.25	1	0.060433131

The land suitability for future urban development has thus been evaluated using the selected factors in detailed procedures. According to the statistics calculated for the final suitability map, only 1.86 % of the total area has been found to be highly suitable, 20.91 % of area has been found to be suitable, 45.82 % of area has been found to have weak suitability and 31.41 % of area has been found to have negligible or very weak suitability (Fig. 5.34). Figure 5.35 has the final suitability map for urban development using AHP adapted WLC process, which shows that very less percentage of total area has actually been found suitable for future urbanization.

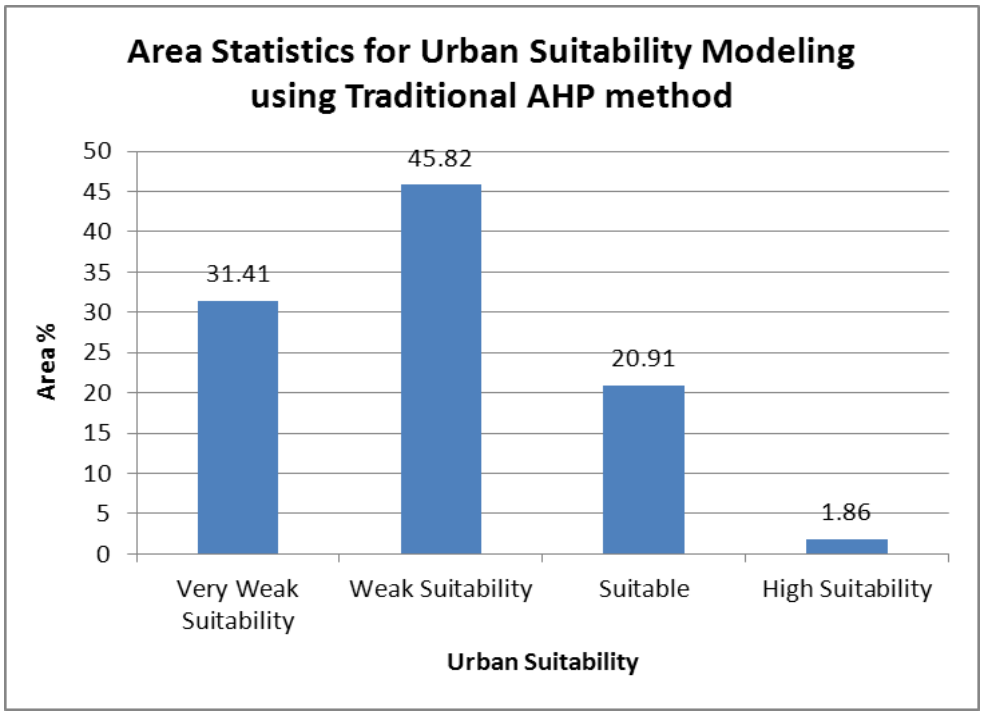


Figure 5.34: Urban Suitability Analysis Statistics (AHP)

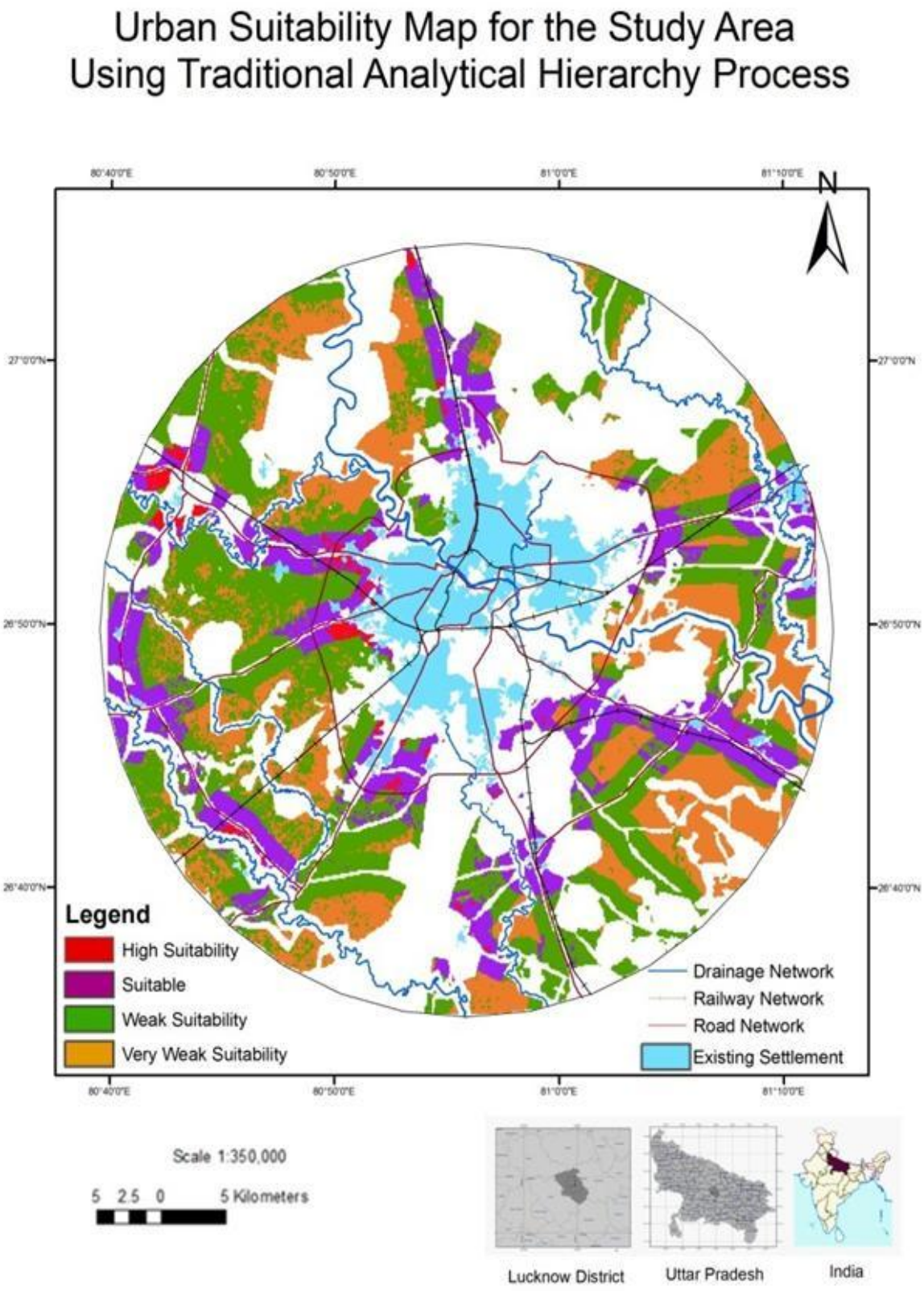

Urban Suitability Map for the Study Area
Using Traditional Analytical Hierarchy Process
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
N
27°0'0"N
26°50'0"N
26°40'0"N
Legend
High Suitability
Suitable
Weak Suitability
Very Weak Suitability
Drainage Network
Railway Network
Road Network
Existing Settlement
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.35

5.4.2 LSA using Fuzzy Analytical Hierarchy Process (FAHP)

Inputs for the fuzzy AHP approach were the crisp PCMs (Annexure 1), which were fuzzified using the triangular membership functions as described in chapter 4. Fuzzy PCMs for each suitability class were the inputs for fuzzy extent analysis, resulting in fuzzy performances per suitability class. Similarly, for evaluation of criteria, the PCMs were fuzzified to obtain fuzzy performances per criteria. The fuzzy performances for criteria were then multiplied with the fuzzy performances of the classes and finally processed with alpha cut analysis and lambda functions. The result of the approach are described in following figure (figure 5.36) which shows urban development suitability under different classes, obtained using Fuzzy AHP approach.

Land Suitability for urban development has been analyzed using fuzzy analysis with alpha value of 0.6 indicating 60% certainty in the expert knowledge in deciding the urban development suitability parameters and their requirements for habitation. The uncertainty over deciding their importance is incorporated through the optimism index, Lambda. At Lambda = 0.5 (.i.e 50 % uncertainity, the statistics of suitability zonation shows only 1.37 % of area as Highly suitable, 22.31 % of area as suitable, 33.30 % of area as weak suitability and 43.03 % of area as negligible or very weak suitability (Fig 5.36). Figure 5.37 has the final suitability map for urban development using Fuzzy AHP adapted WLC process, which matches the traditional AHP approach in finding very less percentage of area suitable for future urbanization.

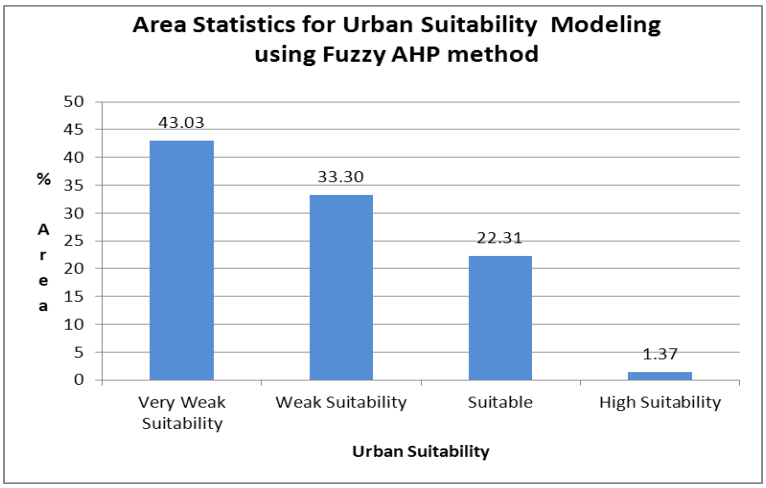


Figure 5.36: Urban Suitability Analysis Statistics (FAHP)

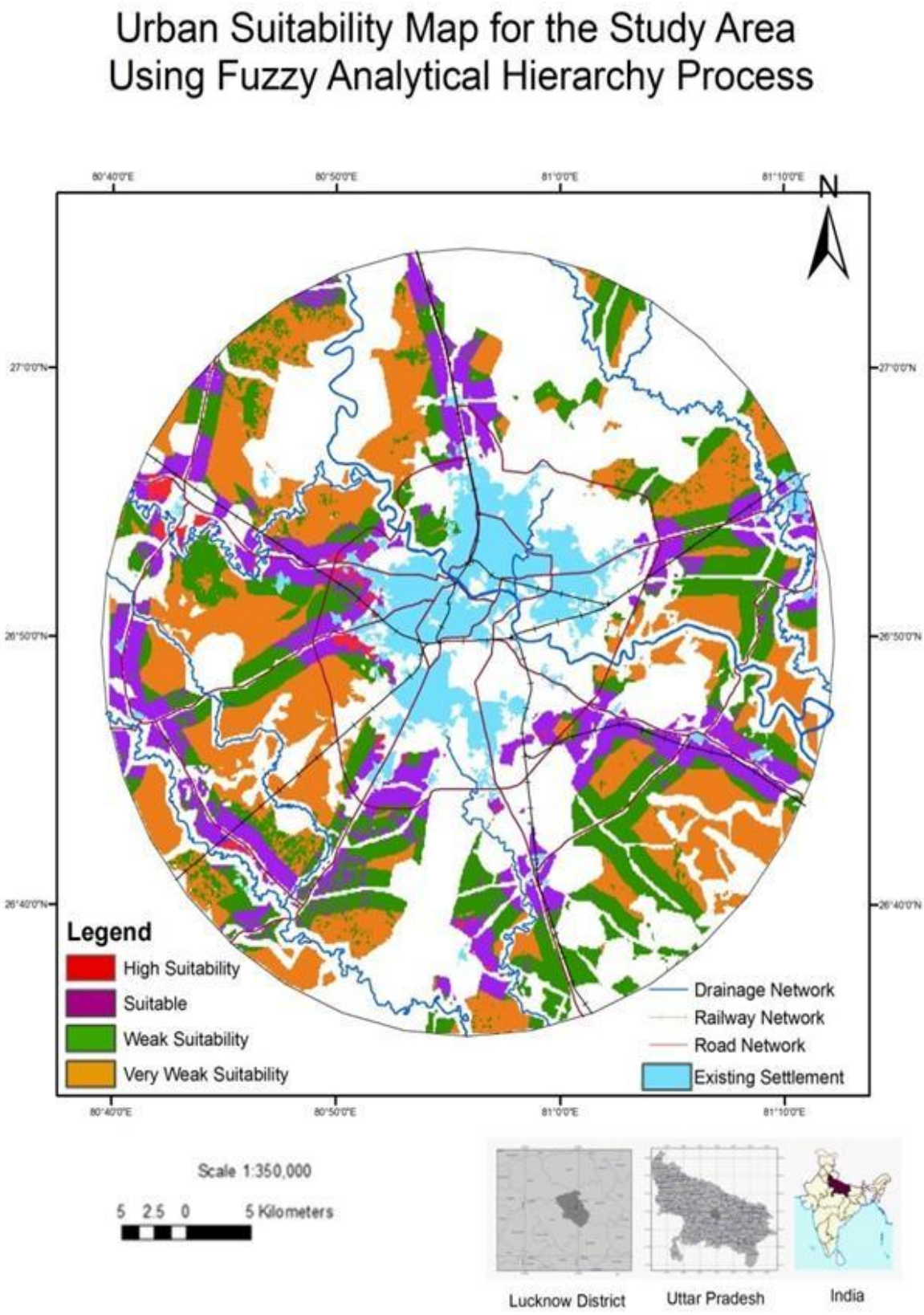

Urban Suitability Map for the Study Area
Using Fuzzy Analytical Hierarchy Process
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
N
27°0'0"N
26°50'0"N
26°40'0"N
Legend
High Suitability
Suitable
Weak Suitability
Very Weak Suitability
Drainage Network
Railway Network
Road Network
Existing Settlement
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.37

5.4.3 Comparative Evaluation

The results of two land suitability approaches are evaluated here for their abilities to model land suitability evaluation and addressing uncertainties involved in it.

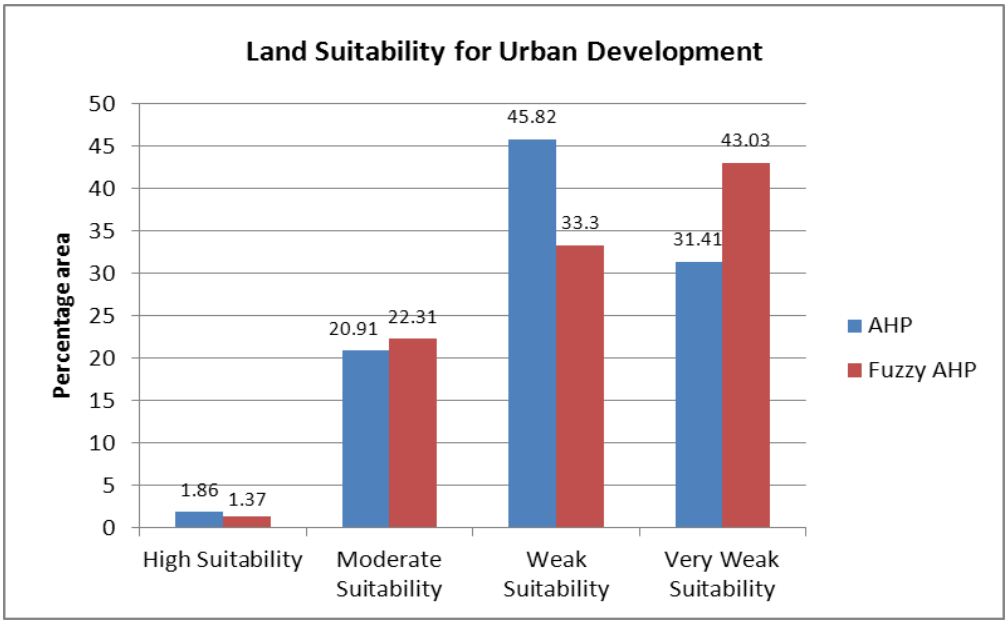


Figure 5.38: Evaluation of Land Suitability Results

It is evident from the result of the two approaches that the majority of area is under weak suitability for future urban development and very less area is under high suitability for urban development (Fig 5.38). The results of the AHP approach are satisfactory and comparable with that of Fuzzy AHP. Although AHP incorporates expert knowledge, it fails to incorporate the uncertainity involved in the expert knowledge, his judgement and opinions. Fuzzy AHP can give considerably good results as it incorporates uncertainity of expert opinions while comparing the criteria.

5.5 Conflict Analysis

The constraints selected for Land Suitability analysis were buffered at variable diameters and combined to render a Conserved / Restricted area map (Fig 5.39). The conserved / restricted area map when overlaid on digital layer of master plan 2021 of the Lucknow city highlighted various conflicts between planned future development and restriction preferences recommended in the study as detailed in Figure 5.40. Potential zoning conflicts included planned residential areas and supporting infrastructures (roads, streets etc.; proposed plantation and agricultural areas.

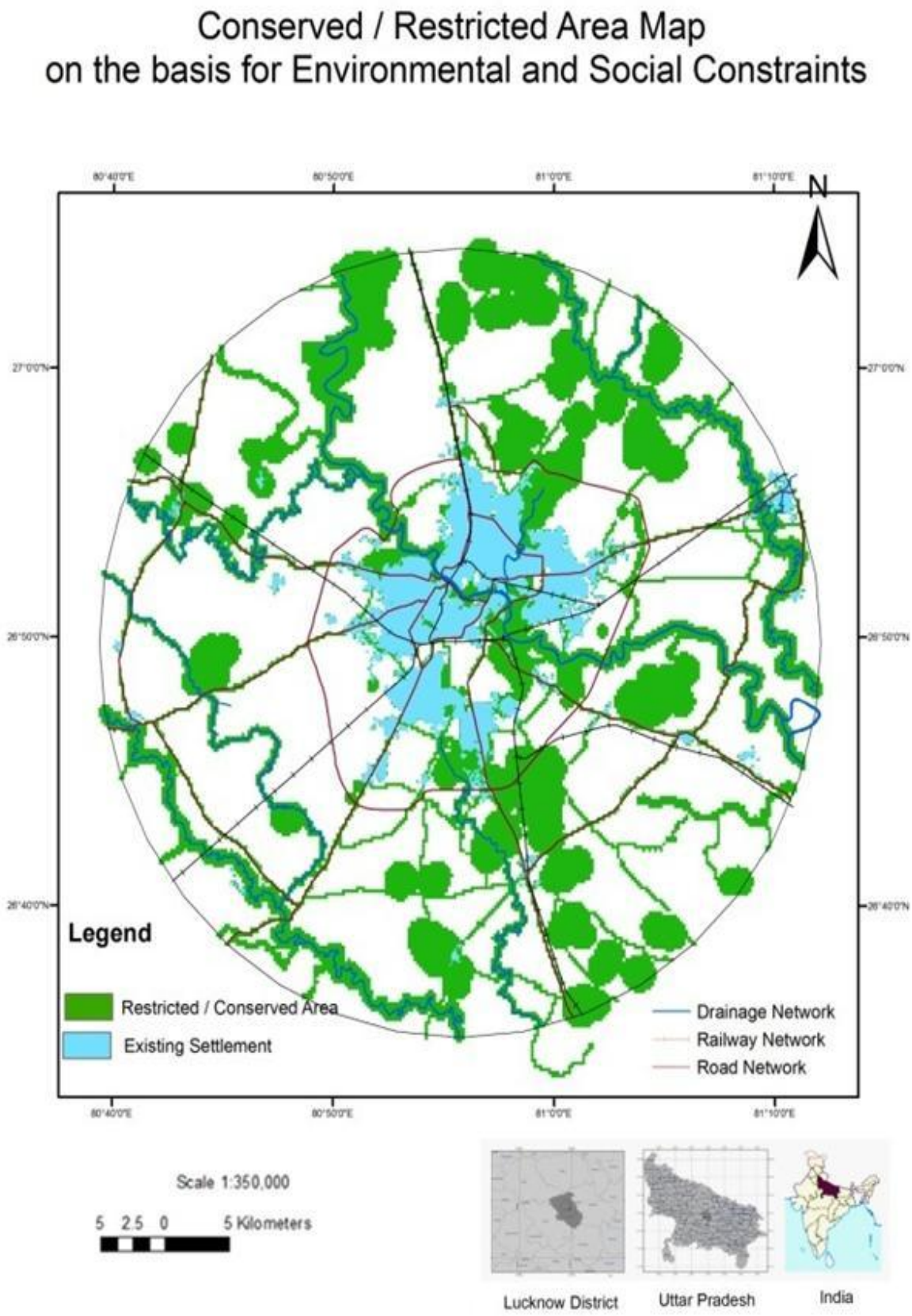

Conserved / Restricted Area Map
on the basis for Environmental and Social Constraints
80°40'0"E
80°50'0"E
81°0'0"E
81°10'0"E
N
27°0'0"N
26°50'0"N
26°40'0"N
Legend
Restricted / Conserved Area
Existing Settlement
Drainage Network
Railway Network
Road Network
Scale 1:350,000
5 2.5 0 5 Kilometers
Lucknow District
Uttar Pradesh
India

Figure 5.39

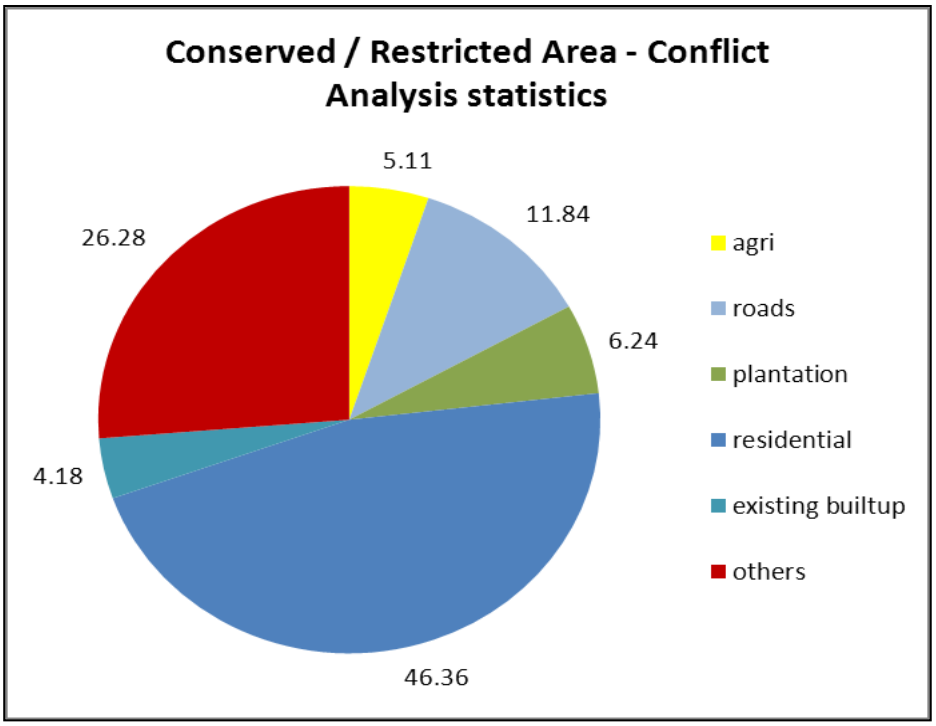


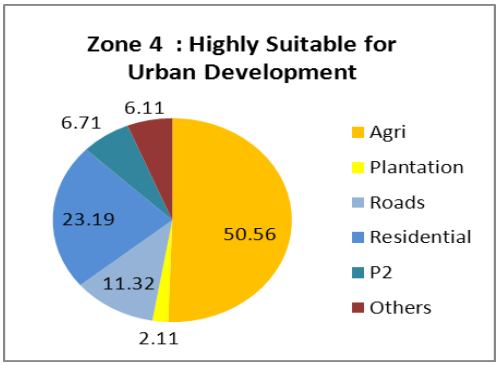
Figure 5.40: Conflict Analysis Statistics

As observed from the figure above, 46.36 % of the area under restricted zone has already been planned as residential area and 11.84 % of the area under restricted zone as transport infrastructure required for the ensuing development.

5.5.1 Urban Suitability-AHP/FAHP and Master Plan 2021

The final suitability maps rendered from AHP and FAHP adapted WLC method were overlaid on digital layer of master plan 2021 to highlight the developmental/planned conflicts with respect to the urban suitability zonation recommended by the study. The overlay analysis highlighted lack of planning in highly suitable and moderately suitable zones, where majority of the area has been planned as agriculture.

As per AHP weighted zonation, 50 % of highly suitable area and 44 % of moderately suitable area has been planned as cropland only; as per Fuzzy AHP weighted zonation, 38 % of highly suitable areas and 45 % of moderately suitable areas have been planned as cropland (Figure 5.41 and figure 5.42). Very weak and weak suitability zones although were planned appropriately for mainly agriculture and plantations (Fig. 5.43 and Fig 5.44).



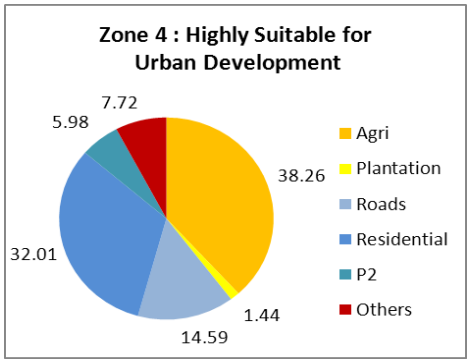
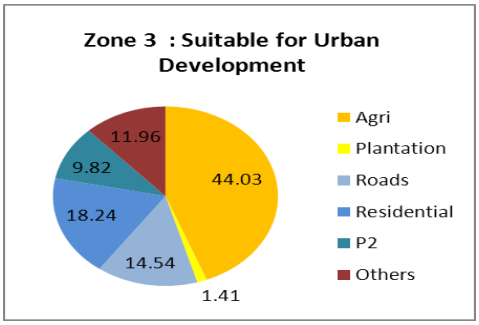


Figure 5.41: AHP LSA ; FAHP LSA



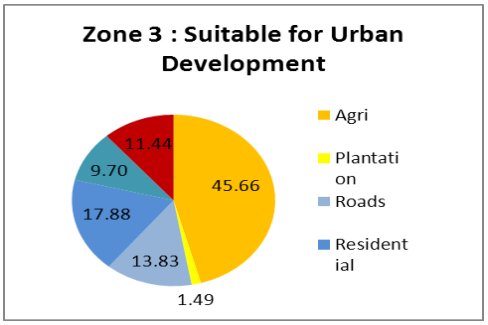
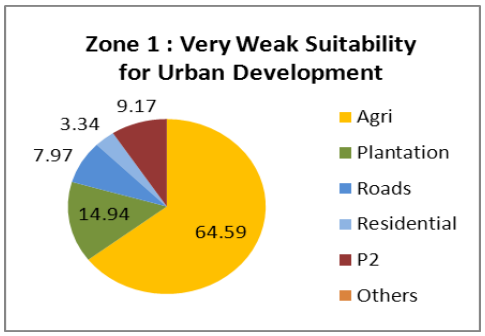


Figure 5.42: AHP LSA ; FAHP LSA



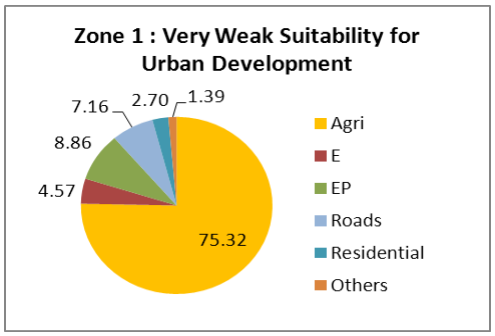
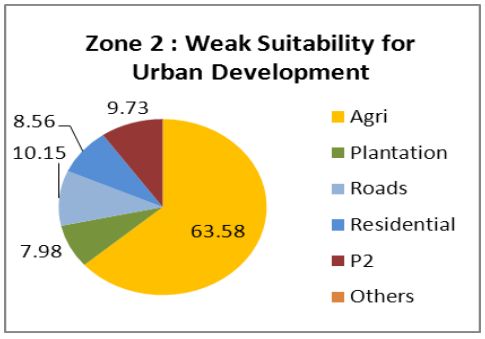


Figure 5.43: AHP LSA ; FAHP LSA



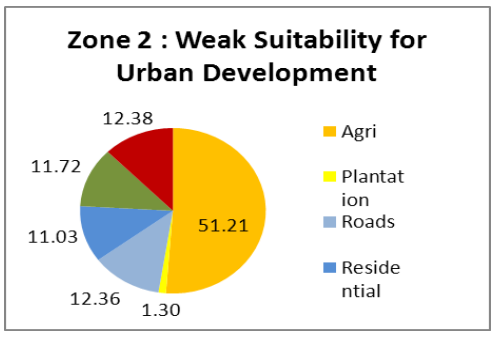


Figure 5.44: AHP LSA ; FAHP LSA

It is evident from the conflict analysis that though the Master Plan 2021 does not present stark differences from the zoning recommended by Suitability study, still the restricted/conserved areas recommended by the study are majorly conflicting with the planned future development.

The following observations are made during the study of the peri urban growth in lucknow city:

1. Cities, townships and minor habitations throughout the developing world are growing at an unprecedented rate, transforming themselves into extensive urbanized landscapes. Every one of us has been witnessing these changes in our local environment but without a clear understanding of their impact on social, economic and environmental systems. It is not until we study these landscapes from a spatial perspective under changing time scale that we begin to appraise the changes of the past and envisage the impact of any future changes.

2. Quest towards a more comfortable living and better overall quality of life for mankind should be able to strike a balance between the need for economic development and the need for conservation of natural resources within the same management plan in a coherent manner. Planning for sustainable development is a process that comprehensibly and holistically analyses natural resources conditions, human uses and socio-economic aspects.

3. A rapid urbanization process with a simultaneous significant development in economy and industrialization has augmented considerable land use change in Lucknow, the capital city of State Uttar Pradesh of India, more so in the latest decade. The city apparently represents a typical urbanization process taking place throughout India as it has witnessed swift urbanization in recent years, leading to multifold increase in employment opportunities but a rapid degradation of basic natural resources like land and water (Dutta et al., 2010). Once dominated by agriculture, the region is fast converting into a mosaic of interspersed rural-urban landscape with depleting natural land covers and increasing paved surfaces of urban land use.

4. A micro-level case study was also undertaken in the present work, which focuses exclusively on peri-urban test sites which were selected on the basis of presence of abundant cropland in competition for land from non-agricultural uses outside the demarcated urban territory of land development authority.

5. The case study observed that developmental infrastructure in form of roads; telecommunications etc. do not seem to play the focal role in urban development in majority of PUI sites although urbanization is rampant in study area. It was recommended that a significant amount of recoverable land cover in PUI presently under transformation be restored and focus of development be shifted on underutilized areas in city core. It is also suggested that older urban areas with dense horizontal urbanization can be considered for urban redevelopment using vertical urbanization methods.

6. The main study primarily proposes urban development in moderately constrained environment, where the natural resources were inventoried in detail with

highest possible accuracy and classified as per their relevance for human use in order to categorize natural land covers for conservation and identify recoverable land uses to suitably encourage them. The landscape transformations that have resulted from the growth of a populous city and development of its extended peri-urban area over a time span of 12 years have been observed using sources such as satellite data, maps and master plans. The retrospective urban land use databases of three time periods have been assembled that reflect a decade of change and give an insight on change pattern with its drivers. To identify prime farmlands in abundant cropland, Agricultural capability assessment was done and further the identified areas were excluded from further analysis.

7. As finding suitable sites for urbanization is one of the most critical challenges so an urban suitability assessment has been performed using multi-criteria weighted linear combination (WLC) method. AHP (Analytical Hierarchy Process) and FAHP (Fuzzy Analytical Hierarchy Process) driven WLC has been done and compared for better results. An important step in the suitability assessment process was to identify critical zones requiring immediate environmental conservation and their henceforth elimination from the areas under consideration for urbanization. Determination of urban suitability further involved an evaluation of natural and anthropogenic limitations of a certain area in order to decide if the locality can support habitation. The procedure was finalized by performing a conflict analysis which finds disagreements between the study's Suitability recommendations and the authorized master plan of the city. Suitability process and a simultaneous conflict analyses support the interdisciplinary aspects of sustainable planning which addresses where, how and why urbanization in particular and development in general will mostly succeed in sustainable manner.

8. Main outputs of the integrated multi-criteria evaluation process were: A GIS database of temporal landuse maps, a decadal landuse change map, identified prime farmlands, an established site suitability criterion rendering assortment of suitable sites and detailed conflict analysis of proposed suitable sites w.r.t existing or planned development.

9. The study observed that due to rapid economic development, the city has expanded in size and structure, becoming increasingly more complex, and heterogeneous. Most of the prevailing and planned landuse changes are unplanned as urban developments are being observed in severely restricted areas like major drainage buffer and in vicinity of conserved landcovers, which is not only a threat to the existing landcovers but also to the people supposed to inhabit them. The authorized master plan although seems to take care of any chaotic development in croplands (areas found unsuitable for urbanization) where urbanization has been planned to be minimum but then the master plan happens to underutilize the highly suitable zones by planning the majority %area to be under cropland. It is recommended that any further development in city periphery strictly follows the Environmental impact assessment recommendations to stop further degradation of the fertile landscapes.

10. The study aims to enable the local authorities and public service departments to have access to data generated and information derived by the study for appraising

individual projects and inhibiting environmental conflicts. Future work can focus on implementing the method separately for individual urban land uses .i.e. suitability for multiple urban land use to address the choice between development and conservation in a developing city. Further work can also be done for development of the methods into customized software, in order to add usability and generic nature.

11. With a motive of examining the above facts, this study attempts to decipher the land use transformation pattern and assessment of the direction of this transformation w.r.t sustainable development in the extended peri-urban interface of a fast developing city Lucknow, the capital of state Uttar Pradesh in India. The area has long been known for its fertile croplands and juiciest mangoes apart from an illustrious history. With the advent of technology and industries, as anywhere in the world, influx of migrants and urbanization has augmented the process of incessant city expansion. The pace of growth is such that it hinders proper planning and management of available resources causing chaotic development and degradation of precious natural resources. It is unreasonable to expect increase in natural resources in vicinity of a growing city, nevertheless it is generally anticipated that the loss in any natural resource at the cost of development is marginal and that the development makes up to the nature by restoring the loss gradually.

12. The study involves a land use transformation analysis using three datasets of high resolution imagery encompassing more than a decade of time from 1997 to 2009. The analysis observes that though the city has grown multifold during the last ten years, its periphery and beyond persistently remains largely a cropland interspersed with fruit orchards. The immediate city boundary although seems to have suffered as is reflected by the case study focused on four test sites situated on the transforming city boundary. The case study and the study on the whole highlight the fact that conversion of cropland into urban landuse is gradual, interrupted by transforming of resource rich croplands into wastelands, which is then taken up for urban development. Also since such a change does not take place overnight, hence plenty of resource rich croplands are in midst of such change at any given time, making it possible for planners and decision makers to intercept and reverse the process to help restore the fast degrading areas.

13. In order to assess the direction of recent and planned development, the study involves a couple of suitability analysis; agricultural capability and urban suitability analysis. The mentioned procedures are further undertaken using two techniques, AHP driven WLC and Fuzzy AHP driven WLC to facilitate a comparison between the two techniques in order to ascertain the advantages of using any one of them over another. It is observed by agricultural capability analyses that only a total of 9 % of study area is under prime farm lands or Class I agricultural capability area but as 50% of the area is under Class II agricultural land hence the study area is majorly a fertile cropland area. Restricting the prime farmland (class I and II) using results from agricultural capability, the study proceeds with urban suitability analyses to ascertains the most suitable and most unsuitable areas for urbanization in future. The results of AHP led WLC and Fuzzy AHP led WLC were quite comparable as both identified less than 2 % (AHP: 1.37%; FAHP: 1.86 %) of the total area as highly suitable for urbanization and more than 25 % of the total area as unsuitable for urbanization. The

results of the analysis surely indicated a need for reviewing the recent urban development schemes so that urbanization in unsuitable areas can be discouraged.

14. To further the efforts for ensuring urbanization in appropriate areas, a conflict analysis was performed to find disagreements between recommended urban suitability and the planned city expansion. The city development plan and city master plan were used to represent the future city planning by authorities. The same were digitized in GIS standard format to enable the comparison with the urban land suitability output. It was found that several disagreements existed between the inputs, most remarkable being the current and planned urban growth in restricted areas. Although disagreements existed still the planned growth as per the master plan was not as derogatory as the recent development in urban sector seen over last few years.

15. During the study a need was felt for a further expansive study on multiple urban suitability assessment, which assesses individual urban landuses for their suitability w.r.t inhabitants and natural resources together. The study is suggested, keeping in mind the distinctive pattern of degradation and pollution observed by industrial sector, particularly brick kilns and hazardous material industries. The pattern of growth of industries has been observed to be the most unplanned, dangerously located amidst residential areas polluting soil, groundwater and air with reckless unconcern. Several other urban landuses are also in chaos, indicating a detailed study to examine their individual suitability.

16. Also, the data development, standardization and management were observed to be the most time taking processes in the whole study, hence it is suggested that a step further may be development of customized software which inputs data from several sources and is capable of standardizing and managing it in spatial formats. The analysis procedures used in the study use standard GIS operations which can be customized in software capable of handling GIS data. A development in this direction would definitely improve the pace of any further study in this direction.

On the basis of the study of peri urban growth of the lucknow city four sites are selected in the lucknow for the determination of Effectiveness of EIA for Housing Projects

5.6 Data Collection: Ancillary and Satellite data was collected and Comparative study between pre to pre project (baseline environmental status) and post to post projects (Current environmental status) of housing projects of Lucknow was done.

5.6.1 Ambient Air Quality:

5.6.1.1 Pre project (baseline environmental status)

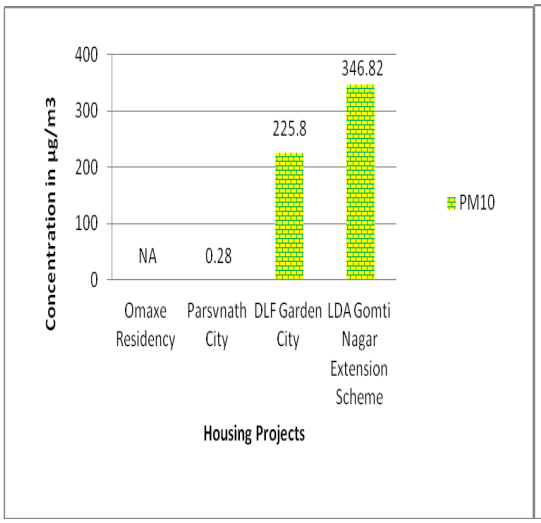
An assessment of air quality was under taken to establish the status of exposure of the major sensitive receptors and to identify the air pollution sources and their impacts on the project site and surroundings. This assessment was accomplished by reviewing historical ambient air quality data, examining sources of air emissions within a 10km radius of the proposed site, and by conducting a site specific sampling program. In

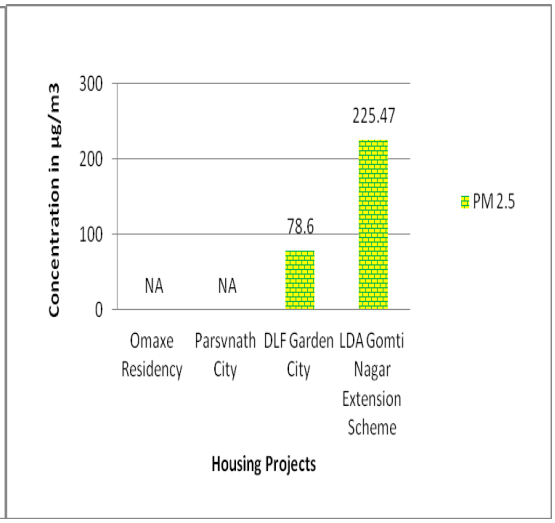
this manner, background data collected were compared to the applicable NAAQS. The ambient air quality for the different areas are is given below in the Table 5.8

Table 5.8 Ambient Air quality pre project

S.No	Projects /parameters	Particulate Matter PM^{10} ($\mu g/m^3$)	Patriculate Matter $PM_{2.5}$ ($\mu g/m^3$)	Sulphur di-oxide ($\mu g/m^3$)	Nitrogen di-oxide ($\mu g/m^3$)	Carbon Monooxide ($\mu g/m^3$)
BASELINE DATA						
NAAQS for residential, rural and other areas ($\mu g/m^3$)		200	100	80	80	2000
1.	Omaxe Residency	NA	NA	NA	NA	NA
2.	Parsvnath City	0.28	NA	0.44	NA	30.3
3.	DLF Garden City	225.8	78.6	6.9	18.9	565.6
4.	LDA Gomti Nagar Extension Scheme	346.82	225.47	17.78	26.79	NA

Source: *Compliance report of EIA(2006 to 2010) from SPCB Lucknow,Uttar Pradesh.*





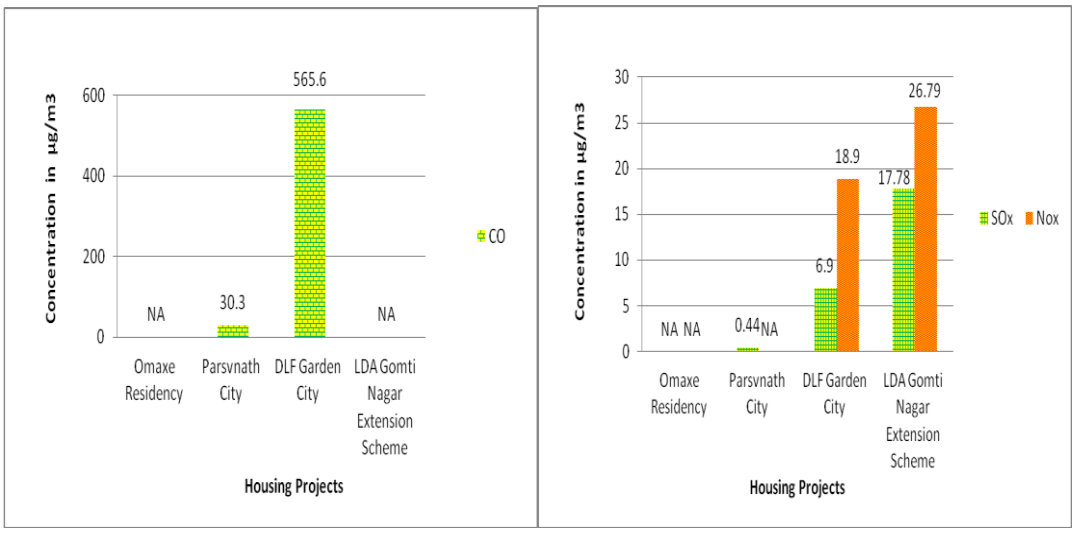


Figure 5.45 Pre-project Ambient Air Quality

Since the EIA Compliance report collected from SPCB does not possess the ambient air quality with respect to omaxe residency (all parameters) and $PM_{2.5}$ and NO_X with respect to parsvnath city. So after the comparative study of housing projects it was found that LDA Gomti Nagar Extension Scheme possess high PM_{10} and SO_X and parsvnath city possess low PM_{10} and $SO_{X.}$ Similarly, with respect to $PM_{2.5}$ and NO_X LDA Gomti Nagar Extension Scheme possess high $PM_{2.5}$ and NO_X and parsvnath city possess low $PM_{2.5}$ and $NO_{X.}$ The detail can be seen in the figure 5.46 and table 5.8 mentioned above.

5.6.1.2 Post-project (current environmental status)

The air quality data of the different housing projects that was collected after monsoon period 2014 are given below in table 5.9

Table 5.9 Ambient Air quality post-project

S.No	Projects /parameters	Particulate Matter PM10 (µg/m3)	Patriculate Matter PM 2.5 (µg/m3)	Sulphur di-oxide (µg/m3)	Nitrogen di-oxide (µg/m3)	Carbon Monooxide (µg/m3)
Current Data						
NAAQS for residential, rural and other areas (µg/m3)		100	60	80	80	4
1.	Omaxe residency	105.89	54.3	7.2	19.7	1.2

2.	Parsvnath city	NA	NA	NA	NA	NA
3.	DLF garden city	94.0	52.3	8.2	16.7	0.8
4.	LDA Gomti Nagar Extension Scheme	120.8	59.3	8.2	16.2	0.9

Source: *based on sampling done during September 2014 to October 2014*

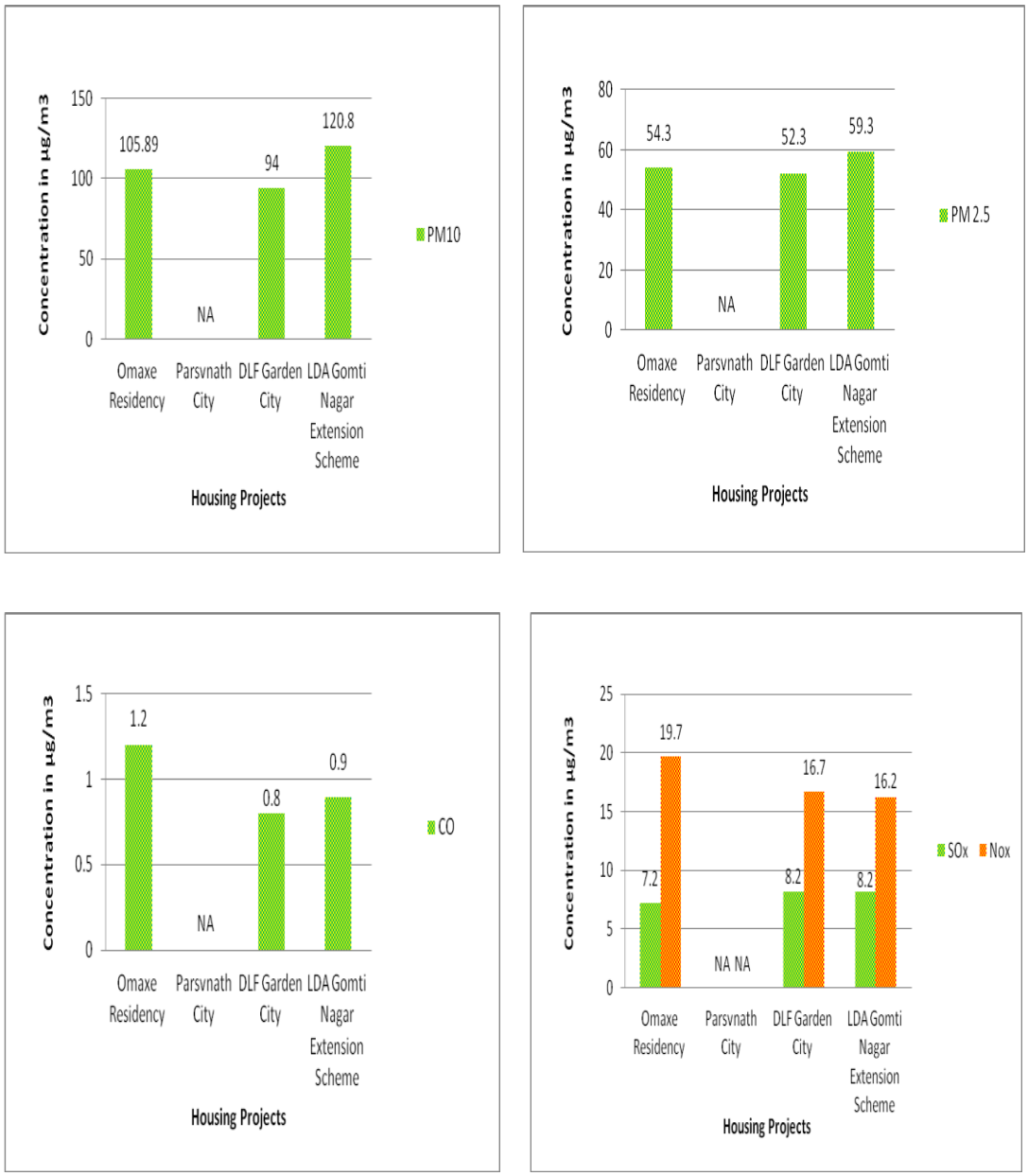


Figure 5.47 Post-project Ambient Air Quality

On comparing the housing projects of the study area with respect to air quality parameters (2014 data) it was found that air pollution level (SPM, RSPM, Sox, NOx, and CO) was high in LDA Gomti Nagar Extension Scheme (due to crowded place near main Gomti nagar area) and low in Omaxe residency. The detail can be seen in the figure 5.47 and table 5.9 mentioned above.

5.6.2 Ambient Noise Quality:

5.6.2.1 Ambient Noise Quality Pre-project (baseline environmental status)

An assessment of noise quality was under taken to establish the status of exposure of the major sensitive receptors and to identify the noise pollution levels of approach road. The noise level was recorded continuously 24 hours from 6:am to 10:pm and 10:pm to 6:am.The National ambient noise quality standards for the different areas are is given below in the table 5.10

Table 5.10 The standard NANQ

S. No.	Location	Noise Level leq dB(A) Max	Noise Level leq dB(A) Min
	Standard (Ambient Noise)		
	Industrial area	75	70
	Commercial area	65	55
	Residential area	55	45
	Silence Zone	50	40

Since the baseline data of omaxe residency and parsvnath city was not mentioned in the compliance report that's why comparative study was done between the DLF garden city (shows high noise level) and LDA Gomti Nagar Extension Scheme (possess low noise level) during day and night time which was shown in Table 5.10 and figure 5.48 This is so because the area is lying near the Amar shaheed path, sultanpur road and faizabad road.it is also a poss and crowded area.

Table 5.6.2.1.2 Ambient Noise Quality Pre-project (baseline environmental status)

S. No.	Location	Noise Level leq dB(A) Max	Noise Level leq dB(A) Min
		Baseline data	**Baseline data**
	Standard (Ambient Noise)	55	45
1.	Omaxe residency	NA	NA
2.	Parsvnath city	NA	NA
3.	DLF garden city	61.27	44.37
4.	LDA Gomti Nagar Extension Scheme	52.20	39.90

Source: *based on compliance reports of EIA (2006 to 2010) and sampling done during September 2014 to October 2014.*

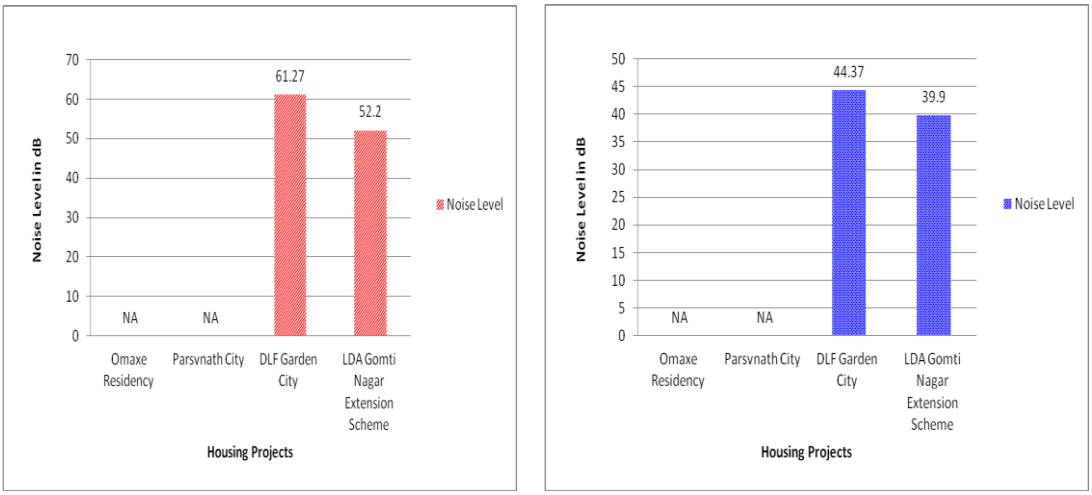


Figure 5.48 Pre-Project Ambient Noise Quality

5.6.2.2 Post-project (current environmental status)

There are so many reasons that noise quality of the particular area will be degrade like transportations, traffic system, entertaining equipments, construction and operation machinery equipments. The ambient noise quality data was collected after the monsoon period 2014. The Recorded Ambient Noise Quality are given as below in table 5.11 and shown in figure 5.49 also.

TABLE 5.11 Ambient Noise Quality Post-project

S. No.	Location	Noise Level leq dB(A) Max	Noise Level leq dB(A) Min
	Standard (Ambient Noise)		
1.	Omaxe residency	66.1	44.2
2.	Parsvnath city	68.1	50.2
3.	DLF garden city	65.1	40.6
4.	LDA Gomti Nagar Extension Scheme	70.1	52.2

Source: *based on sampling done during September 2014 to October 2014*

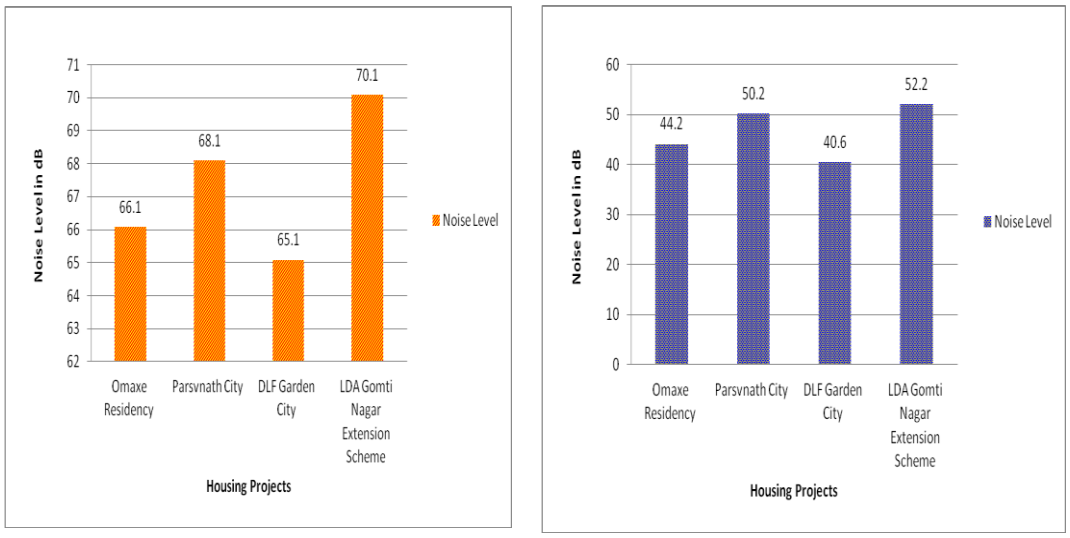


Figure 5.49 Post-Project Ambient Noise Quality.

The noise level recorded in 2014 after monsoon period in the study area from the graph shows that LDA Gomti Nagar Extension have high level of noise and Omaxe Residency have low level of noise quality among all the housing projects of the

study area during day time while during night time DLF Garden city posses low level of noise generation and LDA Gomti Nagar Extension have high level of noise.

5.6.3 Soil Quality:

5.6.3.1 Pre-project (baseline environmental status)

Top soil consists of organic carbon that helps in soil aggregation and also improves water holding capacity of the soil which in turn helps in slowing down the flow of water through the soil. Basic inorganic nutrients present in the soil in adequate amount are required for healthy growth of vegetation. Thus, it is important to preserve top soil from soil pollution which is caused by construction materials and equipment during construction. The analytical data of the soil are given below in table 5.12

Table 5.12 Soil Quality pre-project

SL.NO	Parameters	Omaxe Residency	Parsvnth City	DLF Garden City	LDA Gomti Nagar Extension Scheme
1.	pH	00	00	7.6	7.5
2.	Conductivity (mS/cm)	00	00	792.3	258
3.	Bulk Density, gm/Cc	00	00	1.45	1.56
5.	Potassium available as K (kg/ha.)	00	00	82	238
6.	Available Nitrogen as N (kg/ha.)	00	00	68	654
7.	Available Phosphorus (kg/ha.)	00	00	54	34

Source: *Compliance report of EIA(2006 to 2010) from SPCB Lucknow,Uttar Pradesh*.

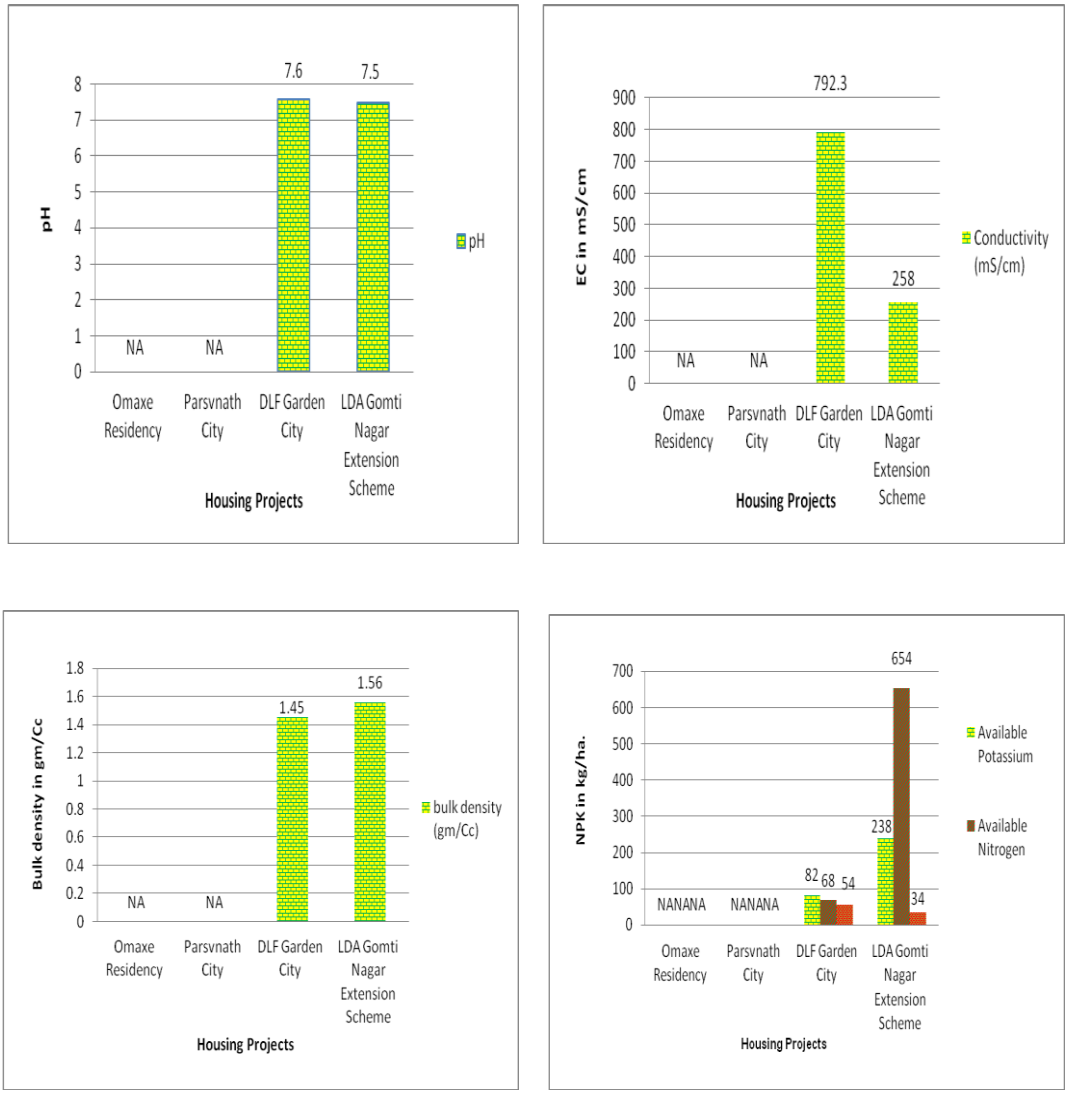


Figure 5.50 Soil Quality pre-project

Since data of Omaxe residency and Parsvnath city was not mentioned in the compliance report that's why the comparative study was done between the DLF garden city and LDA Gomti Nagar Extension Scheme. The comparative study indicates that the level of PH, Conductivity, and available phosphorous was high in DLF garden city as compared to LDA Gomti Nagar Extension Scheme. Similarly, the bulk density, available Nitrogen and Potassium was found to be high in LDA Gomti Nagar Extension Scheme as compared to DLF garden city (see the figure 5.50 and table 5.12 for detail.).

5.6.3.2 Post-project (current environmental status)

The soil is sedimentary in nature and contains the transported alluvial sediments spared from the shivalik Himalayas. Topsoil is rich in organic content and is essential to establish new vegetation. Development projects involve disturbance to the existing soil conditions, removal of existing trees, which result into soil erosion, instability and overall change in the microclimate and drainage pattern of the site.

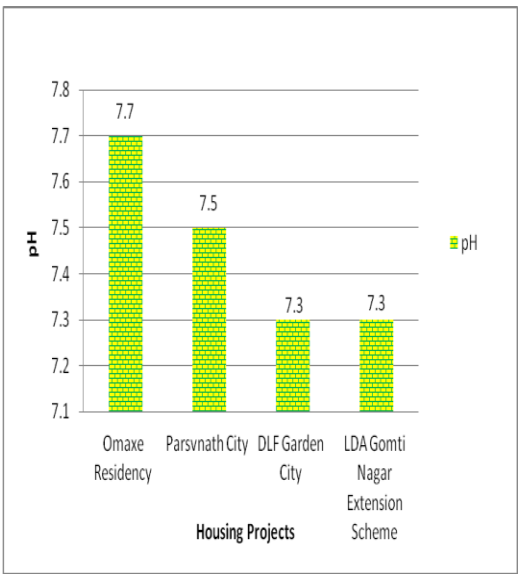
To assess the soil quality of the different housing projects sampling was done after the monsoon period 2014. The soil quality of the different housing projects are given as below in the table 5.13.

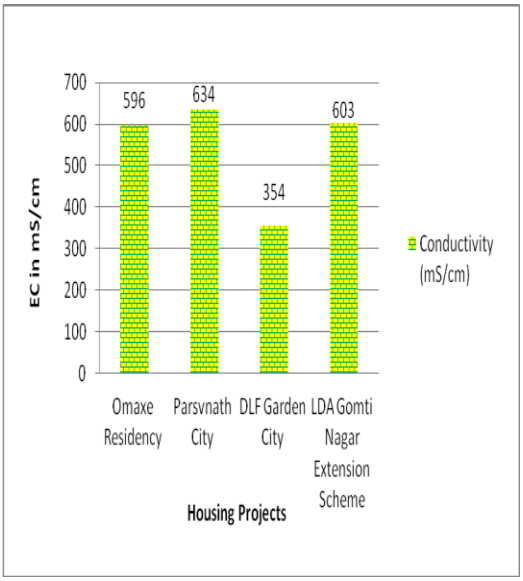
Table 5.13 Soil Quality post-project

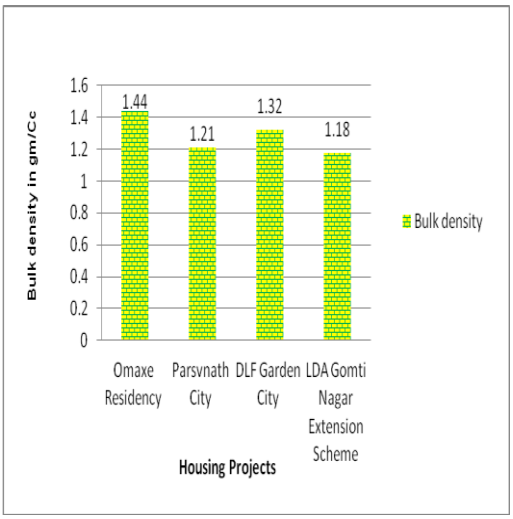
S.NO.	Parameters	Omaxe Residency	Parsvnth City	DLF Garden City	LDA Gomti Nagar Extension Scheme
1.	pH	7.7	7.5	7.3	7.3
2.	Conductivity (mS/cm)	596.0	634.0	654.0	603.0
3.	Bulk Density, gm/Cc	1.44	1.21	1.32	1.18
4.	Sodium available as Na (mg/100g)	42.4	36.4	52.4	133.4
5.	Potassium available as K (kg/ha.)	50.4	43.2	32.6	54.1
6.	Available Nitrogen as N (kg/ha.)	154.2	143.2	162.3	137.2
7.	Available Phosphorus (kg/ha.)	16.4	14.6	17.2	15.4
8.	Zinc (as Zn)	22.4	18.4	20.2	21.4
9.	Lead (as Pb)	<0.01	<0.01	<0.01	<0.01
10.	Copper (as Cu)	<0.03	<0.05	<0.05	<0.02
11.	Iron (as Fe)	14.2	14.2	14.2	14.2
12.	Moisture Content	8.6	7.6	9.6	8.6

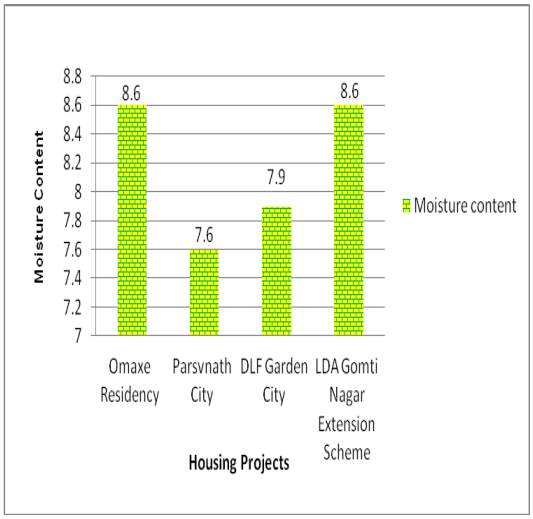
Source: *based on sampling done during September 2014 to October 2014*

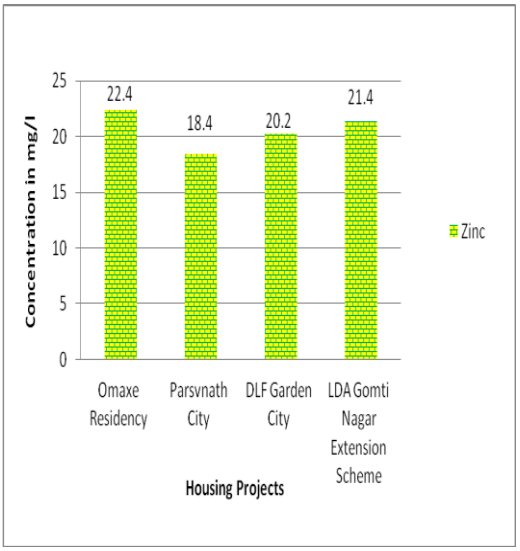
On comparative study based on sampling done during September 2014 to October 2014 it was found that moisture content, available phosphorous, with respect to the DLF garden city was maximum and lowest in parsvnath city. Similarly, PH, bulk density was found to be maximum in Omaxe Residency and lowest in LDA Gomti Nagar Extension Scheme. The content of zince was maximum in Omaxe residency and lowest in Parsvnath city. Also, the available Nitrogen was high in DLF garden city and minimum in LDA Gomti Nagar Extension Scheme. The electrical conductivity was found to be high in DLF garden city and minimum in Omaxe residency. The quantity of Fe and Pb was costent. The available sodium was maximum in LDA Gomti Nagar Extension Scheme but minimum in parsvnath city (see table 5.13 and figure 5.51 mentioned above).


7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
pH
7.7
7.5
7.3
7.3
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
pH


700
600
500
400
300
200
100
0
EC in mS/cm
596
634
354
603
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Conductivity (mS/cm)


1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Bulk density in gm/Cc
1.44
1.21
1.32
1.18
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Bulk density


8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
Moisture Content
8.6
7.6
7.9
8.6
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Moisture content


25
20
15
10
5
0
Concentration in mg/l
22.4
18.4
20.2
21.4
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Zinc

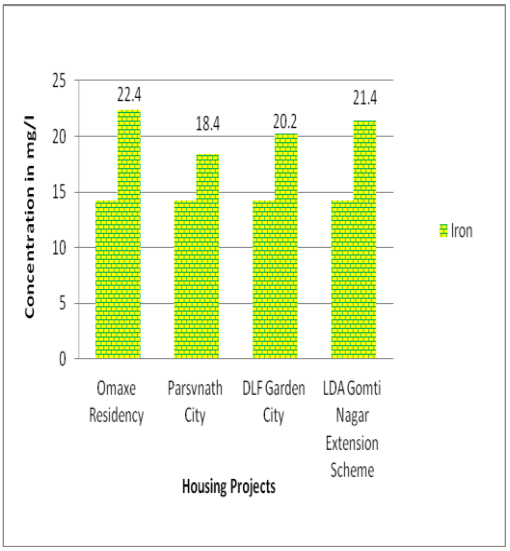

25
20
15
10
5
0
Concentration in mg/l
22.4
18.4
20.2
21.4
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Iron

Figure 5.51 Soil Quality post-project

5.6.4 Water Quality Status:

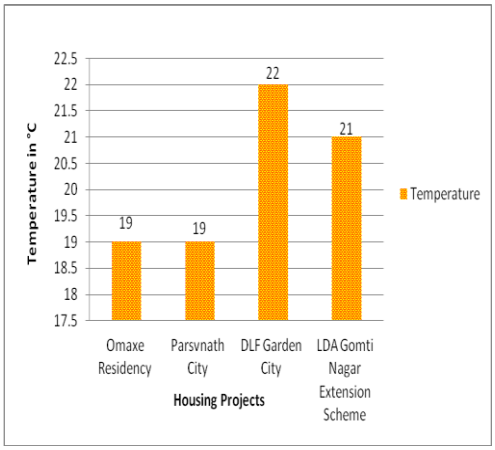
5.6.4.1 Pre-project (baseline environmental status)

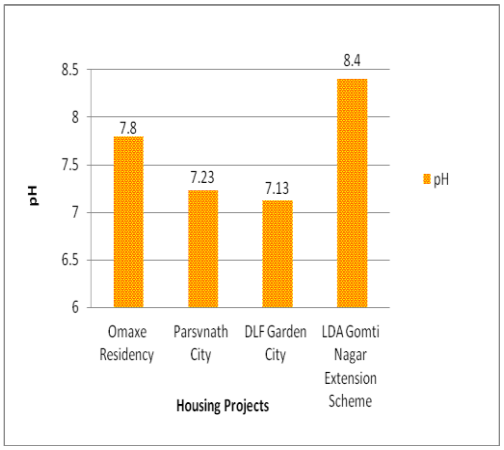
In India, there is a growing demand on the existing water resources, which includes the river water sources, precipitation and ground water sources. The area is primarily dependent on ground water as the source of portable water and irrigation. The water sampling and analysis has been conducted to establish baseline water quality in the area. Sampling has been done following the standard guidelines for physical chemical and biological parameters. The water quality status of the different housing projects are given below in the table 5.14

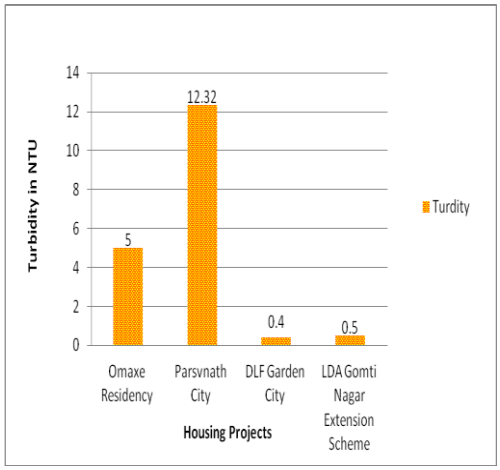
Table 5.14 Water quality status pre-project

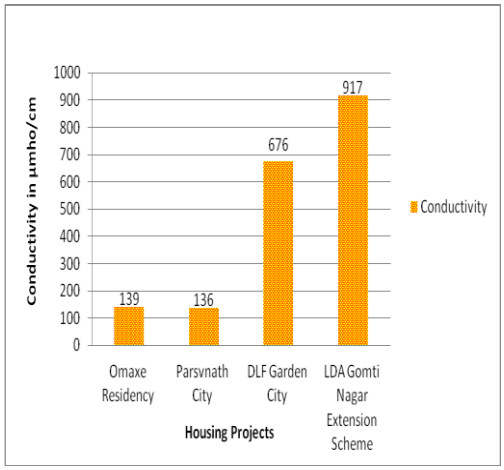
S.N.	Parameters	Unit	Omaxe Residency	Parsvnth City	DLF Garden City	LDA Gomti Nagar Extension Scheme
1	Temperature		19	19	22	21
3	pH	-	7.8	7.23	7.13	8.4
4	Turbidity	-	5	12.32	0.4	5
5	Conductivity	NTU	139	136	676	917
6	TDS	µmhos/ cm	876	90	434	448
8	Hardness as $CaCO_3$	mg/l	424	119	484	208
9	Alkalinity	mg/l	580	87	225	296
10	Chloride as Cl	mg/l	114	4.98	82	19
11	Sulphate as SO_4	mg/l	84	48	54	14
12	Fluoride	mg/l	0.6	0.56	0.02	0
14	Calcium as Ca	mg/l	96.1	125	0	0
15	Magnesium as Mg	mg/l	44.7	51.63	0	0
16	Sodium as Na	mg/l	186	21	60	70
17	Potassium as K	mg/l	13.9	4	22	0
19	Copper as Cu	mg/l	0.02	0.01	0	0
20	Mercury as Hg	mg/l	0.002	0.001	0	0

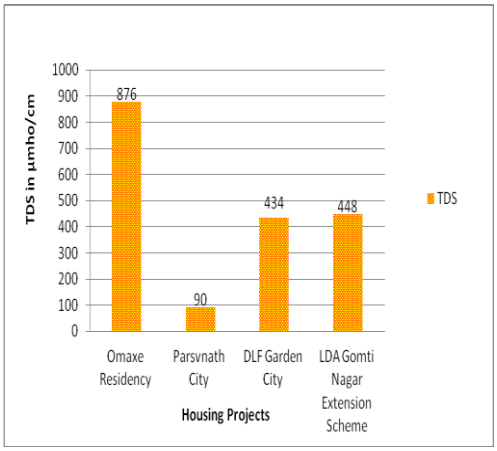
Source: *Compliance report of EIA(2006 to 2010) from SPCB Lucknow,Uttar Pradesh*

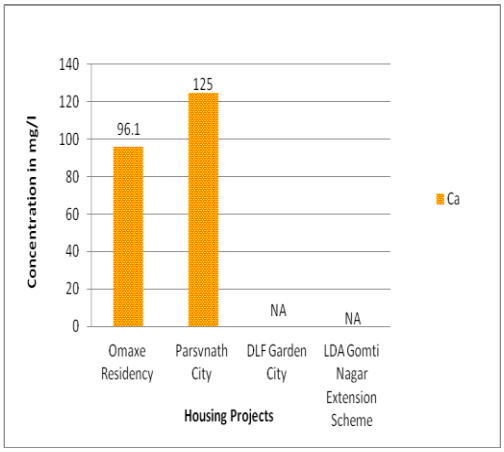


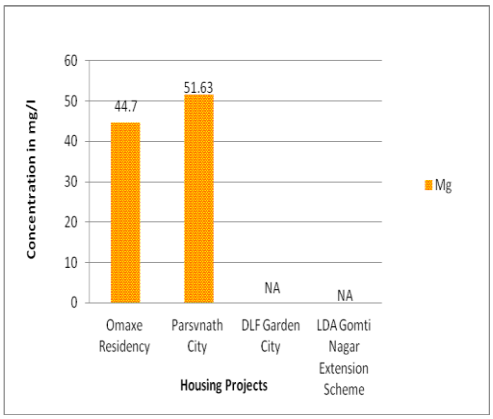


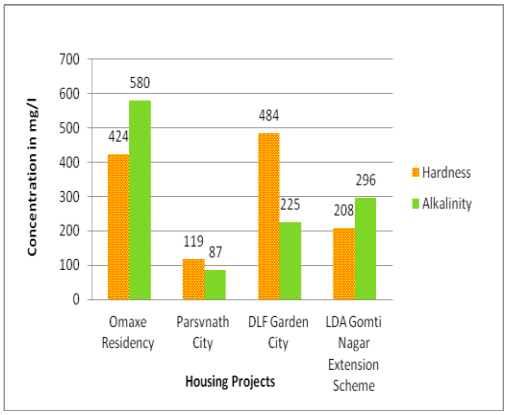

Turbidity in NTU
14
12
10
8
6
4
2
0
5
12.32
0.4
0.5
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Turdity

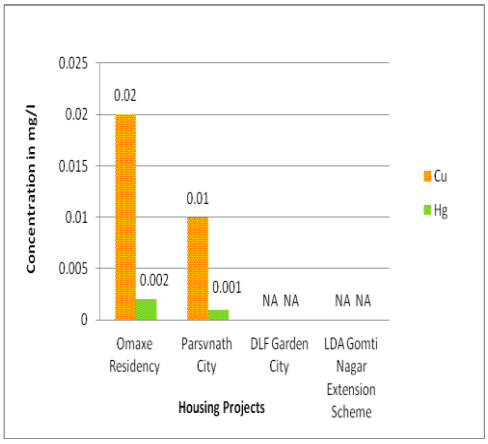

Conductivity in µmho/cm
1000
900
800
700
600
500
400
300
200
100
0
139
136
676
917
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Conductivity

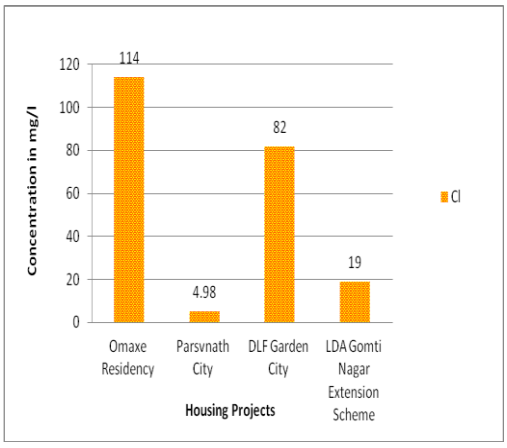

TDS in µmho/cm
1000
900
800
700
600
500
400
300
200
100
0
876
90
434
448
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
TDS


Concentration in mg/l
140
120
100
80
60
40
20
0
96.1
125
NA
NA
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Ca


Concentration in mg/l
60
50
40
30
20
10
0
44.7
51.63
NA
NA
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Mg


Concentration in mg/l
700
600
500
400
300
200
100
0
424
580
119
87
484
225
208
296
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Hardness
Alkalinity


Concentration in mg/l
0.025
0.02
0.015
0.01
0.005
0
0.02
0.002
0.01
0.001
NA NA
NA NA
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Cu
Hg


Concentration in mg/l
120
100
80
60
40
20
0
114
4.98
82
19
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Cl

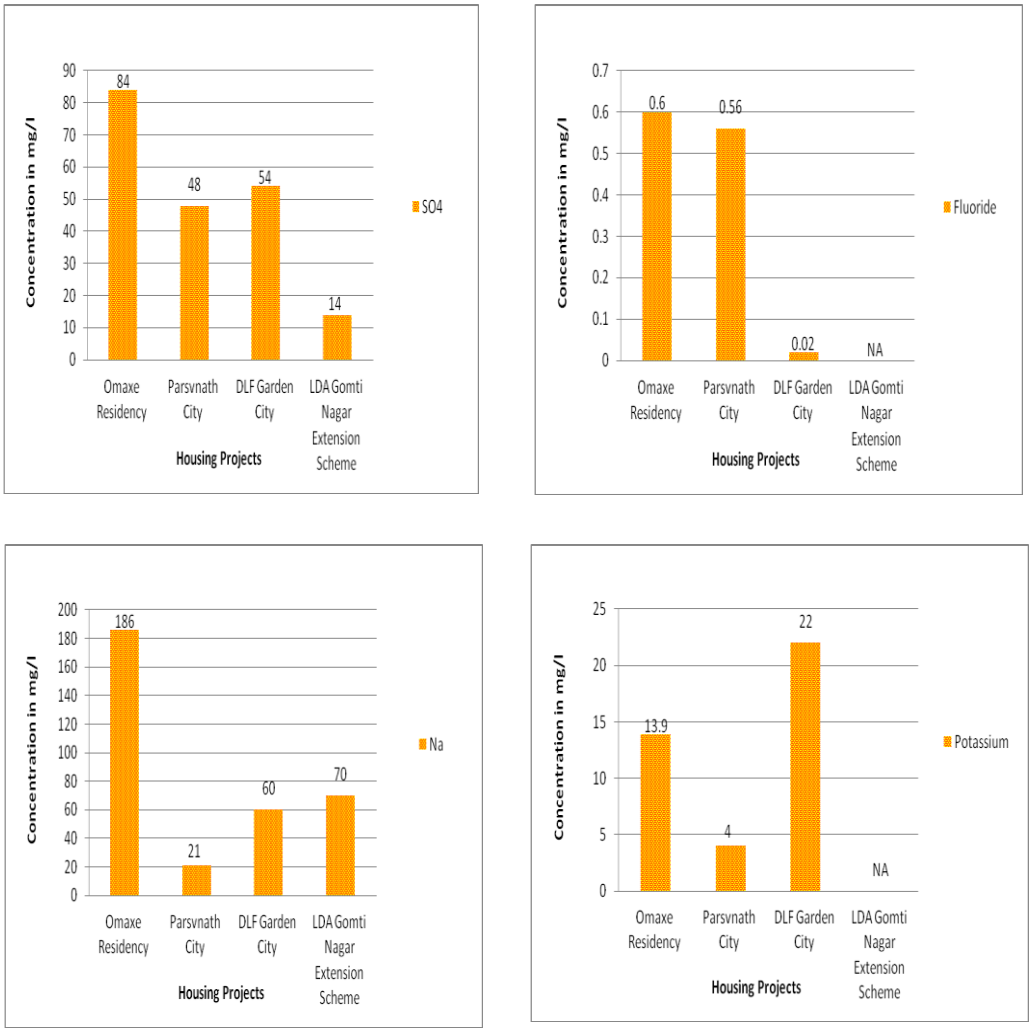


Figure 5.52 Water quality status pre-project

From the above table 5.14 and figure 5.52 following points are concluded:

- With respect to temperature LDA Gomti Nagar Extension Scheme possess maximum and Omaxe residency and Parsvnath city possess minimum.
- LDA Gomti Nagar Extension Scheme shows high PH and omaxe residency shows low PH value.
- Omaxe residency indicates high Alkalinity, chloride and sodium and low level in Parsvnath city.
- With respect to turbidity Parsvnath city possess maximum level and DLF garden city minimum level.
- LDA Gomti Nagar Extension Scheme shows high conductivity and Parsvnath city possess low conductivity.
- The TDS of Omaxe residency was found to be maximum and Parsvnath city possess minimum level.

- With respect to hardness of water DLF garden city indicates maximum hardness and Parsvnath city possess minimum hardness.
- The content of fluoride was found to be maximum in Omaxe residency and minimum in DLF garden city.

5.6.4.2 Post project (current environmental status)

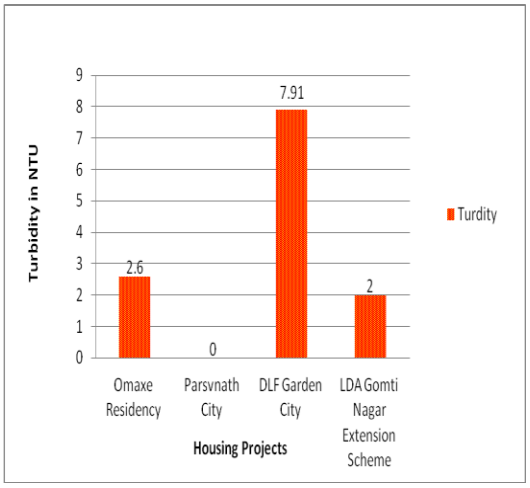
Water is the most important component for any society and is an important sustainable development indicator. Water use in a residential building includes the demand for human consumption, cleaning, washing, flushing and gardening. It is important that any sustainable urban development project should integrate the sustainable and environment friendly water management plan at the design stage. The current water quality data was collected in year 2014 after monsoon and analyzed in the laboratory. The analyzed water quality data is shown in the table 5.15 given below:

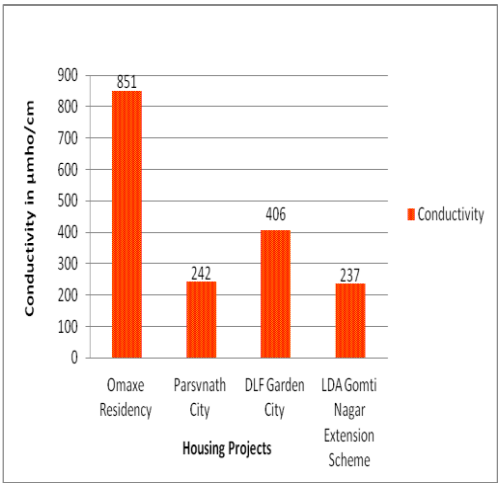
Table 5.15: Water quality status post-projects

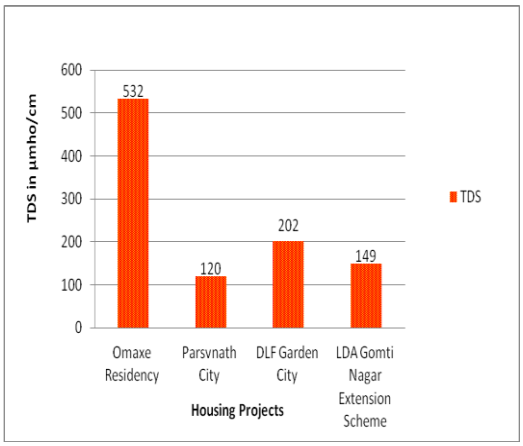
S.No.	Parameters	Unit	Reference Method*	**Omaxe Residency**	**Parsvnath City**	**DLF Garden City**	**LDA Gomti Nagar Extension Scheme**	**BIS Standard IS 10500: 2012**	
								Requirement (Acceptable limit)	**Permissible limit in the absence of alternate source**
1	Colour	Hazen	2120 B	Clear	Clear	Clear	Clear	5	15
2	Odour	-	2150 A	Odorless	Odorless	Odorless	Odorless	Agreeable	Agreeable
3	pH	-	4500H+ B	8.09	7.91	7.58	7.94	6.5 - 8.5	NR**
4	Turbidity	NTU	2130 B	2.6	0.0	7.91	2.0	1	5
5	Conductivity	µmhos/ cm	2510 B	851	242	406	237	--	--
6	TDS	mg/l	2540 C	532	120	202	149	500	2000
7	TSS	mg/l	2540 D	35.3	14	19.1	14.6	---	---
8	Hardness as $CaCO_3$	mg/l	2340 C	194	102	174	124	200	600
9	Alkalinity	mg/l	2320 B	105	104	112	86	200	600
10	Chloride as Cl	mg/l	4500-Cl,B	14.9	33.5	15.6	33.9	250	1000
11	Sulphate as SO_4	mg/l	4500-SO_4	4.2	3.1	4.5	2.7	200	400
12	Fluoride	mg/l	4500-F,C	0.2	0.2	0.3	0.2	1.0	1.5
13	Dissolved Oxygen	mg/l	4500-O,C	5.2	5.6	5.3	5.4	-	-
14	Calcium as Ca	mg/l	3500-Ca,	45	51	55	50	75	200
15	Magnesium as Mg	mg/l	3500-Mg	36.2	12.3	28.9	17.9	30	100
16	Sodium as Na	mg/l	3500-Na,D	4.5	4.0		5.0	7.0	---

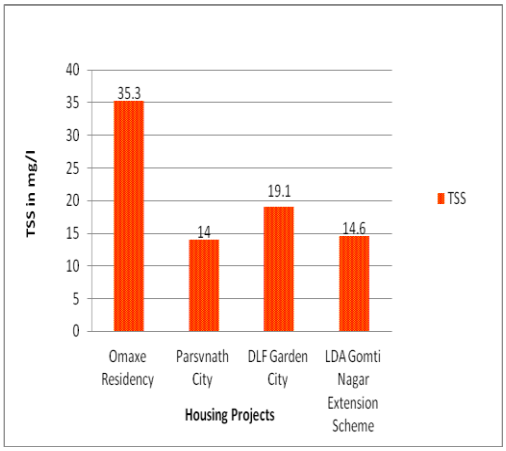
17	Potassium as K	mg/l	3500-K,D	8.0	7.0	12.0	7.0	---	---
18	Oil & Grease	mg/l	5520 B	<0.01	<0.01	<0.01	<0.01	---	---
19	Copper as Cu	mg/l	3500-Cu, B	0.002	0.003	0.002	0.003	0.05	1.5
20	Chromium as Cr^{+6}	mg/l	3500-Cr, D	0.013	0.002	0.012	0.001	0.05	NR**
21	Cadmium as Cd	mg/l	3500-Cd, B	0.001	0.001	0.001	0.001	0.003	NR**
22	Iron as Fe	mg/l	3500-Fe,D	0.124	0.138	0.132	0.118	0.3	NR**
23	Manganese as Mn	mg/l	3500-Mn,D	0.001	0.012	0.001	0.012	0.1	NR**
24	Nickel as Ni	mg/l	3500-Ni, D	0.001	0.002	0.001	0.002	0.02	NR**
25	Lead as Pb	mg/l	3500-Pb,B	0.004	0.003	0.004	0.003	0.01	NR**
26	Zinc as Zn	mg/l	3500-Zn, D	0.023	0.029	0.022	0.025	5	15
27	Arsenic as As	mg/l	3500-As,B	0.012	0.004	0.013	0.003	0.01	0.05
28	Mercury as Hg	mg/l	3500-Hg,B	0.0003	0.0004	0.0003	0.0004	0.001	NR**
29	Total coliforms	MPN/100ml	9221	Absent	Absent	Absent	Absent	Should be absent in any 100/ml sample	
30	Faecal coliforms	MPN/100ml	9221	Absent	Absent	Absent	Absent		

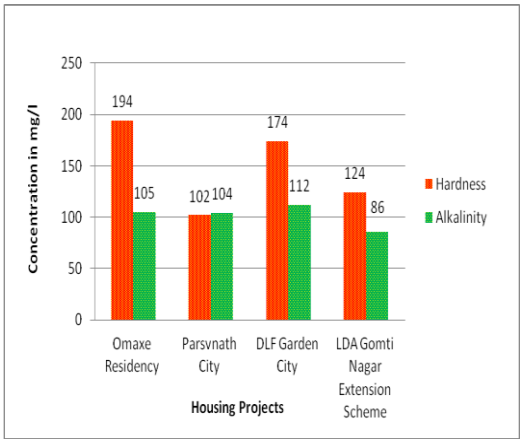
Source: *based on sampling done during September 2014 to October 2014*

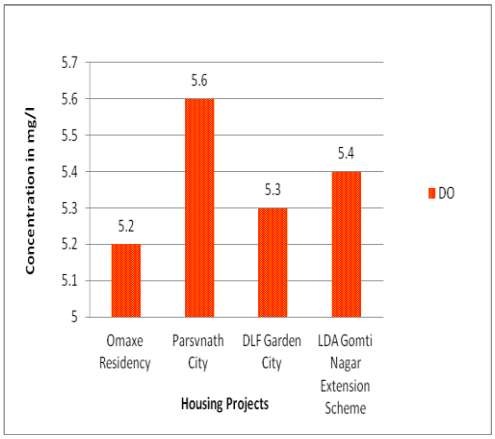

Turbidity in NTU
9
8
7
6
5
4
3
2
1
0
2.6
0
7.91
2
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Turdity

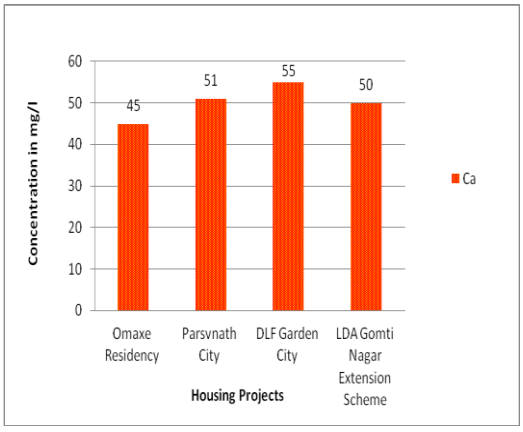

Conductivity in µmho/cm
900
800
700
600
500
400
300
200
100
0
851
242
406
237
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Conductivity

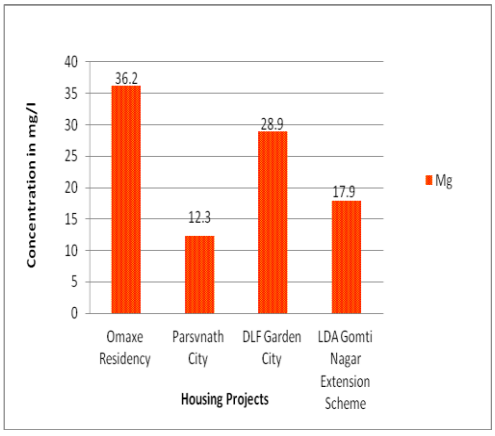

TDS in µmho/cm
600
500
400
300
200
100
0
532
120
202
149
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
TDS


TSS in mg/l
40
35
30
25
20
15
10
5
0
35.3
14
19.1
14.6
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
TSS


Concentration in mg/l
250
200
150
100
50
0
194
105
102
104
174
112
124
86
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Hardness
Alkalinity


Concentration in mg/l
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
5.2
5.6
5.3
5.4
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
DO


Concentration in mg/l
60
50
40
30
20
10
0
45
51
55
50
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Ca


Concentration in mg/l
40
35
30
25
20
15
10
5
0
36.2
12.3
28.9
17.9
Omaxe Residency
Parsvnath City
DLF Garden City
LDA Gomti Nagar Extension Scheme
Housing Projects
Mg

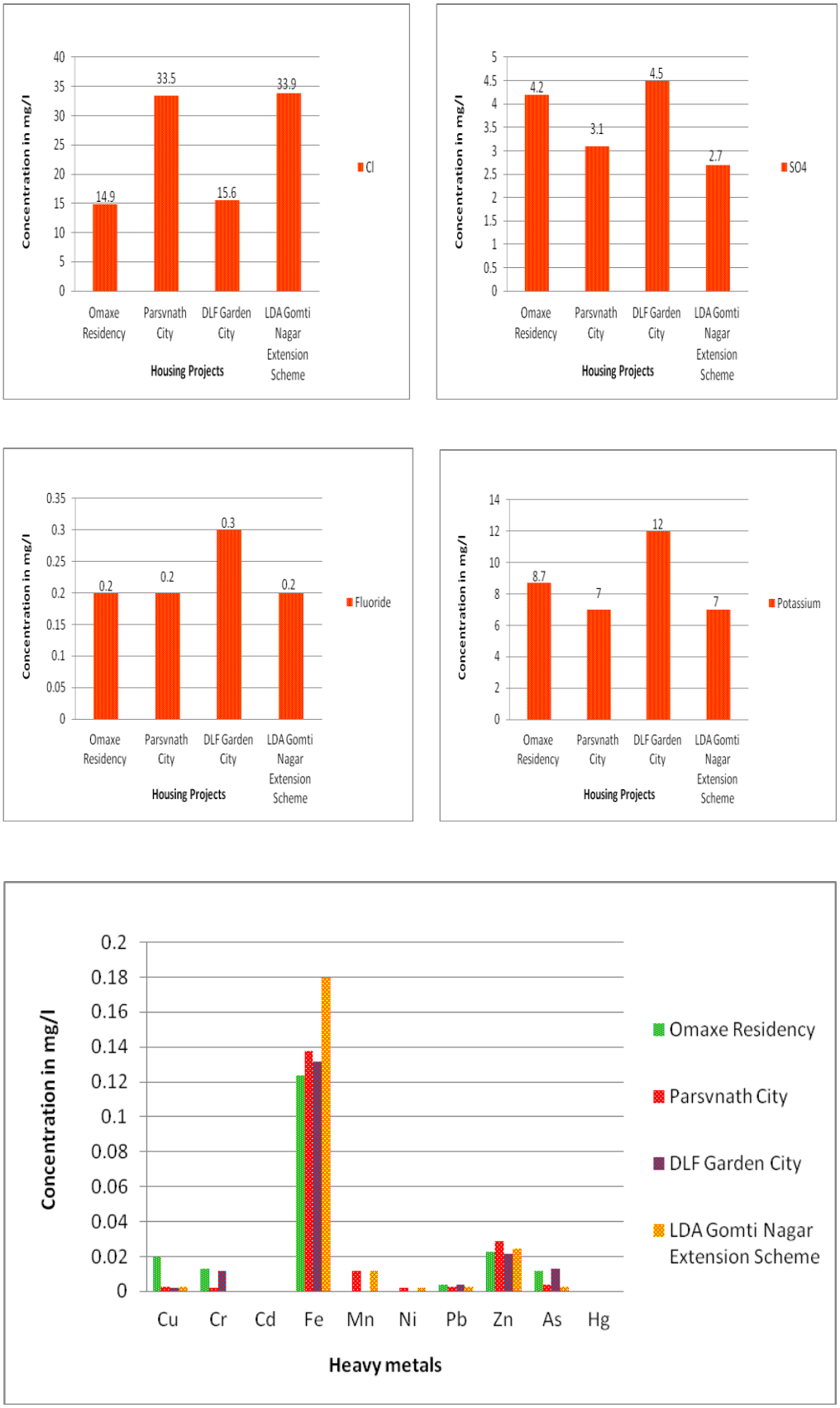


Figure 5.53 Water quality status post-projects

From the above table 5.15 and figure 5.53 following points are concluded:

- LDA Gomti Nagar Extension Scheme shows highest Fe, Zn, Ni and Mn and Omaxe residency shows lowest level of Fe, Zn and Mn.
- Omaxe residency shows highest level Cu, Cr^{+6} and Pb content and LDA Gomti Nagar Extension Scheme shows lowest level of Cu, Cr^{+6} and Pb content.
- DLF Garden City possess high content of arsenic and LDA Gomti Nagar Extension Scheme possess lowest content of arsenic in water.
- LDA Gomti Nagar Extension Scheme and Parsvnath city possess high content of mercury. Similarly, Omaxe residency and DLF Garden City possess low content of mercury.
- With respect to PH it is maximum in Omaxe residency and minimum in DLF Garden city.
- With respect to turbidity it is maximum in DLF Garden city and minimum in Parsvnath city.
- With respect to conductivity it is maximum in Omaxe residency and minimum in LDA Gomti Nagar Extension Scheme.
- With respect to TDS and TSS it is highest in Omaxe residency and lowest in Parsvnath city.
- With respect to dissolved oxygen it is highest in Parsvnath city and lowest in Omaxe residency.
- With respect to hardness it is maximum in DLF Garden City and minimum in Parsvnath city.
- With respect to alkalinity and sulphate it is maximum in DLF Garden City and minimum in LDA Gomti Nagar Extension Scheme.

5.6.5 Flora and Fauna Status: Pre project (baseline environmental status)

Plants/animals and environment are interrelated to each other., with the change in environmental conditions, the vegetation covers as well as animals reflects several change in structure, density and composition. The study was carried out in two separate heading for floral and faunal community respectively. The following table (table 5.16) tells about the different types of flora and fauna that are found in different housing projects in luck now city.

Table 5.16 Flora and fauna

S.NO.	Housing Projects	Floral community	Faunal community
1.	Omaxe Residency	Babool, neem, ashok, ,jamun, ber, amrud, rose, etc	The birds (like Crow, sparrow, bulbul, and pigeon) arthropods (grasshopper, cockroach, housefly, mosquitoes), amphibians(toad and frogs),reptiles (house lizards, cobra, and viper) and among mammals (cat, dog, cow, buffalo, rat etc.) are reported.
2.	Parsvnath City	It includes the species as Acacia catechu, Acacia excels, dalbergia sissoo ,azadirachta indica,ficus infectoria,ficus religiosa etc.	The birds (like pariah kite,white breasted kingfisher, black drongo, myna, little egret,darter, blue jay,hoopoe,green bee eater,red wishkered bulbul,redvented bulbul) arthropods (graashopper, cockroach,housefly,beetles,wasps, dragonfly,mosquitoes), amphibians(toad and frogs),reptiles (house lizards,cobra,and viper) and among mammals (cat,dog,cow,buffalo,rat etc) are reported
3.	DLF Garden City	Babool,neem, imli,kaitha, jamun, ber,amrud,rose,gulmohar.	The birds (like Crow,sparrow,baya) arthropods (graashopper, cockroach,housefly,beetles,wasps,dragonfly,mosquitoes), amphibians(toad and frogs),reptiles (house lizards,cobra,and viper) and among mammals (cat,dog,cow,buffalo,horse rat etc) are reported.
4.	LDA Gomti Nagar Extension Scheme	Khajur,babool, , dhatura, arandi ber,peepal, chilbil,mahua, raunjh etc;among road side teak,eucalyptus sp.,bottle and also some medicinal plants like;amla,ashok, atees,brahmi, chandan,daruhaldi,kutki,giloe, tuli, sarpgandha, ashwagandha, are also found	The birds (like Crow,sparrow,bulbul,myna,wood pecker,blue jay,bays,peafowl and pegion) arthropods (graashopper, cockroach,housefly,beetles,wasps, dragonfly,mosquitoes), amphibians(toad and frogs),reptiles (house lizards,cobra,and viper) and among mammals (cat,dog,cow,buffalo,rat etc) are reported.

Source: *Compliance report of EIA (2006 to 2010) from SPCB Lucknow,Uttar Pradesh*

5.6.6 Socio Economic status of Post project (current environmental status): Since no populations are living in the selected housing projects in the study area so that the Socio Economic status are determined on the basis of the near village of the proposed projests. The details of the Socio Economic status are given in the Table 5.17 which are given below:

Table 5.17 Socio Economic status

S.No	Housing Projects / Parameters	Omaxe Residency (Chiraiyamau Village)	Parsvnth City (Uttardhona Village)	DLF Garden City (Purseni Village)	LDA Gomti Nagar Extension Scheme (Ugarioan Village)
1.	Availability of Water	Available	Available	Available	Available
2.	Quality of Water	Good	Average	Average	Good
3.	Soil Quality	Good	Average	Average	Good
4.	Air Quality	Good	Average	Good	Average
5.	Noise Quality	Average	High	High	High
6.	Types of Waste Generation	Household Waste	Agricultural Waste	Agricultural Waste	Household and Medical Waste
7.	Types of Houses	Semi Pucca	Kuccha	Semi Pucca	Pucca
8.	Availability of Electricity	16 Hours	Above 18 Hours	16 to 18 Hours	Above 20 Hours
9.	Education Status	Average	Average	Average	More than Average
10.	Income Status	Low	Low	Average	More than Average
11.	Traffic Status	Low	Average	Average	Average
12.	Climate Condition	Good	Average	Good	Average
13.	Health Status	Average	Good	Average	Good
14.	Landmark	Amar Shaheed Path	Faizabad Road	SGPGI	Amar Shaheed Path
15.	Medical Facilities	Available	Available	Available	Available

Source: *based on survey carried out during September 2014 to October 2014*

5.7 Effectiveness of EIA system:

There are several ways by which the EIA system can be effective like to be effective, an Environmental Impact Assessment (EIA) system, first, has to minimize the probability that projects with significant environmental effects are implemented without EIA, and second, minimize the number of EIAs, which do not provide decision makers with essential information, so that the decision is improved as a result of EIA. But in this chapter the effectiveness of the EIA system implemented in the housing projects can be determined by two methods viz; Leopold interaction matrix and land use / land cover change detection analysis.

5.7.1 Leopold interaction matrix:

Leopold matrix is a significant methods used in EIA process and provides a format for comprehensive review of the interactions between proposed anthropogenic actions and environmental factors including its characteristics and conditions. It was applied for the evaluation of impacts of housing projects in Lucknow city. . The matrix method developed by Leopold et al., 1971, is an illustration. Leopold interaction matrix is a comprehensive matrix, which had initially 88 environmental characteristics, along the top axis, and 100 project actions in the left hand columns (Leopold *et al.*, 1971). This method is flexible and allows extension of component or characteristics to be affected by the environment. It shows the relations between causes and effects or actions and impacts relationship. It enabled us to make unbiased decision which depends on experience. This method employs the use of scaling to rate environments quality. Possible impacts are marked in the suitable cell and a numerical value can be assigned to indicate their magnitude and significance. Typically the numerical value ranged from 1, for small magnitude, to 10, for large magnitude. The assignment of numerical values is based on an assessment of available facts and data. In the same way, the scale of importance also ranges from 1, for very low interaction, to 10, for very important interaction.

Table 5.18 Type of impacts and their scale of importance and magnitude

Sl. No.	Types of impacts	Scale of magnitude 1-10	Scale of importance 1-10
1.	No impact	1	1
2.	Low impact	2-4	2-4
3.	Medium impact	5-6	5-6
4.	High impact	7-10	7-10

Table 5.19 Air Environment

SL.NO.	Information/checklist confirmation	Omaxe Residency, Gomti Nagar	Parsvanath Developers, Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Garden City, Raibareli Road	Total score of impact	Average of impact
1.	Emissions from combustion of fossil fuels from stationary of mobile sources.	4/6	6/7	9/9	7/8	26/30	6/7.5=6/7
2.	Emission from construction activites including plant & equipment	7/7	5/6	9/8	8/7	29/28	7.2/7=7/7
3.	Dust or odours from handling of materials including construction materials, sewage & waste.	7/7	7/7	8/9	7/8	29/31	7.2/7.7=7/8
	Total score of impact	18/20	18/20	26/26	22/23		
	Average score of impact	6/6.6=6/7	6/7	8.6/8.6=9/9	7.3/7.6=7/8		

Table 5.20 Noise Environment

SLNO.	**Information/checklist confirmation**	**Omaxe Residency, Gomti Nagar**	**Parsvanath Developers, Faizabad Road**	**LDA Gomti Nagar Extension Scheme**	**DLF Garden City Raibareli Road**	**Total score of impact**	**Average score of Impact**
1.	From operation of equipment e.g. engines, ventilation plant, crushers.	7/6	7/7	8/9	8/8	30/30	7.5/7.5

2.	From industrial or similar processes.	1/1	1/1	1/1	1/1	4/4	1/1
3.	From construction or demolition	6/6	7/6	9/9	8/7	30/28	7.5/7
4.	From blasting or pilling	1/1	1/1	1/1	1/1	4/4	1/1
5.	From construction or operational Traffic	5/6	6/7	9/9	7/8	27/30	6.7/7.5
6.	From lighting or cooling system	1/1	1/1	1/1	1/1	4/4	1/1
	Total score of impact	21/21	23/23	29/21	26/26		
	Average score of impact	3.5/3.5	3.8/3.8	4.8/3.5	4.3/4.3		

Table 5.21 Water and Land Environment

SL.NO.	**Information/checklist confirmation**	**Omaxe Residency, Gomti Nagar**	**Parsvanath Developers Faizabad Road**	**LDA Gomti Nagar Extension Scheme**	**DLF Garden City, Raibareli Road**	**Total score of impact**	**Average score of impact**
1.	From handling storage use of hazardous materials	7/6	8/7	9/9	8/9	32/31	8/7.7
2.	From discharge of sewage or other effuents to water or the land	7/7	7/8	9/9	8/8	31/32	8/7.7
3.	By deposition of pollutants emitted to air into the land or into water	6/7	7/8	8/9	8/7	29/31	7.2/7.7
	Total score of impact	20/20	22/23	26/27	24/24		
	Average score of impact	6.6/6.6	7.3/7.6	8.6/9	8/8		

Table 5.22 Environmental Sensitivity

SL.NO.	Information/checklist confirmation	Omaxe Residency, Gomti Nagar	Parsvanath Developers, Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Garden City, Raibareli Road	Total score of impact	Average score of impact approximately
1.	Areas protected under international conventions national or local legislation for their ecological value.	1/1	3/5	1/1	1/1	6/8	4.5/2
2.	Ares which are important or sensitive for ecological reasons wetlands, water courses or other water bodies, coastal zone biosphere, mountains forests	1/5	3/7	6/7	1/1	11/20	1.1/2
3.	Ares used by protected important or sensitive species of flora and fauna for breeding, nesting, foraging, resiling over wintering migration	1/1	1/1	1/1	1/1	4/4	1/1
4.	Inland coastal marine or underground waters	1/1	6/7	1/1	1/3	9/12	2.2/3
5.	State national boundaries	1/1	1/1	1/1	1/1	4/4	1/1
6.	Densely populated area	4/7	4/7	1/3	1/2	10/19	2.5/1.9
7.	Ares occupied by sensitive	4/5	6/8	3/7	3/6	16/26	4/6.5

	man made land uses .						
8.	Ares already; subjected to pollution or environmental damage.	1/1	3/2	1/1	1/1	6/5	1.5/1.2
9.	Areas susceptible to natural hazard which could cause the project to present environmental problems.	1/1	3/2	1/1	1/1	6/5	1.5/1.2
10.	Defence installations.	1/1	1/1	1/1	1/1	4/4	1/1
	Total score of impact	16/27	29/40	17/24	12/18		
	Average score of impact	1.6/2.7	2.9/4	1.7/2.4	1.2/1.8		

Table 5.23 Fauna

SL.NO	**Information/checklist confirmation**	**Omaxe Residency, Gomti Nagar**	**Parsvanath Developers, Faizabad Road**	**LDA Gomti Nagar Extension Scheme**	**DLF Garden City, Raibareli Road**	**Total Score of impact**	**Average score of impact**
1.	Is there likely to be any displacement of fauna-both terrestrial and aquatic or creation of barrier for there movement?	2/6	3/7	5/9	4/8	14/30	3.5/7.5
2.	Are there any direct or indirect impacts on avifauna of the area?	3/6	4/7	6/9	5/8	18/30	4.5/7.5
	Total score of impact	5/12	7/14	11/18	6/16		
	Average score of impact	2.5/6	3.5/7	5.5/9	4.5/8		

Table 5.24 Vegetation

SL.NO.	Information\checklist confirmation	Omaxe Residency, Gomti Nagar	Parsvanth Developers Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Graden City, Raibareli Road	Total score of impact	Average score of impact
1.	Is there any threat to of project to the biodiversity?	2\5	2\6	4\8	3\7	11\26	2.7\6.5
2.	Will the construction involve extensive clearing or modification of vegetation?	2\5	3\6	5\9	4\7	14\27	3.5\6.7
	Total score of impact	4\10	5\12	9\17	7\14		
	Average score	2\5	2.5\6	4.5\8.5	3.5\7		

Table 5.25 Risk Assessment Risk of Accidents during Construction or Operation of Project Which Could Affect Human Health or the Environment

SL.No.	Information\checklist confirmation	Omaxe Residency, Gomti Nagar	Parsvanath Developers, Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Graden City, Raibareli Road	Total score of impact	Average score of impact
1.	From explosions and spillages, fires etc, from storage handling, use of production of hazardous substances From any other causes	4\5	5\6	8\9	7\8	24\28	6\7
2.	From any other causes	1\1	1\1	1\1	1\1	4\4	1\1
3.	Could the projects affected by natural disasters causing, environmental damage e.g; floods, earthquakes, landslides, cloud burst etc.	6\5	6\5	8\7	7\6	27\23	6.7\5.7
	Total score of impact	11\11	12\12	17\17	15\15		
	Average score of impact	3.6\3.6	4\4	5.6\5.6	5\5		

Table 5.26 Production of Solid Waste during Construction or Operation Phase

SL.NO.	Information/checklist confirmation	Omaxe Residency, Gomti Nagar	Parsvanath Developers, Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Garden City Raibareli Road	Total score of impact	Average score of impact
1.	Municipal waste domestic or commercial wastage	4/6	5/7	8/9	6/8	23/30	5.7/7.5
2.	Hazardous wastage	5/7	6/8	7/8	8/9	26/22	6.5/5.5
3.	Other industrial processes wastes	1/1	1/1	1/1	1/1	4/4	1/1
4.	Sewage sludge or other sludge from effluent Treatment	4/6	5/7	8/9	7/8	24/30	6/7.5
5.	Construction of demolition wastes	5/6	6/7	9/9	7/8	27/30	6.7/7.5
	Total score of impact	19/26	23/30	33/36	29/32		
	Average score of impact	3.2/5.2	4.6/6	6.6/7.2	5.8/6.4		

Table 5.27 Socio-Economic Status

SL.No.	Information\checklist confirmation	Omaxe Residency, Gomti Nagar, Lucknow	Parsvanath Developers, Faizabad Road	LDA Gomti Nagar Extension Scheme	DLF Garden City, Raibareli Road	Total score of impact	Average score of impact
1.	Will the proposal results in any change to the demographic structure of local population?	1/5	1/6	1/8	1/7	4/26	1/6.5

2.	Will the project cause adverse effects on local communities, disturbance to sacred sites or other cultural values?	1/1	1/1	2/2	1/1	4/4	1/1
	Total score of impact	2/6	2/7	3/10	2/8		
	Average score of impact	1/3	1/3.5	1.5/5	1/4		

Source: *All these table are taken from FORM-1 A (only for construction projects listed under item 8 of the Schedule of EIA Notification 2006).*

Table 5.28 Overall Results of Four Houshing Projects

SL.NO.	**Information\checklist confirmation**	**Omaxe Residency, Gomti Nagar**	**Parsvanath Developers, Faizabad Road**	**LDA Gomti Nagar Extension Scheme**	**DLF Garden City, Raibareli Road**
1.	Air Environment	6/6.6	6/7	8.6/8.6	7.3/7.6
2.	Noise Environment	3.5/3.5	3.8/3.8	4.8/3.5	4.3/4.3
3.	Water and Land Environment	6.6/6.6	7.3/7.6	8.6/9	8/8
4.	EnironmentalSenstivity	1.6/2.7	2.9/4	1.7/2.4	1.2/1.8
5.	Fauna	2.5/6	3.5/7	5.5/9	4.5/8
6.	Vegetation	2/5	2.5/6	4.5/8.5	3.5/7
7.	Risk Assiessment	3.6/3.6	4/4	5.6/5.6	5/5
8.	Solid Waste Management	3.2/5.2	4.6/6	6.6/7.2	5.8/6.4
9.	Socio-Economic Status	1/3	1/3.5	1.5/5	1/4
	Total	29.9/42.2 =3.2/4.4 =0.72727	32.6/47.9 =3.5/5.2 =0.67308	47.4/56.8 =5.2/6.2 =0.83871	40.6/52.1 =4.4/5.7 =0.77193

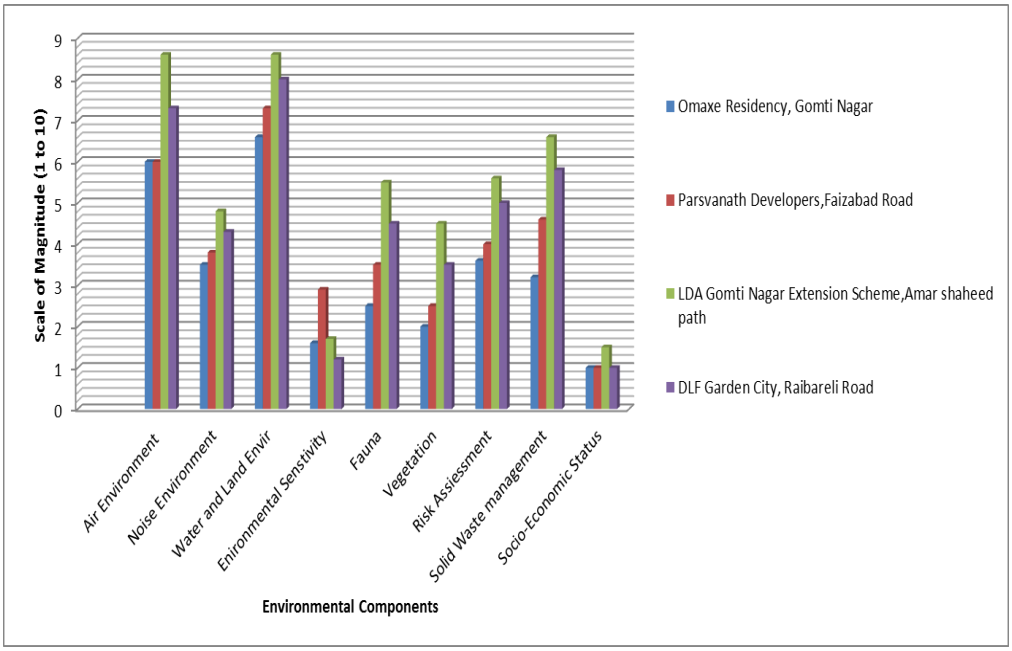


Figure 5.54 Scale of Magnitude for various components for different housing colonies

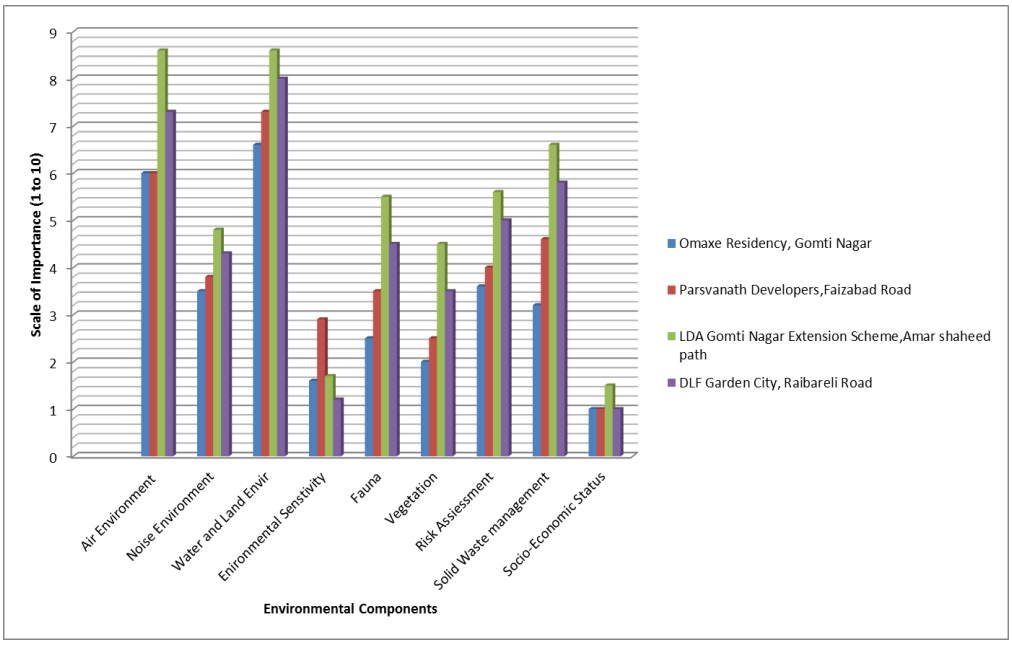


Figure 5.55 Scale of Importance for various components of different housing colonies

- With respect to air quality the magnitude and importance of LDA Gomti Nagar Extension Scheme and DLF Garden City was high whereas Omaxe Residency and Parsvnath City was observed medium. But, in case of noise quality and environmental sensitivity the magnitude and importance of all four housing projects (LDA Gomti Nagar Extension Scheme, Parsvnath City, DLF Garden City and Omaxe Residency) was observed to below:

- With respect to water and land environment magnitude and importance of LDA Gomti Nagar Extension Scheme, Parsvnath City and DLF Garden City was observed to be high except Omaxe Residency whose magnitude and importance have medium impact on environment.
- With respect to fauna the magnitude of LDA Gomti Nagar Extension Scheme was observed to be medium and the magnitude of other three housing projects (Parsvnath City, DLF Garden City and Omaxe Residency) are observed to be low whereas, the importance of LDA Gomti Nagar Extension Scheme, Parsvnath City and DLF Garden city was observed to be high except Omaxe Residency which have medium impact on environment.
- With respect to risk assessment the magnitude and importance of LDA Gomti Nagar Extension Scheme and DLF Garden City was observed medium but Parsvnath City and DLF Garden City having low magnitude.
- With respect to vegetation all four housing projects (LDA Gomti Nagar Extension Scheme, Parsvnath City, DLF Garden City and Omaxe Residency) shows low magnitude whereas the importance of LDA Gomti Nagar Extension Scheme and DLF Garden City was observed to be high in comparision to Parsvnath City and DLF Garden City (medium impact)
- With respect to socio-economic status all four housing projects (LDA Gomti Nagar Extension Scheme, Parsvnath City, DLF Garden City and Omaxe Residency) have low magnitude and but the importance of all the three projects (Parsvnath City, DLF Garden City and Omaxe Residency) are observed to be low except LDA Gomti Nagar Extension Scheme.
- With respect to Solid Waste Management the magnitude of LDA Gomti Nagar Extension Scheme and DLF Garden City was observed medium but the other two projects (Parsvnath City and Omaxe Residency) have low magnitude whereas the importance of Parsvnath City, DLF Garden City and Omaxe Residency was observed to be medium except the LDA Gomti Nagar Extension Scheme which was observed to be high.

NOTE: *On the basis of the Leopold interaction matrix method of table 7.4.3.10 Overall Results of Four Housing Projects of averaged total impact of housing projects on the environmental components which are marked red in the box in order to find out the effectiveness of EIA for housing projects (scaling was again done) in luck now whose ranking are given below in the table 7.4.3.11.*

So, after analysing the Leopold interaction matrix it was found that EIA is highly effective in Parsvnath City (3.5/5.2=0.67308), and moderate effective in DLF Garden

City (4.4/5.7=0.77193) and Omaxe Residency (3.2/4.4=0.72727). Similarly with respect to LDA Gomti Nagar Extension Scheme EIA is low/less effective (4.4/5.7=0.77193)

Table 5.29: Scale of Effectiveness

Sl. No.	Effectiveness	Scale of environmental impact 0 to 1
1.	Neutral	0 to 0.50
2.	High effective	0.51 to 70
3.	Medium effective	0.71 to 80
4.	Low effective	0.81 to 1.0

5.7.2 Land use / land cover change analysis:

Land holds a central position in human existence and development. Since their appearance on earth, humans have used land and its resources to meet their material, social, cultural, and spiritual needs. They have used land for the provision of food, clothing, shelter, and heat; for producing a large variety of goods and services for their own use or market exchange; for moving around and transporting goods; for recreation and leisure; for aesthetic pleasure; for attaining social status and prestige; for spiritual satisfaction; and for claiming territorial sovereignty. Land cover denotes the physical, chemical, or biological categorization of the terrestrial surface, for example, grassland, forest, or concrete, whereas land use refers to purposes associated with that cover—raising cattle, recreation, or urban living. Land use relates to land cover in various ways and affects it with various implications. A single land use may correspond to a single land cover, for instance, pastoralism to unimproved grassland; a single class of cover may support multiple uses (forest used for combinations of timbering, slash-and-burn agriculture, hunting/gathering, fuel-wood collection, recreation, wildlife preservation, and watershed and soil protection); and, a single system of use may involve the maintenance of several distinct covers (as certain farming systems combine cultivated land, woodlots, improved pasture, and settlements).

Land-use and land-cover change is influenced by a variety of biophysical and societal factors operating on several spatial and temporal levels, and acting in intricate webs of place- and time-specific relationships. At the level of the individual land unit, relevant biophysical factors include local climate and weather, topography, bedrock and soil type, surface water, and groundwater. The choice of land use and decisions to change it are influenced by the size of the household, age, gender, education, employment, attitudes, values, and personal traits of household members, site-specific conditions accessibility, *landesque* capital, regional land-use structure as well as by transportation cost, profits, parcel size, competition, costs of production, product prices, public and private financial support, land-management practices, land tenure, and ownership.

The land use and land cover change on the basis of the Google earth images are shown below:

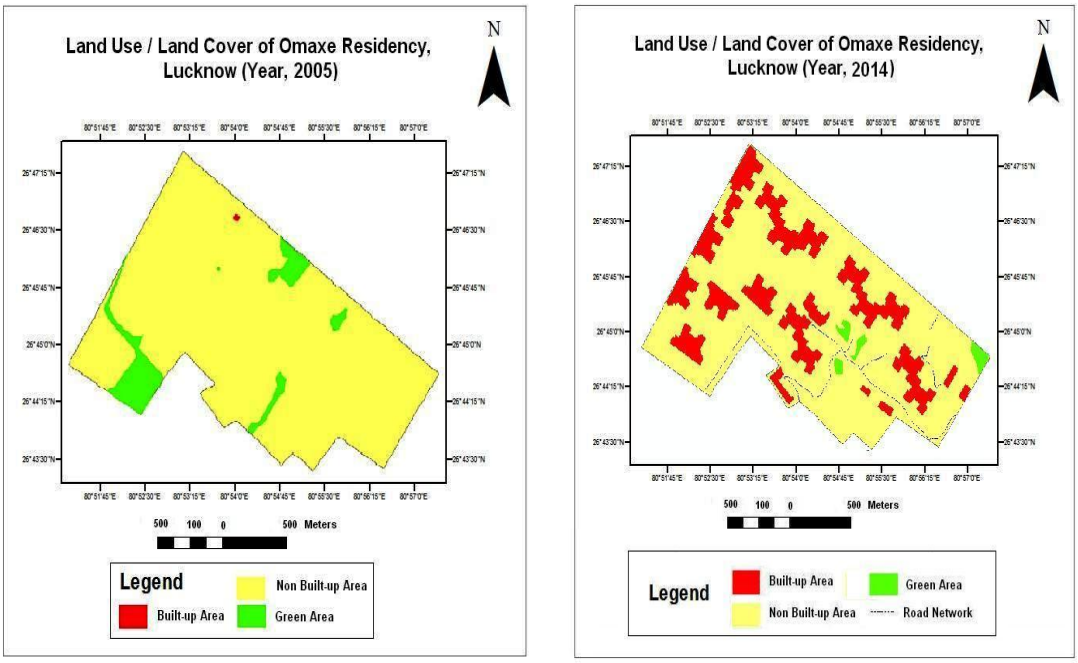


Figure 5.56 Land use map of Omaxe 2005 and land use map of Omaxe 2014

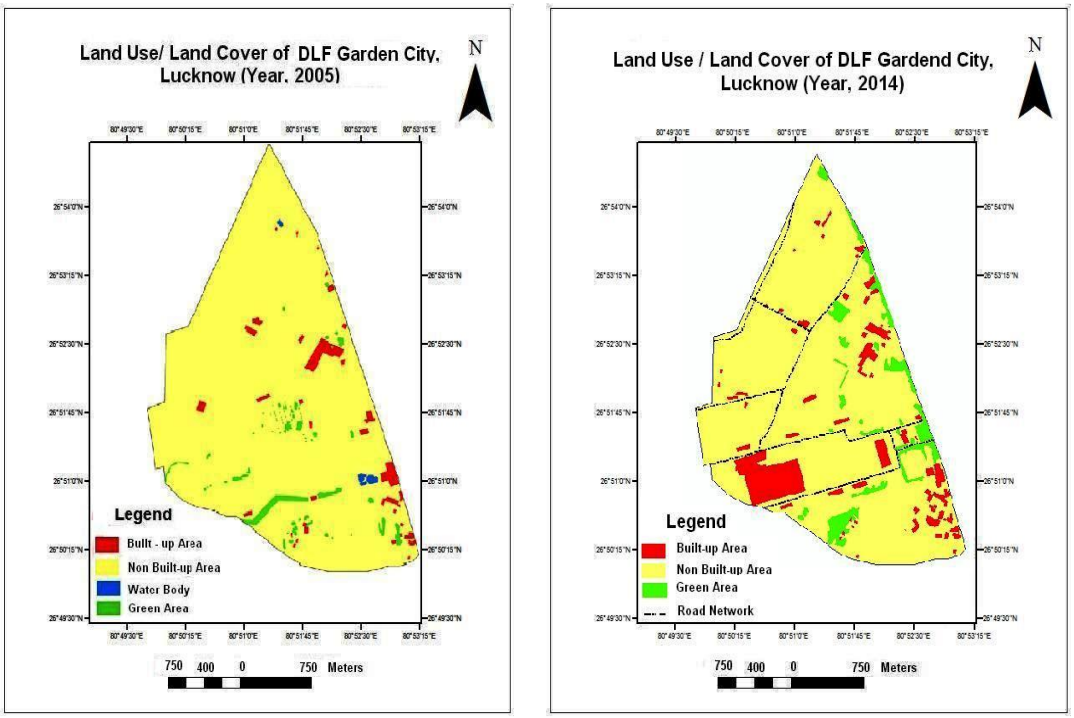


Figure 5.57 Landuse map of DLF 2005 and landuse map of DLF 2014

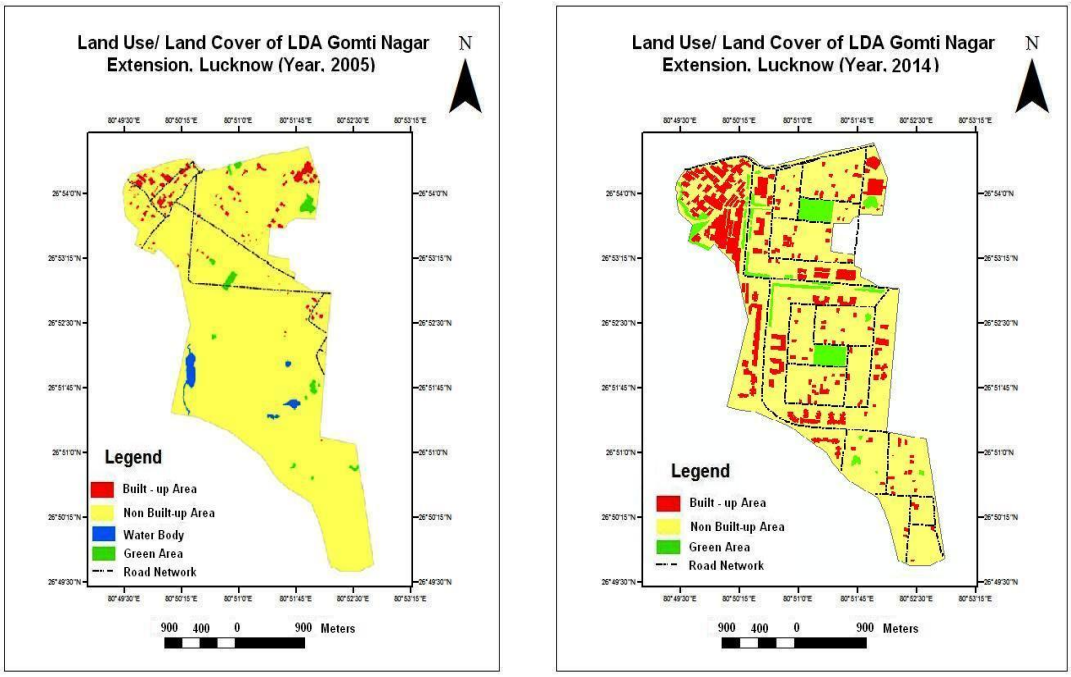


Figure 5.58 Land use map of LDA 2005 and land use map of LDA 2014

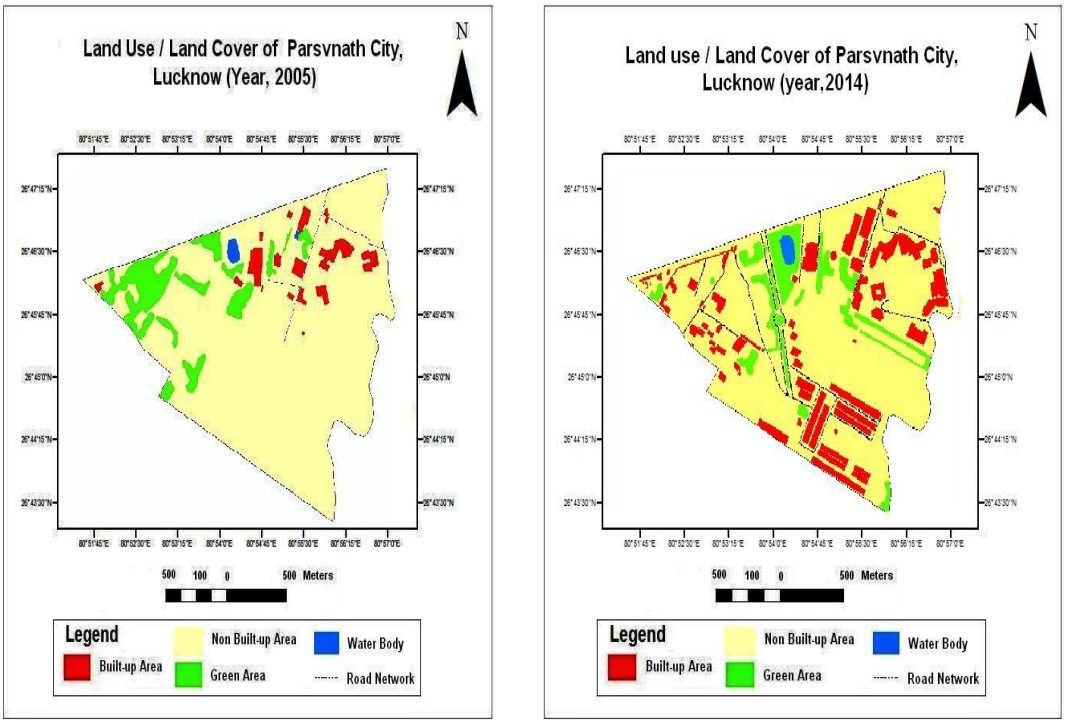


Figure 5.59 Land use map of Parsvnath 2005 and land use map of Parsvnath 2014

On comparative study of the land use/land cover change in omaxe residency it was found that there was no built up area except green area after that there was slightly increase in green area and developments of road network, built up area but no water bodies are found (figure 5.56). With respect to DLF Garden city there is loss of water bodies in 2014 (figure 5.57), increase in road network (but in 2005 according to figure no road network were found),built up area. In parsvnath city (figure 5.58) there was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Similarly with respect to LDA Gomti Nagar Extension (figure 5.59) there was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Overall from the land use/land cover change detection there was increase in built up area,road network and green area.

Land-use and land-cover change are strongly linked; the environmental impacts of land-use change and their contribution to global change occur through physical processes associated with land-cover change. In order to find out the effectiveness it was found the EIA is effective implemented in the selected study area of the housing projects. The effectiveness determination of EIA by the land use/land cover change analysis are given in the table 5.7.2**.**

Table: 5.30 Effectiveness of EIA system on the basis of land use / cover change analysis

S.No.	Housing projects	Built up areas	Non built up areas	Green areas	Water bodies	Road network	Effectiveness
1.	Omaxe Residency	Increased	Decreased	Decreased	No change	Increased	Moderate
2.	Parsvnath City	Increased	Decreased	Increased	Loss (decreased)	Increased	Effective
3.	DLF garden City	Increased	Decreased	No change	Loss (decreased)	Increased	Moderate
4.	LDA Gomti Nagar Extension Scheme	Increased	Decreased	Increased	Loss (decreased)	Increased	Effective

From the table 5.30 it was observed that EIA is effective with respect to LDA Gomti Nagar Extension Scheme and Parsvnath City while it is moderate (neither effective nor non effective) with respect to Garden City and Omaxe Residency.

5.8. Comparative checklists:

Today constructions and development are increasing rapidly which leads to serious global environmental problems. To beat these problems there are several checklists that given by the governments and non government organisatios that any construction projects either have environmental impact or not. So the comparative checklists to identify the nvironmental impact of the different housing projects (study area) are listed below in the table.

Table 5.31 Air environment

S. No.	AIR ENVIRONMENT Information/checklist confirmation	Omaxe residency, ,omti Nagar, Lucknow	Parsvanath Developers, faizabad road Lucknow	LDA gomti Nagar Extension , Lucknow	DLF Garden City, Raibareli Road Lucknow
1	Emissions from combustion of fossil fuels from stationary or mobile sources.	Yes	Yes	Yes	Yes
2	Emission from construction activities including plant & equipment.	Yes	Yes ,.	Yes	Yes
3	Dust or odours from handling of materials including construction materials, sewage & waste.	Yes	Yes.	Yes	Yes

Table 5.32 Water Environment

S. No.	2. WATER AND LAND ENVIRONMENT Information/checklist confirmation	Omaxe residency ,Gomti Nagar, Lucknow	Parsvanath Developers, faizabad road Lucknow	LDA gomti Nagar Extension, lucknow	DLF Garden City, Raibareli Road Lucknow
1	From handling storage use of hazardous materials	NO	Yes	Yes	Yes
2	From discharge of sewage or other effluents to water or the land	Yes	No	No	Yes
3	By deposition of pollutants emitted to air into the land or into water.	No	No .	No	No

Table 5.33 Noise environment

S. No.	**3.NOISE ENVIRONMENT** Information/checklist confirmation	**Omaxe residency ,Gomti Nagar,**	**Parsvanath Developers, faizabad road Lucknow**	**LDA gomti Nagar Extension,luckn**	**DLF Garden City, Raibareli Road Lucknow**
1	From operation of equipment e.g. engines, ventilation plant, crushers.	Yes	Yes.	Yes	Yes
2	From industrial or similar processes.	No	No	No	No
3	From construction or demolition.	Yes	Yes	Yes	Yes
4	From blasting or pilling	No	No	No,	No,
5	From construction or operational traffic	Yes	Yes	Yes	No
6	From lighting or cooling system	Yes ,	Yes	No ,	No

Table 5.34 Environmental sensitivity

S. No.	**4 Environmental sensitivity** Information/checklist confirmation	**Omaxe residency ,Gomti Nagar, Lucknow**	**Parsvanath Developers faizabad road Lucknow**	**LDA gomti Nagar Extension, Lucknow**	**DLF garden ciy raibareli road Lucknow**
1	Areas protected under international conventions national or local legislation for their ecological value .	No	Yes	No	No
2	Areas which are important or sensitive for ecological reasons, wetlands, water courses or other water bodies, coastal zone biosphere biosphere, mountains, forests	Yes	Yes	Yes	No

3	Areas used by protected important or sensitive species of flora and fauna for breeding, nesting, foraging, resiling over wintering migration	No	No	No	No
4	Inland coastal marine or underground waters	No	Yes	No	Yes,
5	State national boundaries	No	No	Yes	No
6	Densely populated area	Yes	Yes	No	No
7	Areas occupied by sensitive man made land uses	Yes	Yes	Yes	Yes

Table 5.35 Risk assessment

S. No.	**5. Risk assessment** Information/checklist confirmation	**Omaxe residency ,Gomti Nagar, Lucknow**	**Parsvanath Developers, faizabad road Lucknow**	**LDA gomti Nagar Extension ,lucknow**	**DLF Garden City, Raibareli Road Lucknow**
1	From explosions and spillages, fires etc, from storage handling, use of production of hazardous substances From any other causes	Yes ,	Yes	No	No
2	From any other causes	No	No	No	No
3	Could the projects affected by natural disasters causing environmental damage (e.g;floods, earthquakes, landslides, cloud brust etc.	Yes	Yes	Yes	Yes

Table 5.36 Solid Waste Management

S. No.	6. SOLID WASTE MANAGEMENT Information/checklist confirmation	Omaxe residency ,Gomti Nagar, Lucknow	Parsvanath Developers, faizabad road Lucknow	LDA gomti Nagar Extension ,lucknow	DLF Garden City, Raibareli Road Lucknow
2	Municipal waste domestic or commercial wastage	Yes	Yes	Yes	Yes
3	Hazardous wastage	Yes	Yes	No	No
4	Sewage sludge or other sludge from effluent Treatment	Yes	No	Yes	Yes
5	Construction or demolition wastes	Yes	Yes	No	Yes

Table 5.37 Natural Resources

S. No.	7. NATURAL RESOURCES Information/checklist confirmation	Omaxe residency ,Gomti Nagar, Lucknow	Parsvanath Developers, faizabad road Lucknow	LDA gomti Nagar Extension ,lucknow	DLF Garden City, Raibareli Road Lucknow
1	Land specially undeveloped or agricultural land	Yes	Yes	No	No
2	Water expected source and competing users unit	Yes	Yes	Yes,	Yes
3	Construction material stone aggregate sand/soil	Yes	Yes	Yes,	Yes
4	Use of forest and timber	Yes	Yes	Yes	Yes
5	Energy including electricity and fuels	Yes	Yes	Yes	Yes

Table 5.38 Vegetation

S. No	**8. VEGETATION** Information/checklist confirmation	**Omaxe residency ,Gomti Nagar, Lucknow**	**Parsvanath Developers, faizabad road Lucknow**	**LDA gomti Nagar Extension lucknow**	**DLF Garden City, Raibareli Road Lucknow**
1.	Is there any threat to of project to the biodiversity?	NO	NO	NO	NO
2.	Will the construction involve extensive clearing or modification of vegetation?	NO	NO	Yes	Yes

Table 5.39 Fauna

Sl.no	**9. FAUNA** **Information/checklist confirmation**	**Omaxe residency ,Gomti Nagar,Lucknow**	**Parsvanath Developers, faizabad road Lucknow**	**LDA gomti Nagar Extension, lucknow**	**DLF Garden City, Raibareli Road Lucknow**
1.	Is there likely to be any displacement of fauna –both terrestrial and aquatic or creation of barrier for there movement?	NO	NO	Yes	Yes
2.	Is there any direct or indirect impacts on avifauna of the area?	NO	NO	Yes	Yes

Table 5.40 Socio-economic status

Sl. no	**10. Socio-economic status** Information/checklist confirmation	**Omaxe residency, Gomti Nagar, Lucknow**	**Parsvanath Developers, faizabad road, lucknow**	**LDA Gomti Nagar Extension, Lucknow**	**DLF Garden city, Lucknow**
1.	Will the proposal results in any change to the demographic structure of local population?	No	No	No	No
2.	Will the project cause adverse effects on local communities,disturbance to sacred sites or other cultural values?	No	No	No.	No

Source: *All these table are taken from FORM-1 A (only for construction projects listed under item 8 of the Schedule of EIA Notification 2006).*

6

SUMMARY AND CONCLUSIONS

In India's growing towns and cities, unplanned sprawled development due to public and private housing projects is leading to use of more resources like land, water, energy etc. which puts enormous pressure on physical infrastructure as well as on environmental quality. There is a need of an integrated approach that could assist housing and settlement planning while preparing the EIA of new and upcoming colonies. Although ElAs can certainly improve housing projects, there are still several limitations to what they can achieve.

The upcoming housing projects in the city of Lucknow during the EIA process state that the projects would contribute to development of green spaces, gardens, constructed wetlands, permeable pavement, and integrated rainwater harvesting systems, however, the situation on the ground depicts a different picture. The review of the EIA of housing projects reveal that some of the newly developed projects are characterized by severe shortage of basic services like potable water, well laid-out drainage system, sewerage network, sanitation facilities, electricity, roads and waste disposal.The land developers tend to be disconnected from the realities of resource limitations and largely inattentive to the long-term environmental impacts of land use modifications. This process will continue with time if not checked through proper intervention and strict planning measures and can adversely impact the quality of life of urban and peri urban dwellers. The research outcome is summarised under the following sections:

6.1 Spatio-temporal patterns of land transformations

Pattern of urban growth in Lucknow city as explored by the study is not linear or nodal. Urbanization seems to spread radially in all the directions and influence of transport infrastructure is minimal. Drivers of such changes are many and very site specific. Some areas have developed out of older city core, but others developed out of new industrial zones. In the latter case, the lack of reliable transport infrastructure has not inhibited the development and nor is the direction of development controlled by presence of transport routes as observed in earlier studies (Taragi, 1997). A large chunk of urban middle class prefer cheap housing in the suburbs even when there is not enough transportation infrastructure. Many people buy land in such areas from investment point of view as they know that land price would go up substantially once the area is earmarked for housing in the future. As a result, peri-urban locations look increasingly investment attractive, which leads to spatial growth of the city.

In the study area two major land use/cover trends between 1997 and 2010 can be discerned: (i) Intensification of urbanization in central/core areas where a few remaining open areas and water bodies were occupied and landfilled to accommodate residential developments; (ii) Urban expansion in peri-urban/ suburban areas, where the extension of urban core increased at the cost of permanent crops and pastures. As is revealed from the statistics, there are four classes displaying significant land

transformation; *Agricultural cropland shows major decrease, urban built-up shows major increase, wasteland shows moderate decrease and area under construction shows significant increase; all other land use classes exhibit relatively insignificant change.*

Peri-urban areas are currently experiencing the most active urbanization. Results indicated that the prominent urban growth in such areas follows two main physical processes:

- Urban growth in three peripheral sites (N, NW and S) is occurring through '*Edge expansion and Envelopment'* i.e., annexation of surrounding landscape through the growth of existing urban areas (Seto & Fragkias, 2005). *Since the study area is primarily dominated by agricultural land, urban growth through 'edge expansion and envelopment' is happening mostly at the expense of such cultivable lands.*

- Urban growth in North Eastern site is occurring through '*Attainment*' – occupation of small built-up clusters (mostly rural) dispersed in landscape by extending urban areas. Attainment seems to be the direct result of improvement in accessibility due to development of transport infrastructure. Rural settlements located amidst predominantly agrarian areas are urbanized when major roads pass through them and the urban development along these routes intensifies to engulf them. Along with the economic development and ensuing urbanization, an impetus on improvement of major transport routes is obvious. Accessibility to the far flung townships and villages have led to development of hitherto underdeveloped areas on fringes of the city, which welcome the conversion of rural land for upcoming industries and educational institutions requiring vast unutilized land resources and spelling major financial gain to marginal farmers.

Furthermore, multi-temporal land use change statistics showed that substantial class I agricultural land was lost by urban growth during 1997 – 2010, with an average annual rate being 13%. The major land use transformations class is – *Rural to Urban* being 41.91% of the total change (Table 6.1). Of importance to the study are *other* categories, specifically the *rural to transitional* and *natural to transitional* which together contribute a fair 16.84% to the LULC change and are placed in the transformation category of *Critical*. This *Critical* category is generally the result of land cover degradation and is prevalent in peri-urban areas on brink of being urbanized. *Although the allocation of land is governed by competition between urban and agricultural uses, the outcome has increasingly tipped in favor of urban use, leading to substantial spatial growth in peri-urban areas.* Also important is the observation of a small but significant amount of change (7.64%) from *transitional to natural* and *transitional to rural*, mostly observed in the study as conversion of wastelands into croplands, which confirms that above reconversion is possible and takes place naturally also, although at much smaller percentage than required.

Table 6.1: Land transformation from 1997 to 2010 at four peri-urban sites showing transformation classes

"From" Class	"To" class	Change (2002-2010)	
		Area	%
Natural	Rural	0.22	*0.63*
	Transitional	1.46	*4.24*
	Urban	1.43	4.16
Rural	Urban	14.46	41.91
	Transitional	4.36	*12.64*
	Natural	0.29	0.84
Transitional	Urban	9.47	27.45
	Natural	1.29	3.74
	Rural	1.35	3.90
Urban	Rural	0.02	0.07
	Transitional	0	0
	Natural	0.14	0.42

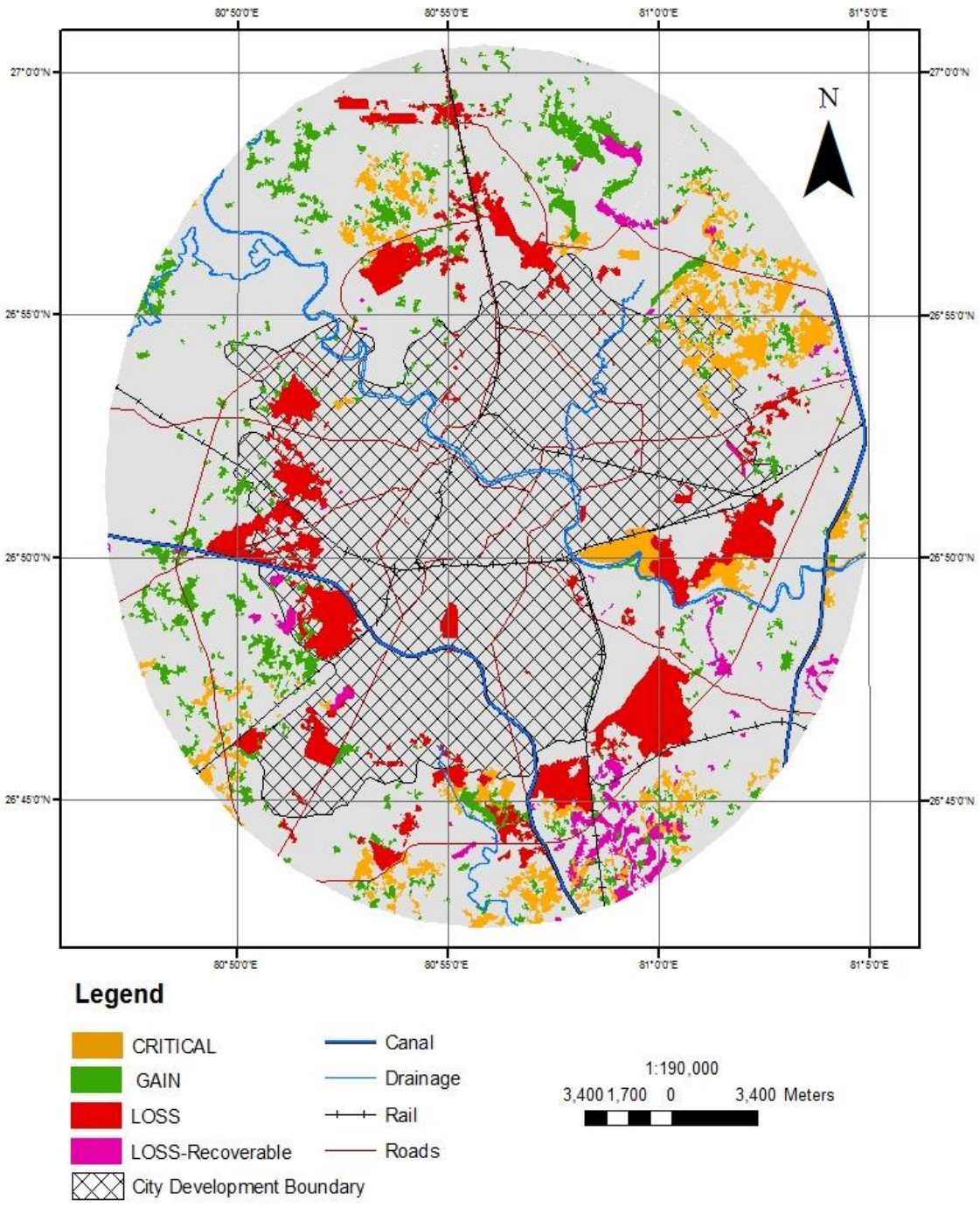


Figure 6.1: Spatial occurrence of land use transformations in the peri-urban areas.

Detailed results from the study reveal that urban land use for all four sites has increased over the study period (year 1997 to 2010) with the largest growth of 17.5 % being observed for Northern site and lowest of 10% for Southern site (Figure 6.2). On an average, more than 70% of the total land use /land cover change has been towards the transformation category of *Loss* towards urban land use, there has been practically negligible amount of *Gain* and an insignificant amount of *Loss-recoverable*. Only the *Critical* class holds some hope especially for Northern and North Eastern sites where more than 20% of the total land use is in *Critical* stage. Also observed is an insignificant for now (0.04%) conversion of forest into urban vegetated wherein *open forest patches on city fringes degrade rapidly as expanding settlement approaches them*. These open forests are soon converted into urban-vegetated class which is vegetation interspersed with urban built-up, feared to be quickly engulfed by densification of the city. Also, 75 % of *Loss-recoverable* category accounts for change of lakes into cropland and horticulture, wherein water bodies have been landfilled and are being used for agriculture or plantations. Loss of water bodies in Southern site is also alarming, making it a fragile area as well. North Eastern area exhibits the change of maximum amount of cropland into transitional category. Site specific observation of *Critical* land transformation category, reveals that at Northern site, *Critical* category is being formed by conversion of four rural land use classes, out of which conversion from cropland is maximum (63%), followed by a substantial 28% being formed by conversion of forest to urban-vegetated. *This observation is alarming, making this site fragile, since presence of forest on a city periphery is already rare and its being lost to urban land use means extensive loss of natural habitation with severe threat to the remaining areas of core natural forest.*

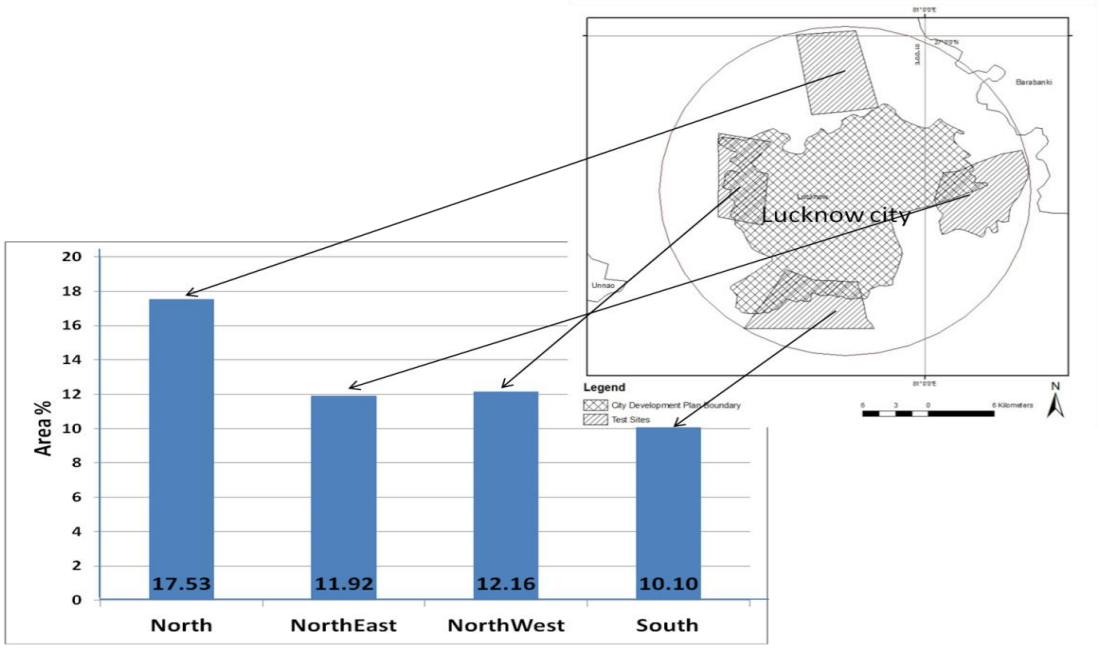


Figure 6.2: Growth rate of urban land use in peri-urban areas between 1997 and 2010

Due to peri-urban land takeover by urban development agency, competition for land between real estate developers and nonurban users, mainly farmers and other agricultural users, have increased tremendously in the last decade. For the city to grow spatially, public and private developers bid away additional land from agricultural users in the peri-urban areas. Increased demand for housing and commercial space means that land is worth more in urban use than in agriculture, thus reflecting greater economic benefits in its developed state. According to *Brueckner* (2000), land conversion in such situations is guided by the 'economist's "invisible hand", which directs resources to their highest and best use'. In this process productive agricultural land is often converted into urban land use. As the value of agriculture output is fully reflected in the amount that agricultural users are willing to pay for the land, a successful bid by public and private developers means that society values the houses and other structures built on the land more than the agriculture output that is forgone.

It is observed that site along the North western direction (enroute to suburban Malihabad town) has experienced maximum amount of relative increase in urban built-up (17.18%), with a simultaneous decrease in rural built-up (4.71%), wherein the latter seems to have merged with extending urban land use. This finding is unexpected, as it was anticipated that this area would experience least urban growth due to its location along state highways, as opposed to location of other sites along national highways and absence of adjacent major industrial town as opposed to North east (adjacent to Barabanki) and South (adjacent to Kanpur). The site also shows a significant decrease in cropland (9.68%) and wasteland (2.82%), indicating the conversion from these classes to urban land use. Surprisingly, this site displays minimum area under construction (3.04%) amongst the study sites; indicating a reduction in rate of future urbanization and pointing towards occurrence of a probable land speculation prevalent in recent past which may have spurred the observed urbanization.

Decrease in cropland area (18.25%) is observed to be maximum in North-eastern site, which falls along the Lucknow-Barabanki national highway. The area is intensely industrialized, with increasing number of unplanned factories/industries. Capacity of existing environmental infrastructure in the area for sewage, industrial and solid waste management is inadequate, spelling serious environmental deterioration. The site displays maximum amount of area under construction (7.72%), a significant increase in urban built-up (11.02%) and fair decrease in cropland. The area also shows a significant amount of area under long fallow (3.15%), indicative of a trend where farmers leave their cultivable land fallow, waiting for urban development opportunities and in event of selling their land towards urban development, gain compensation used to develop farmlands further from city. For these farmers, the uncertainty of when exactly the land might be taken over by urban structures is too great to make it worthwhile continuing with serious, intensive agricultural production. This explains the widespread abandoned fallow or unutilized land found around many expanding cities (Van den Berg *et al.*, 2003).

Southern site, falling on Lucknow-Kanpur route, displays a marked decrease in wasteland (5.59%) and cropland (8.08%), with a simultaneous increase in area under construction (7.51%) indicating an increased rate of future urbanization. A careful observation of initial (1997) and final (2009) images of the site, reveals that most of the defined wastelands are being used for real-estate development. *Southern site alone shows a decrease in water bodies, owing to the fact that this area was marked by presence of numerous big and small water bodies in past, which have been transformed to agricultural uses or land filled for real estate development.*

Northern test site displays significant decrease in most rural land use classes; Cropland (12.50%), Wasteland (2.07%) and Open Forest (1.28%) with a simultaneous increase in urban built-up (9.17%) which is understandably due to urbanization (Figure 6.4). *The transformation class of area under construction (5.21%) also shows significant increase indicating a continuous urbanization in future.*

As the city's population expands, it must grow spatially to accommodate more people. In addition, people's rising incomes and quality of life concerns affect urban growth because residents demand better housing conditions and more living space as they become richer over time. The greater demand for space causes the city to expand spatially as the population increase. This effect is further reinforced by the 'urban-social-aspirations' to expand and buy additional lands for their housing needs in a location where land price is cheap, mainly the peri-urban areas. Therefore, the spatial expansion due to rising incomes and quality of life concerns among the residents is strengthened by a price incentive favoring urbanization along the city's periphery.

6.2 Land capability and urban suitability

Poorly regulated land governance has led to unscientific urban expansions that do not conform well to the land suitability and carrying capacity of the city. Industrial areas are being built upon environmentally sensitive area; some residential areas have also encroached upon lakes and ponds and new residential areas lack open space and greenbelts. Existing infrastructure has not been integrated in the design of the layout, for eg: there is absence of logistic zones, sidewalks, bicycle lanes, parking lots, and so on. Majority of area (around 77%) in the peri-urban interface has weak or very weak suitability for future urban development primarily because of the high conservation and agriculture suitability and incompatibility of physical land use to enabling infrastructure (Figure 6.3 and Figure 6.4).

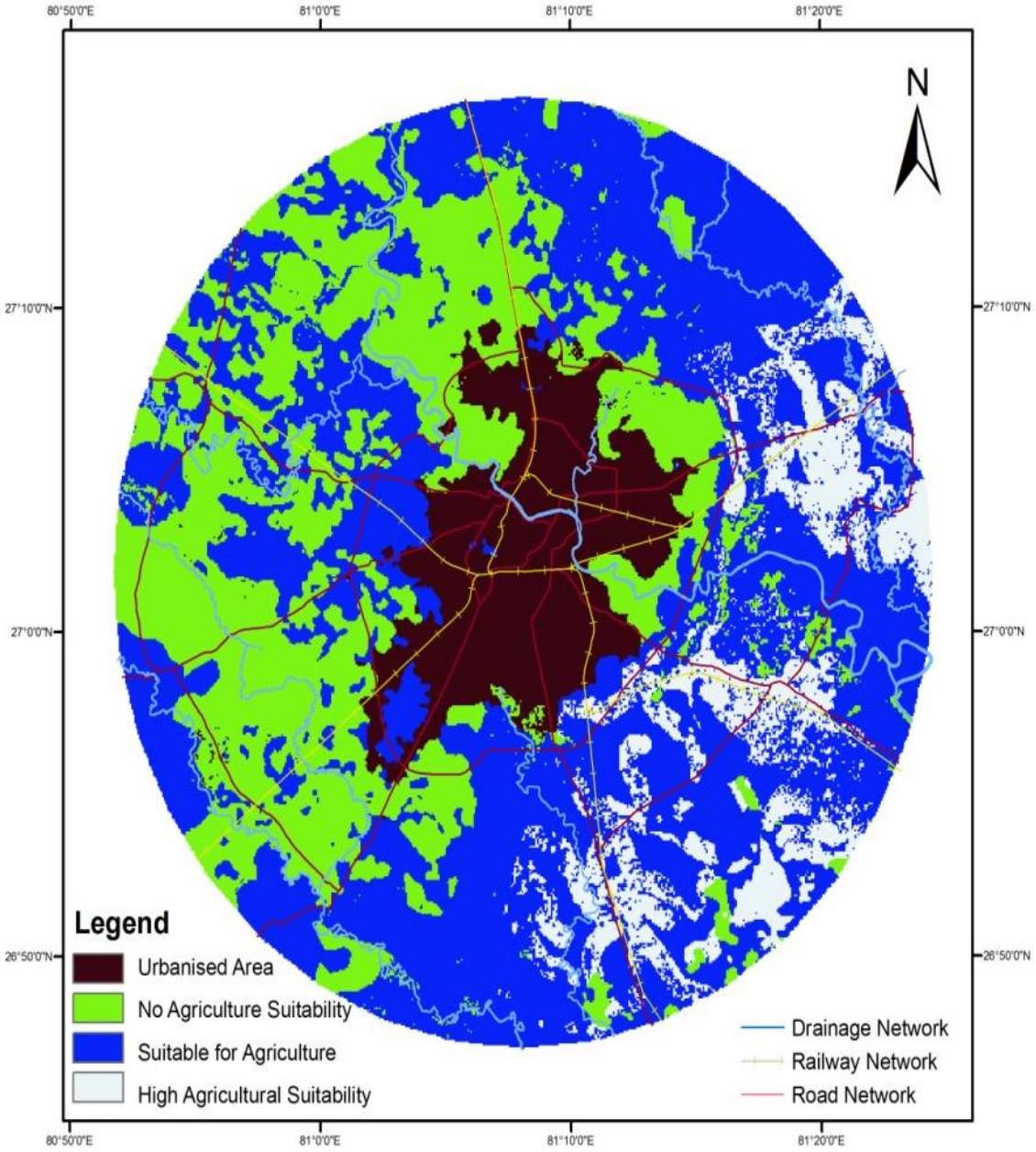


Figure 6.3: Agricultural suitability based upon Weighted Linear Combination of multiple criteria

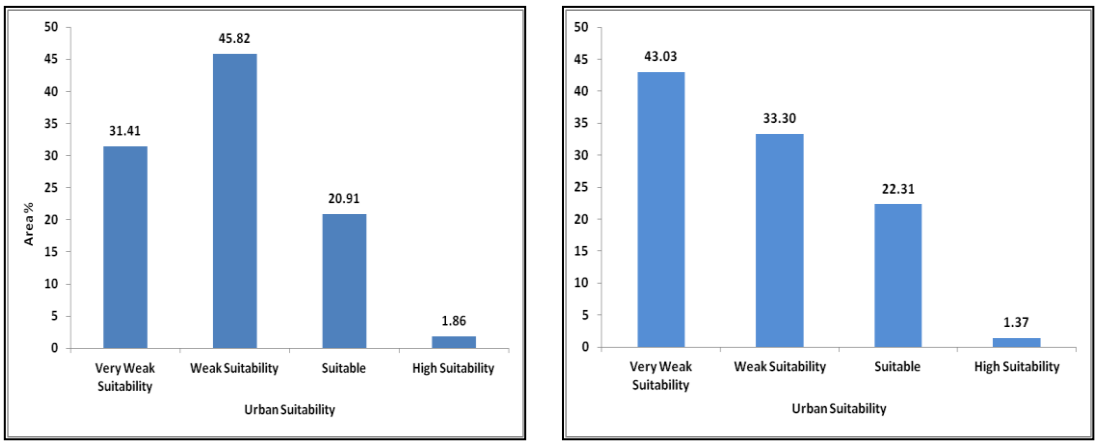


Figure 6.4: Area statistics for urban suitability using (a) traditional AHP method, and (b) Fuzzy AHP method

6.3 Land use conflicts

Patterns of urban growth do not follow Master Plan 2021 and even Master Plan deviate profoundly from the preferred land suitability. As per the land use statistics of 2010, high value class I agriculture land and horticulture fields constitute 57% and 15% of the area respectively. Therefore, converting them to urban land use will affect future food sustainability. Around 20% of the area, i.e. 500 sq. km. has moderate suitability whereas about 2% (50 sq. km.) of the area has high suitability for urban development. Since out of the 2500 sq. km, about 303 sq. km. has already been under active urban land use including the denser urban core, any future urban land transformation should be done very carefully taking into account the zoning regulations and importance of open space, greenbelt and class I agriculture land. It is also evident from the conflict analysis that the Master Plan 2021 is conflicting from the zoning restrictions recommended by the urban suitability analysis; the restricted/conserved areas recommended by the study are certainly in conflict with the planned future development. Of the total area of the conserved, greenbelt, reserved forests and floodplain as per the defined land suitability class, 4.18% of the area has been converted into existing built-up/settlements whereas 46.36% of the total area is proposed under residential settlements, business districts and commercial land use under the Master Plan 2021, 11.84% under transportation network and 5.11% under agriculture (Figure 6.5). Therefore, with the process of urban sprawl in the core and at the peri-urban interface, conserved area such as greenbelt, reserved forests and floodplains are threatened and will be rendered fragile.

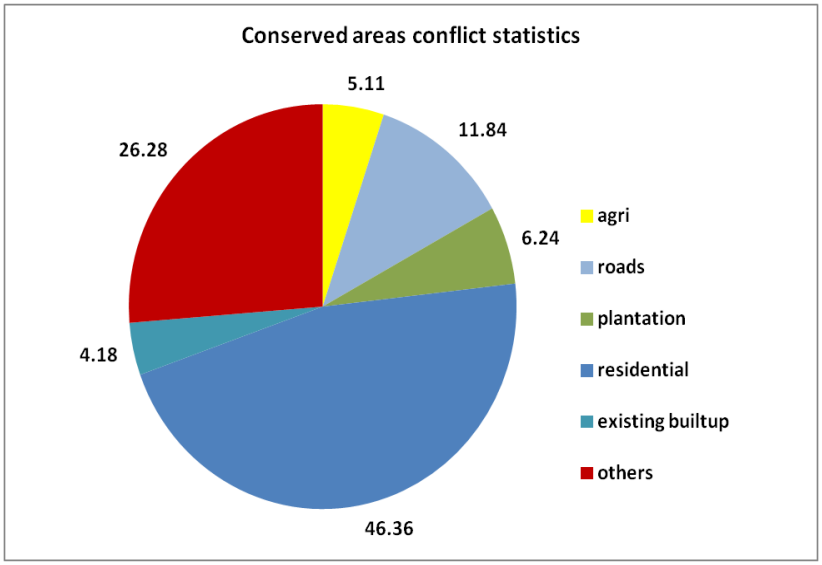


Figure 6.5: Conserved areas conflict statistics with respect to the Master Plan 2021

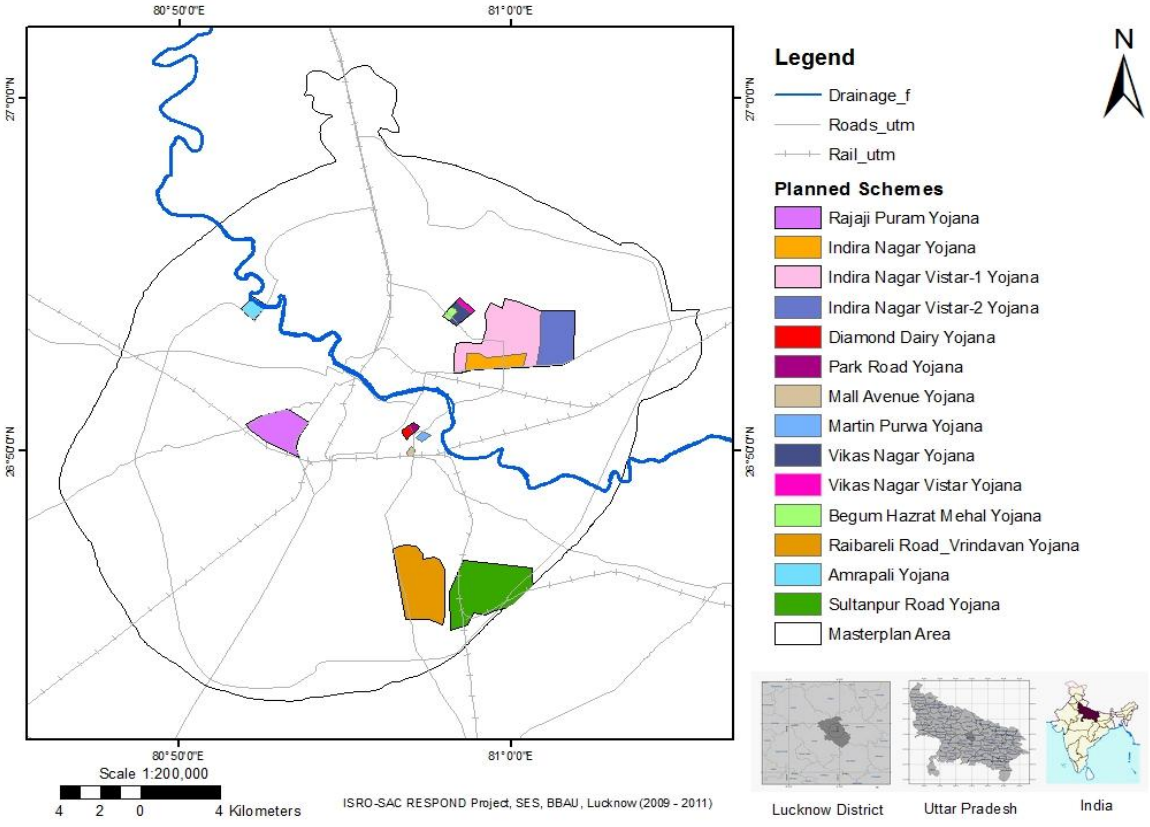


Figure 6.6: New housing schemes as planned by Avas-Vikas (Uttar Pradesh Housing Development Board) under their Master Plan 2021

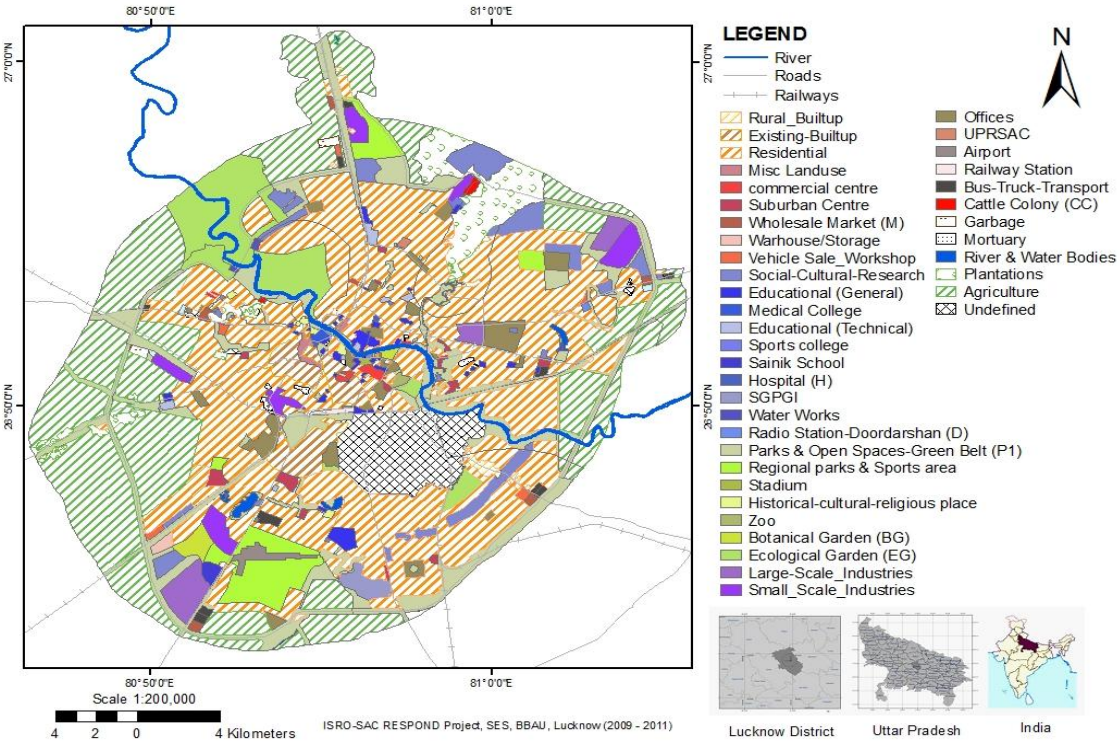


Figure 6.7: Map showing the proposed Lucknow's city Master Plan 2021

Master Plans concentrate on planning land use in isolation from other critical infrastructure and resource constraints such as water and sewerage facilities and transport network. They are not followed by local area plans and investment decisions, strategies are often inconsistent with city's spatial structure. Urban renewable schemes such as Jawaharlal Nehru National Urban Renewable Mission (JNNURM) and Rajiv Avas Yojna (RAY) are implemented as isolated projects removed from the regional policies, land use plans and their growth dynamics. Peri-urban land conversion is guided by the market's invisible hand and 'agglomeration economies' which directs resources to their highest market price ignoring the long-term environmental impacts. Multiple jurisdictions with multiple plans by the land authorities, each independent of the other, also result in fragmented development across commercial and residential areas at the micro level. Land agencies (LDA: Lucknow Development Authority and UPHDB: Uttar Pradesh Housing Development Board) do not coordinate regarding subdivision regulations creating fragmented discontinuous urban areas.

6.4: Policy implications of the study

Urban transition is a major challenge in growing cities of the developing world. Disorderly urban sprawl creates war on cities' dream to become engines of growth and threatens the future growth and vibrancy of cities' economy. Urbanization in the Indian context should be looked at beyond mega-cities like Mumbai and Delhi with a holistic view to include second-tier towns and medium size agglomerations such as Lucknow which has not been studied in detail. This paper quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the

core and along the city periphery of Lucknow city, the capital of India's largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models. The methodology provides a cost effective rapid land evaluation framework which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth.

It is observed that due to rapid economic development, the city has expanded in size and structure, becoming increasingly more complex, heterogeneous and irregular in shape. Development has been muddled in peri-urban areas, causing natural and rural land cover to degrade over time and the trend suggests more such degradation in coming years. The land developers tend to be disconnected from the realities of resource limitations and largely inattentive to the long-term impacts of land use modifications. Natural land covers like forest and water bodies are experiencing major deterioration rendering some of the PUI sites as fragile. Each of these impacts is linked to changes in the extent of urban, agricultural, and forest lands, and (or) transportation, housing and other critical infrastructure systems. This process will continue with time if not checked through proper intervention and strict planning measures and can adversely impact the quality of life of urban and peri-urban dwellers.

Although urban sprawl cannot be stopped in a rapidly developing city, a remedy for this problem lies in strict zoning regulations based on land suitability and carrying capacity, which allow land use to be channeled toward more sustainable outcomes. Detailed observations of transformation category statistics reveal that although the pace of urbanization will grow up in the future, a significant amount of recoverable land cover presently under transformation (denoted by Critical class) can be restored and focus of development can be shifted on underutilized areas within the city development boundary. It is also suggested that older urban areas with dense horizontal urbanization can be considered for urban redevelopment using vertical urbanization methods. Primarily, unplanned and unfocussed urbanization, not considering the suitability of land cover or its environmental impacts/aesthetics should be discouraged in order to promote healthy and livable cities. Results from urban growth models can be used by land use planners and policy makers to anticipate and plan for future spatial expansion to ensure growth along the lines of city development plans and enabling infrastructure.

India's mainstream policy and planning for housing growth has been shaped to a great extent by its EIA guidelines. Mehta and Karpouzoglou (2015) note that the mainstream policy and planning for urban growth has negative implications for important natural resources like water for peri-urban areas.

It is understood that rapid, unplanned and uncontrolled urbanization is leading to disorganized growth in developing countries (Amin and Fazal, 2015). The patterns of development resulting from new urban forms are also altering natural landscapes

and their dynamics in the peri-urban areas (Dutta, 2012). Unplanned urban growth is resulting in reduction in the productivity of the land and in the provision of ecosystem services (Malmir et al., 2015; Ceccarelli et al., 2015). This has necessitated understanding of spatial patterns of urbanization and their relation to post-project conflicts arising from new urban landscape. Evolution of urban land density is also a subject of great interests among researchers; however, the methodologies are arbitrary and suffer from the lack of an established foundation (Jiao, 2015; Dutta, 2012). Keeping this reality in the background, the objective of the study is to review the effectiveness of EIA systems implemented in housing projects in Lucknow city through conflict analysis based on post-project monitoring using Fuzzy AHP models and GIS. The outcome of the study would be of great importance for urban planning and decision-making communities of the city in the present and future.

Land use and land cover changes are so pervasive that, when aggregated they define the character of a city. They also define how major infrastructure such as transport, housing, commercial and market places, greenbelt etc will function in the future (Ding *et al.,* 1999). Urbanization becomes synonymous with frequent land use changes that have often negative impacts on the environment. Poorly regulated land governance which is rooted in inefficient intuitional regime leads to often unscientific urban development that do not conform well with the land suitability and carrying capacity of the region. This leads to complex policy challenges faced by planners and policymakers. Land development authorities almost always regulate land and sometimes directly provide settlement support after developing an otherwise non-urban land uses. This can also create externalities as land development agencies in the past have often neglected enabling resources and overall carrying capacity of a region in developing master plans for future growth (Frenkel & Ashkenazi, 2008).

Any future urban land transformation should be supported by a coherent urban planning policy recognizing zoning regulations and importance of open space, greenbelt, water bodies and class 1 agriculture land. Decisions made now will have a major impact on the enabling infrastructure and civic amenities. Unless more aggressive measures are taken, cities' future will be locked for decades to come. Negative externalities in terms of traffic congestion, parking, pollution, water supply and sanitation problems, solid waste disposal and lack of open space will emerge. This will also make conserved areas such as greenbelt, open spaces and floodplains fragile in times to come. Further research is required to delineate a suitable zoning development management plan to sustain a baseline for urban growth keeping in mind the carrying capacity of the city and its peri-urban areas. Furthermore, the integration of a zoning approach associated with the green belt is suggested to play a key role in a transition to continued urbanization. The research outcome would assist planners and land developers to evaluate whether development goals are in agreement with the intended land use objectives and if yes, how the resources should best be used to optimize city's enabling infrastructure and carrying capacity.

6.4.1 EIA in housing projects

EIA certainly has a crucial role to play in addressing environmental issues surrounding project development. Most EIA processes are based on wrong assumptions and/or unclearly defined concepts, such as 'significant impacts'. There are also intractable logistical problems and challenges related to availability of resources and the necessary EIA capacities. The objective of EIA procedures, as opposed to the subjective ones that are prevalent currently, is recommended as the required first step towards addressing the challenges of EIAs. Other recommendations include making proper human resource planning and utilisation; building relevant capacity; modernizing and developing new tools and technologies; increasing budgetary allocation to the EIA function; undertaking to educate politicians and other stakeholders about the sanctity of the EIA business; communicating effectively about the EIA processes; providing the necessary political will to make the EIA administration function effectively and in a more transparent manner; and increasing investment in EIA research.

*6.*4.2 Assessment of Baseline (Pre-project) and Current (Post-project) environmental status

The comparative study shows the ground reality of various parameters in the selected housing projects. The housing project should have rainwater harvesting system, proper parking facilities, and adequate green area and contain the plants/trees that absorb the high level sound/noise, wastewater treatment facility and sound waste management facility.

The upcoming projects in the city of Lucknow can no doubt add to new housing areas with green spaces, gardens, constructed wetlands, permeable pavement, and integrated rainwater harvesting systems, but the situation on the ground depicts a different picture. The review of the EIA of housing projects reveal that some of the newly developed projects are characterized by severe shortage of basic services like potable water, well laid-out drainage system, sewerage network, sanitation facilities, electricity, roads and waste disposal. These in turn result in to numerous environmental and health impacts that must be addressed. The green cover and water bodies have been destroyed to give way to the rapidly developing urban settlements at the outskirts. Urban green infrastructure comprise of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales. The burden of resource use in upcoming buildings or urban housing projects can be minimized in many ways. Properly designed housing projects can provide numerous services such as purification of air and water, pollution control, mitigation of floods and droughts, re-generation of soil fertility, moderation of temperature extremes, climate change mitigation and enhancing the landscape quality.

On comparative study of ***Air Quality*** of baseline data **(Pre project)** it was found that LDA Gomti Nagar Extension Scheme possess high PM_{10} and SO_X and parsvnath city possess low PM_{10} and $SO_{X.}$ Similarly, with respect to $PM_{2.5}$ and No_X

LDA Gomti Nagar Extension Scheme possess high $PM_{2.5}$ and No_X and parsvnath city possess low $PM_{2.5}$ and NO_X. . In comparision to current environmental data **(Post project)** was found to be high with respect to $PM_{10,}$ PM $_{2.5,}$ and NOx except SOx.

On comparative study of ***Water Quality*** of baseline data **(Pre project)** it was found that all four test sites of Lucknow city indicates poor quality of ground water this is due to lack of EIA policy implementation in all these test sites.

On comparative study of ***Water Quality*** of Current **(Post project)** environmental status it was found that all four test sites of Lucknow city shows neither good nor bad quality of Ground water and used for drinking as well as other domestic purposes. Similarly if EIA policy is strictly implemented in all these sites then in future we can maintain the ground water table otherwise we will face water crisis problems in future.

The baseline data of ***Noise Quality*** of **(Pre project)** was found that DLF garden city (shows high noise level) and LDA Gomti Nagar Extension Scheme (possess low noise level) during day and night time. This is so because the area is lying near the Amar shaheed path, sultanpur road and faizabad road.it is also a poss and crowded area. Similarly The noise level recorded in 2014 after monsoon period **(Post project)** in the study area from the graph shows that LDA Gomti Nagar Extension have high level of noise and Omaxe Residency have low level of noise quality among all the housing projects of the study area during day time while during night time DLF Garden city posses low level of noise generation and LDA Gomti Nagar Extension have high level of noise.

With respect to ***Soil Quality*** of baseline data **(Pre project)** it was found that PH, Conductivity, and available phosphorous was high in DLF garden city as compared to LDA Gomti Nagar Extension Scheme. Similarly, the bulk density, available Nitrogen and Potassium was found to be high in LDA Gomti Nagar Extension Scheme as compared to DLF garden city and also, ***Soil Quality*** of current data **(Post project)** indicates that moisture content, available phosphorous, with respect to the DLF garden city was maximum and lowest in parsvnath city. Similarly, PH, bulk density was found to be maximum in Omaxe Residency and lowest in LDA Gomti Nagar Extension Scheme. The content of zince was maximum in Omaxe residency and lowest in Parsvnath city. Also, the available Nitrogen was high in DLF garden city and minimum in LDA Gomti Nagar Extension Scheme. The electrical conductivity was found to be high in DLF garden city and minimum in Omaxe residency. The quantity of Fe and Pb was costent. The available sodium was maximum in LDA Gomti Nagar Extension Scheme but minimum in parsvnath city

On comparative study of the land use/land cover change in omaxe residency it was found that there was no built up area except green area after that there was slightly increase in green area and developments of road network, built up area but no water bodies are found (figure 5.56). With respect to DLF Garden city there is loss of water bodies in 2014 (figure 5.57), increase in road network (but in 2005 according to figure no road network were found),built up area. In parsvnath city (figure 5.58) there

was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Similarly with respect to LDA Gomti Nagar Extension (figure 5.59) there was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Overall from the land use/land cover change detection there was increase in built up area,road network and green area.There was no loss of water body and too much growth was observed with respect to built up area, road network and green area. Overall from the land use/land cover change detection there was increase in built up area,road network and green area.

It was observed that building bye-laws relating to the provisions of vacant areas/spaces as outlined in clause 1.3 of the building bye-laws, 2008 of UP were not adhered to. There is also non-compliance to the norm of open spaces, as the space for parks and recreational areas are limited. As per the government order in November 1999, regarding model costing plan for housing development by the land development authorities and housing boards, cost would include external development including construction of STPs and garbage disposal places. Garbage generated by these colonies is collected by private and informal groups, who ultimately dispose them in open and vacant land due to the absence of any landfills. Similarly LDA has not developed common rain water harvesting (RWH) system which is required for plots of less than 300 square meter area.

6.4.3 Effectiveness of EIA system: The effectiveness of EIA system implemented in the housing projects which was determined by the methods like Leopold matrix, land use / land cover change detection and conflict analysis.

The effectiveness can be checked by the use of Leopold matrix which is a significant method used in EIA process and provides a format for comprehensive review of the interactions between proposed anthropogenic actions and environmental factors including its characteristics and conditions. It was applied for the evaluation of impacts of housing projects in Lucknow city. The conclusions drawn from the evaluation of impacts is magnitude of LDA Gomti Nagar Extension Scheme and DLF garden city was observed medium whereas the other three housing projects have low magnitude. Similarly, the importance of all the three housing projects was observd to be medium except Omaxe Residency.

So, after analysing the Leopold interaction matrix it was found that EIA is highly effective in Parsvnath City (3.5/5.2=0.67308), and moderately effective in DLF Garden City (4.4/5.7=0.77193) and Omaxe Residency (3.2/4.4=0.72727). Similarly with respect to LDA Gomti Nagar Extension Scheme EIA is low/less effective (4.4/5.7=0.77193). The site visits also revealed that actual plantation in the parks do not match with the plan as per the environmental clearance report and the schedule of the compliance criteria. Some of the housing projects began their construction activities before getting their prior stipulated environmental clearance.

The effectiveness of EIA was also achieved by the land use / land cover change detection. Also, analysis on the basis of land use and land cover change

detection with the help of GIS and Remote Sensing from the year 2005 and 2014 it is concluded that Road network and Built up areas of the housing projects are increased. Similarly in case of Non built up areas are decreased and water bodies are lost in LDA Gomti Nagar Extension Scheme, Parsvnath City, DLF Garden City except in Omaxe Residency. Where as in the same way in case of Green areas shows increase graph in LDA Gomti Nagar Extension Scheme and Parsvnath City. Similarly with respect to Omaxe Residency green areas are decreased and in DLF garden City the green area shows no change. *The conclusion drawn with respect to Built up areas, green area and road network EIA is effective while in case of Non built up areas and water bodies, EIA is not effective. Overall EIA is effective with respect to LDA Gomti Nagar Extension Scheme and Parsvnath City while it is moderate (neither effective nor non effective) with respect to Garden City and Omaxe Residency.*

6.4.4 Effectiveness of zoning approach in EIA of housing colonies: Although urban sprawl cannot be stopped in a rapidly developing city, a remedy for this problem lies in strict zoning regulations based on land suitability and carrying capacity, which allow land use to be channelled toward more sustainable outcomes.

It is also suggested that older urban areas with dense horizontal urbanization can be considered for urban redevelopment using vertical urbanization methods. Primarily, unplanned and unfocussed urbanization, not considering the suitability of land cover or its environmental impacts/aesthetics should be discouraged in order to promote healthy and livable cities. Results from urban growth models can be used by land use planners and policy makers to anticipate and plan for future spatial expansion to ensure growth along the lines of city development plans and enabling infrastructure.

Land development authorities almost always regulate land and sometimes directly provide settlement support after developing an otherwise non-urban land uses. This can also create externalities as land development agencies in the past have often neglected enabling resources and overall carrying capacity of a region in developing master plans for future growth. Any future urban land transformation should be supported by a coherent urban planning policy recognizing zoning regulations and importance of open space, greenbelt, water bodies and class 1 agriculture land.

Further research is required to delineate a suitable zoning development management plan to sustain a baseline for urban growth keeping in mind the carrying capacity of the city and its peri-urban areas. Furthermore, the integration of a zoning approach associated with the green belt is suggested to play a key role in a transition to continued urbanization.

7 SCOPE FOR THE FURTHER RESEARCH

The outcome of this study revealed that EIA regulations were not adequately implemented in housing projects and there are conflicts with respect to post-project compliances. The study further revealed that zoning regulations and land-use suitability are not well considered in deciding siting for new housing projects. This land suitability addresses the question of how location and morpho-land use influences overall environmental impacts. The morpho-land use and location of settlements are considered one of the key determinants of the patterns of settlements and resource consumption, and their associated environmental load in future. The resulted analysis of land capability for spatial development in Lucknow city identifies the key factors affecting the future urban spatial development which will aid in appropriate planning and development strategies.

Poor execution of Master Plans and land use plans has been the key issue which is largely due to lack of political will and vested interests of land markets. Currently Master Plans are available for about 1500 towns out of more than 5000 urban centers, many of which are outdated and have not been reviewed. There is also very little integration between Master Plan, Regional Plan and City Development Plan (CDP) which creates problems in planning for new housing projects or new sub-urban settlements. Lack of proper impact assessment and regional planning norms is resulting in rural-urban divide rather than creating a continuum of urban development.

Spatial environmental planning framework for new housing projects and urban extension in India is still weak. There is no agency accountable to local authorities to monitor post-project compliance of EIA studies of housing projects. Planning and land development does not necessarily follow impact assessment or vulnerability assessment/screening in the first phase. The present research has identified following areas where future research should be focused:

(i) There is a need for a detailed study on why post-project compliances are not met, what are the factors responsible for failure of compliances and how they can be effectively designed in the EIA studies. Better understanding of the overall dynamics and linkages of environmental parameters and their relative importance within and among housing and infrastructure projects can result in better EIA of new settlements.

(ii) The EIA studies should also cover cumulative impacts outside the project limits, for example at the watershed/zonal level to show how the project outcomes are heavily dependent on the fate of environmental quality elsewhere outside the project area. These impacts are generally ignored from EIA studies. Future research should also focus on detailed assessment of socio-economic impacts, as most of the EIA studies

apply various methods to assess air or water quality, but nothing comparable is done with respect to social and economic impacts.

(iii) The neighbourhood residential areas near a housing project site affect the quality of life of residents; therefore, it is equally important to identify the residential planning areas other than the project area that make up the colony. *The EIA studies should also acknowledge and integrate the distinctive identity of each neighbourhood area and their special natural and physical conditions including promoting and facilitating strong neighbourhood associations, for example, through corridors and multi-modal circulation systems.*

SUMMARY AND CONCLUSIONS

Rapid urbanization, environmental pollution and resources scarcity greatly influence the ability of town planners to deliver sustainable housing to citizens in developing countries. This has resulted in development of housing colonies that are unsuitable for occupancy generating negative consequences to the surrounding communities and the environment in the long run (Moja and Mnguni, 2014; Poom *et al.,* 2014; Dutta, 2012). Developing more resilient and sustainable settlements requires planners to anticipate and take account of changing socio-ecological and physical conditions (Fitzgerald *et al.,* 2015). Understanding the complex interactions between dynamic environmental, technological, infrastructural and governance systems in relation to housing provisions forms the starting point for impact assessment within the framework of Environmental Impact Assessment (EIA). EIA is the process used to identify, predict, evaluate and mitigate the environmental, social, and other potential impacts and consequences of developmental projects prior to major decisions being taken and commitments made to recommend suitable mitigation measures and to decrease possible adverse impacts (International Association for Impact Assessment (IAIA), 1999; Kaya and Kahraman, 2011). Human activities are both beneficial and harmful for environment such as biological, cultural, social, economic impacts and so on and they must be taken into consideration when the development projects or plans are evaluated (Puri *et al.,* 2015; Deng, et *al.,* 2014). The rapid growth in the population in urban areas has increased the demand of land and cost of living, and it has also increased the housing load and housing projects activities (Jiao, 2015). This high demand of urban land and housing is often in short supply and out of the economic reach of the majority of the urban households (Oladapo and olotuah, 2007; Olotuah, 2010).

The urban areas in developing countries are crowded by a large mushrooming growth of settlements. These parts of the urban population needs special attention and is constrained with limited services, insufficient resources, crowded and squatter settlements and a generally poor environmental quality (McGranahan, 2015; Galbraith, 1968). These are the urban poor that are subjected to a life characterized by precarious conditions of housing, nutrition and health, little or poor material possessions (Walter *et al.,* 2015; Mabogunje, 1975). In India, urbanization trend shows a dramatic shift. Total population has increased from 23.84 crores in 1901 to 102.7 crores in 2001, and number of town has grown from 1827 in 1901 to 7935 in 2011 (Census of India, 2011). The number of urban agglomerations has increased from 384 in 2001 to 475 in 2011, whereas the number of population living in urban areas has increased from 2.58 crores in 1901 to 28.53 crore in 2001.

1.1 EIA for Housing projects

The Environmental Impact Assessment comes from Sec. 102 (2) of the National Environmental Policy Act (NEPA), 1969, USA. In many European

countries, it came into trend with the introduction to the concept of sustainable development after the report of World Commission on Environment and Development (WCED) came in 1987. In India, EIA came into existence informally through isolated project assessment on environmental criteria around 1978-79, it was made a mandatory provision in 1994.

The vast majority of urban residents in India continue to live in sub-standard or informal housing, with few basic amenities (Tiwari and Hingorani, 2014). EIA is a planning and management tool that seeks to identify and assess the type, magnitude and probability of environmental and social changes likely to accrue form a proposed development or policy and to design the possible mitigation plans (Harvey, 1998; Momtaz, *et al.,* 1998; Thomas, 1998). EIA is being used worldwide in order to reduce the harmful consequences of development. It is an illustration of the precautionary principle (Debbarma, 2012) because it focuses on prevention during the early stage of project development. The primary goal of EIA is ensuring environmental protection and management (Bailey, 1997; Morrison and Bailery, 1999). EIA is generally concerned with the prediction and identification of impacts at a pre-decision level focusing only on the steps before and up to the planning decision, but ignoring post development follow-up actions, such as post project monitoring and auditing (Art *et al.*, 2001; Glasson, 1994; Petts and Eduljee, 1993). Moreover, the procedural emphasis of EIA upon the pre-decision investigation keeps it isolated from its final goal, i.e. environmental protection. In a major study on international EIA effectiveness (Sadler, 1996; Cashmore *et al.,* 2004**),** it is found that there was a deficient or poor performance of follow-up activities in EIA. This is considered to be a major weakness of EIA internationally (Arts *et al.*, 2001; Bisset and Tomlinson, 1988; Buckley, 1989; Dipper *et al.,* 1998; Glasson *et al*., 1994; Ortolano and Shepherded, 1995; Sadler, 1996; Wood, 2003).

The living space becomes the centre and instrument for mankind's socio-economic and moral well being (Wang *et al.,* 2015). Since living space affects the very foundation of an individual's life, the house becomes an integral part of it. Besides it is fundamental to people's physical, physiological, social and economic well-being (Kraatz *et al.,* 2015). Housing is the physical structure that man uses for shelter. The quality of life of human being can not be fulfilled without safe, secure and comfortable housing. But, in most of India's towns and growing cities, people are not fortunate to have housing of their own which is safe, sustainable and comfortable. Housing is the biggest challenge associated with urbanization in India. In the absence of proper assessment of environmental significance of ongoing housing projects, the living standards of urban as well as rural area are deteriorating. Thus, the sustainable human settlement and construction of eco-cities or green housing can be achieved by implementing the policies of EIA in housing and construction projects (Kulkarni *et al.*, 2014).

1.2 Research Objectives

EIA has been used as a practical and effective tool in decision making process to identify environmental factors, and consequences for a proposed development project needed to arrive at socio-economic development. This study uses the EIA framework as a lens to evaluate current and future environmental impacts in developing housing projects by both public and private agencies and also evaluates the post-project conflicts through primary and secondary data. This research work quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India's largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models within a framework of environmental assessment. The methodology provides a cost effective and rapid land evaluation framework for EIA which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth and impacts of housing projects on the environment.

There are three main research objectives which are formulated as follows:-

- To assess the baseline and current environmental status (such as air, water, noise, and socio-economic parameters) for housing projects in Lucknow.
- To do a comparative study of the housing projects in the study area on different parameters using Leopold Matrix method.
- To review the effectiveness of EIA systems implemented in housing projects through conflict analysis and post-project monitoring using Fuzzy AHP models and GIS.

The study was used to observe the effectiveness of EIA for housing projects in Lucknow by studying and reviewing the Government of India EIA notifications, with the help of spatial and non-spatial data, use of Fuzzy – AHP modelling techniques, Leopold interaction matrix, land use/cover change detection, and conflict analysis. The methodological framework is schematically outlined below in the figure 1.1

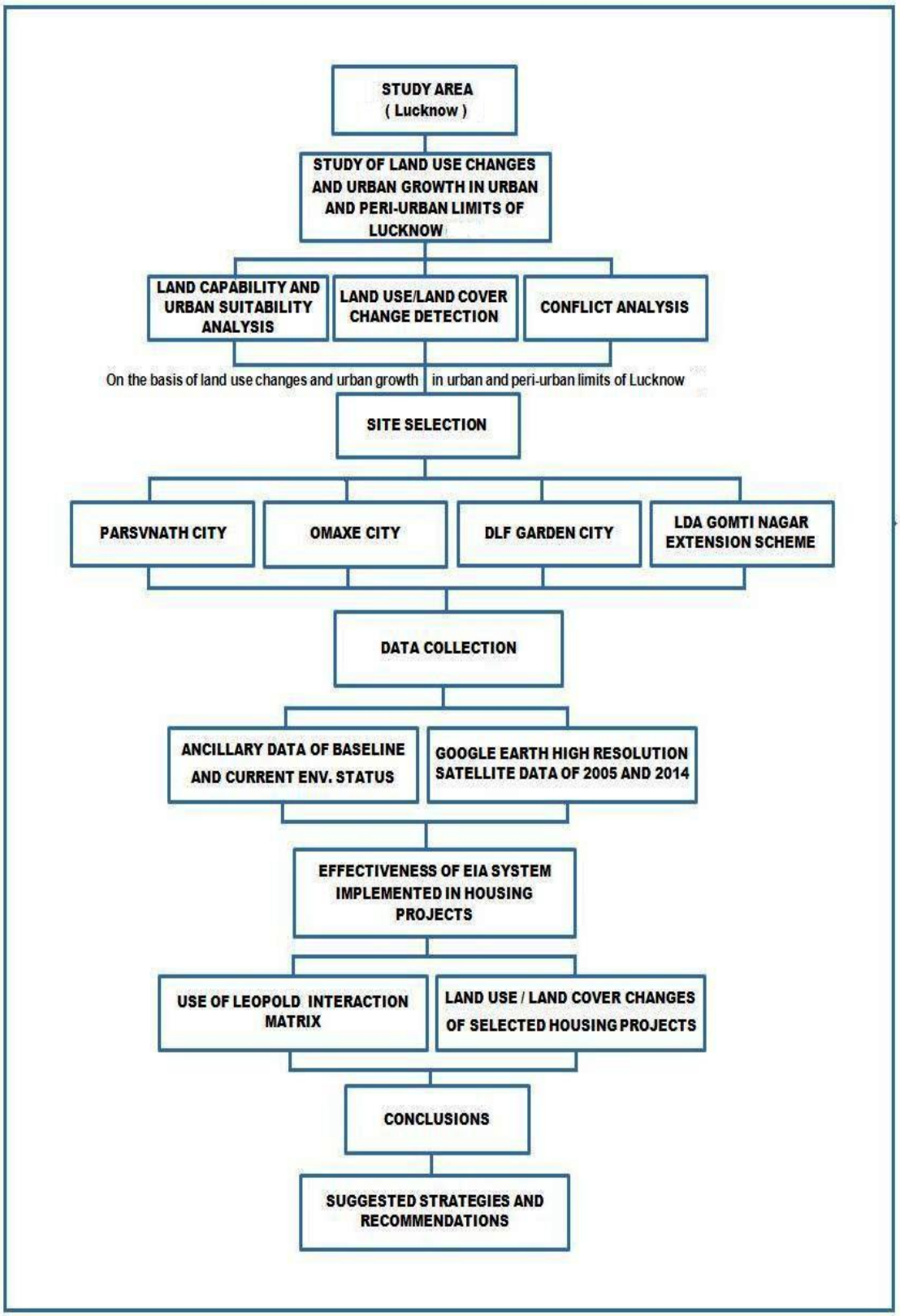


Figure 1.1 Methodological framework adopted for the study

1.3 Summary and Conclusion of the Study

In India's growing towns and cities, unplanned sprawled development due to public and private housing projects is leading to use of more resources like land, water, energy etc. which puts enormous pressure on physical infrastructure as well as on environmental quality. There is a need of an integrated approach that could assist housing and settlement planning while preparing the EIA of new and upcoming colonies. Although ElAs can certainly improve housing projects, there are still several limitations to what they can achieve.

The upcoming housing projects in the city of Lucknow during the EIA process state that the projects would contribute to development of green spaces, gardens, constructed wetlands, permeable pavement, and integrated rainwater harvesting systems, however, the situation on the ground depicts a different picture. The review of the EIA of housing projects reveal that some of the newly developed projects are characterized by severe shortage of basic services like potable water, well laid-out drainage system, sewerage network, sanitation facilities, electricity, roads and waste disposal.The land developers tend to be disconnected from the realities of resource limitations and largely inattentive to the long-term environmental impacts of land use modifications. This process will continue with time if not checked through proper intervention and strict planning measures and can adversely impact the quality of life of urban and peri urban dwellers. The research outcome is summarised under the following sections:

1.3.1 Spatio-temporal patterns of land transformations

Pattern of urban growth in Lucknow city as explored by the study is not linear or nodal. Urbanization seems to spread radially in all the directions and influence of transport infrastructure is minimal. Drivers of such changes are many and very site specific. Some areas have developed out of older city core, but others developed out of new industrial zones. In the latter case, the lack of reliable transport infrastructure has not inhibited the development and nor is the direction of development controlled by presence of transport routes as observed in earlier studies (Taragi, 1997). A large chunk of urban middle class prefer cheap housing in the suburbs even when there is not enough transportation infrastructure. Many people buy land in such areas from investment point of view as they know that land price would go up substantially once the area is earmarked for housing in the future. As a result, peri-urban locations look increasingly investment attractive, which leads to spatial growth of the city.

In the study area two major land use/cover trends between 1997 and 2010 can be discerned: (i) Intensification of urbanization in central/core areas where a few remaining open areas and water bodies were occupied and landfilled to accommodate residential developments; (ii) Urban expansion in peri-urban/ suburban areas, where the extension of urban core increased at the cost of permanent crops and pastures. As is revealed from the statistics, there are four classes displaying significant land transformation; *Agricultural cropland shows major decrease, urban built-up shows major increase, wasteland shows moderate decrease and area under construction*

shows significant increase; all other land use classes exhibit relatively insignificant change.

Peri-urban areas are currently experiencing the most active urbanization. Results indicated that the prominent urban growth in such areas follows two main physical processes:

- Urban growth in three peripheral sites (N, NW and S) is occurring through '*Edge expansion and Envelopment'* i.e., annexation of surrounding landscape through the growth of existing urban areas (Seto & Fragkias, 2005). *Since the study area is primarily dominated by agricultural land, urban growth through 'edge expansion and envelopment' is happening mostly at the expense of such cultivable lands.*

- Urban growth in North Eastern site is occurring through '*Attainment*' – occupation of small built-up clusters (mostly rural) dispersed in landscape by extending urban areas. Attainment seems to be the direct result of improvement in accessibility due to development of transport infrastructure. Rural settlements located amidst predominantly agrarian areas are urbanized when major roads pass through them and the urban development along these routes intensifies to engulf them. Along with the economic development and ensuing urbanization, an impetus on improvement of major transport routes is obvious. Accessibility to the far flung townships and villages have led to development of hitherto underdeveloped areas on fringes of the city, which welcome the conversion of rural land for upcoming industries and educational institutions requiring vast unutilized land resources and spelling major financial gain to marginal farmers.

Furthermore, multi-temporal land use change statistics showed that substantial class I agricultural land was lost by urban growth during 1997 – 2010, with an average annual rate being 13%. The major land use transformations class is – *Rural to Urban* being 41.91% of the total change (Table 1.1). Of importance to the study are *other* categories, specifically the *rural to transitional* and *natural to transitional* which together contribute a fair 16.84% to the LULC change and are placed in the transformation category of *Critical*. This *Critical* category is generally the result of land cover degradation and is prevalent in peri-urban areas on brink of being urbanized. *Although the allocation of land is governed by competition between urban and agricultural uses, the outcome has increasingly tipped in favor of urban use, leading to substantial spatial growth in peri-urban areas.* Also important is the observation of a small but significant amount of change (7.64%) from *transitional to natural* and *transitional to rural*, mostly observed in the study as conversion of wastelands into croplands, which confirms that above reconversion is possible and takes place naturally also, although at much smaller percentage than required.

Table 1.1: Landtransformation from 1997 to 2010 at four peri-urban sites showing transformation classes

"From" Class	"To" class	Change (2002-2010)	
		Area	%
Natural	Rural	0.22	*0.63*
	Transitional	1.46	*4.24*
	Urban	1.43	4.16
Rural	Urban	14.46	41.91
	Transitional	4.36	*12.64*
	Natural	0.29	0.84
Transitional	Urban	9.47	27.45
	Natural	1.29	3.74
	Rural	1.35	3.90
Urban	Rural	0.02	0.07
	Transitional	0	0
	Natural	0.14	0.42

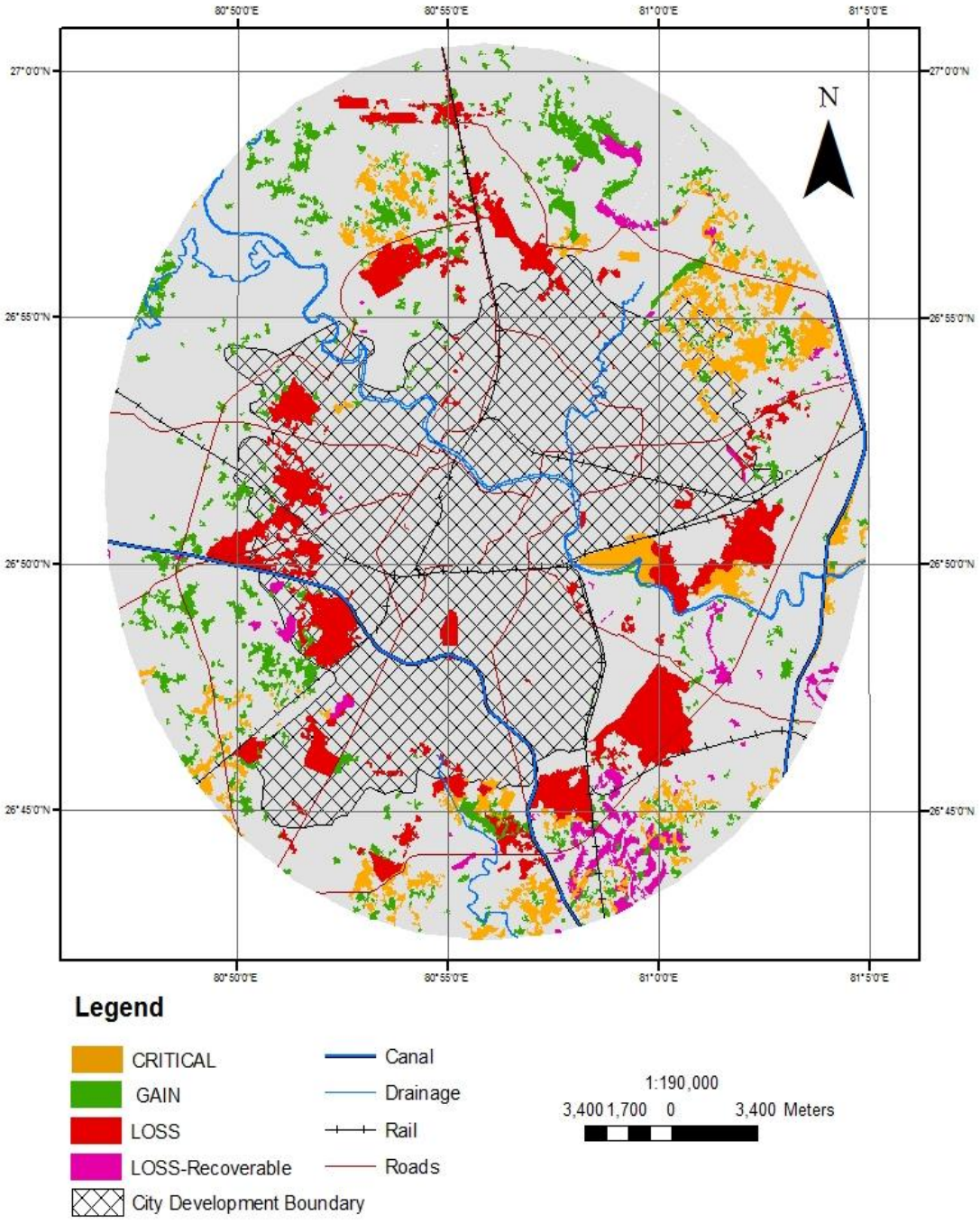


Figure 1.2: Spatial occurrence of land use transformations in the peri-urban areas.

Detailed results from the study reveal that urban land use for all four sites has increased over the study period (year 1997 to 2010) with the largest growth of 17.5 % being observed for Northern site and lowest of 10% for Southern site (Figure 1.3). On an average, more than 70% of the total land use /land cover change has been towards the transformation category of *Loss* towards urban land use, there has been practically negligible amount of *Gain* and an insignificant amount of *Loss-recoverable*. Only the *Critical* class holds some hope especially for Northern and North Eastern sites where more than 20% of the total land use is in *Critical* stage. Also observed is an insignificant for now (0.04%) conversion of forest into urban vegetated wherein *open forest patches on city fringes degrade rapidly as expanding settlement approaches them.* These open forests are soon converted into urban-vegetated class which is vegetation interspersed with urban built-up, feared to be quickly engulfed by densification of the city. Also, 75 % of *Loss-recoverable* category accounts for change of lakes into cropland and horticulture, wherein water bodies have been landfilled and are being used for agriculture or plantations. Loss of water bodies in Southern site is also alarming, making it a fragile area as well. North Eastern area exhibits the change of maximum amount of cropland into transitional category. Site specific observation of *Critical* land transformation category, reveals that at Northern site, *Critical* category is being formed by conversion of four rural land use classes, out of which conversion from cropland is maximum (63%), followed by a substantial 28% being formed by conversion of forest to urban-vegetated. *This observation is alarming, making this site fragile, since presence of forest on a city periphery is already rare and its being lost to urban land use means extensive loss of natural habitation with severe threat to the remaining areas of core natural forest.*

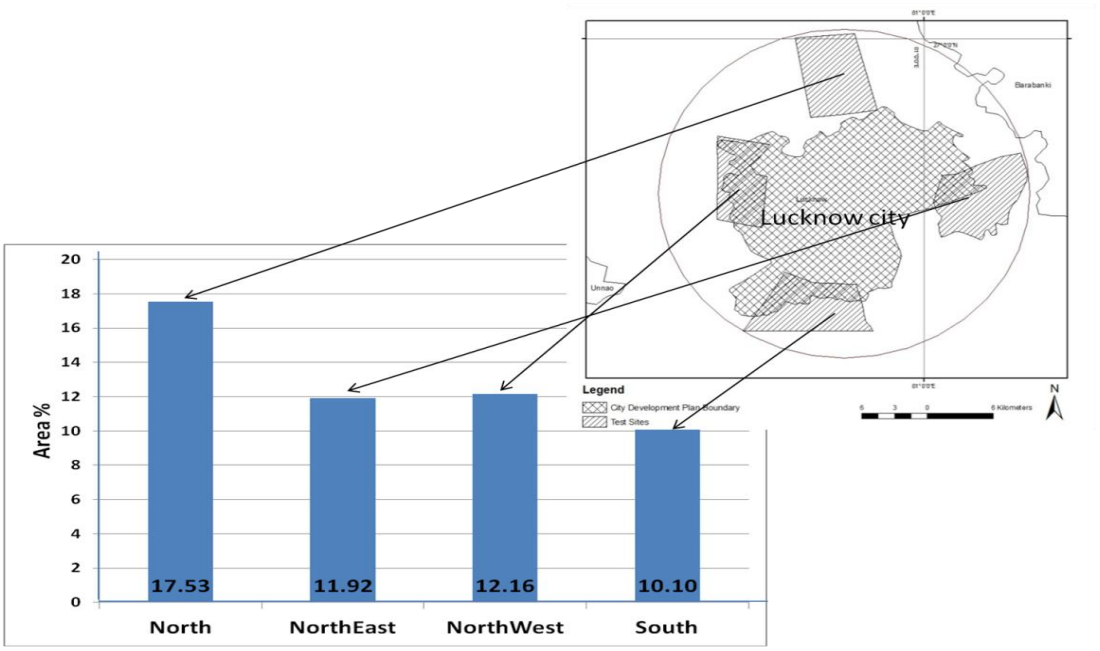


Figure 1.3: Growth rate of urban land use in peri-urban areas between 1997 and 2010

Due to peri-urban land takeover by urban development agency, competition for land between real estate developers and nonurban users, mainly farmers and other agricultural users, have increased tremendously in the last decade. For the city to grow spatially, public and private developers bid away additional land from agricultural users in the peri-urban areas. Increased demand for housing and commercial space means that land is worth more in urban use than in agriculture, thus reflecting greater economic benefits in its developed state. According to ***Brueckner***(2000), land conversion in such situations is guided by the 'economist's "invisible hand", which directs resources to their highest and best use'. In this process productive agricultural land is often converted into urban land use. As the value of agriculture output is fully reflected in the amount that agricultural users are willing to pay for the land, a successful bid by public and private developers means that society values the houses and other structures built on the land more than the agriculture output that is forgone.

It is observed that site along the North western direction (enroute to suburban Malihabad town) has experienced maximum amount of relative increase in urban built-up (17.18%), with a simultaneous decrease in rural built-up (4.71%), wherein the latter seems to have merged with extending urban land use. This finding is unexpected, as it was anticipated that this area would experience least urban growth due to its location along state highways, as opposed to location of other sites along national highways and absence of adjacent major industrial town as opposed to North east (adjacent to Barabanki) and South (adjacent to Kanpur). The site also shows a significant decrease in cropland (9.68%) and wasteland (2.82%), indicating the conversion from these classes to urban land use. Surprisingly, this site displays minimum area under construction (3.04%) amongst the study sites; indicating a reduction in rate of future urbanization and pointing towards occurrence of a probable land speculation prevalent in recent past which may have spurred the observed urbanization.

Decrease in cropland area (18.25%) is observed to be maximum in North-eastern site, which falls along the Lucknow-Barabanki national highway. The area is intensely industrialized, with increasing number of unplanned factories/industries. Capacity of existing environmental infrastructure in the area for sewage, industrial and solid waste management is inadequate, spelling serious environmental deterioration. The site displays maximum amount of area under construction (7.72%), a significant increase in urban built-up (11.02%) and fair decrease in cropland. The area also shows a significant amount of area under long fallow (3.15%), indicative of a trend where farmers leave their cultivable land fallow, waiting for urban development opportunities and in event of selling their land towards urban development, gain compensation used to develop farmlands further from city. For these farmers, the uncertainty of when exactly the land might be taken over by urban structures is too great to make it worthwhile continuing with serious, intensive agricultural production. This explains the widespread abandoned fallow or unutilized land found around many expanding cities (Van den Berg *et al.*, 2003).

Southern site, falling on Lucknow-Kanpur route, displays a marked decrease in wasteland (5.59%) and cropland (8.08%), with a simultaneous increase in area under construction (7.51%) indicating an increased rate of future urbanization. A careful observation of initial (1997) and final (2009) images of the site, reveals that most of the defined wastelands are being used for real-estate development. *Southern site alone shows a decrease in water bodies, owing to the fact that this area was marked by presence of numerous big and small water bodies in past, which have been transformed to agricultural uses or land filled for real estate development.*

Northern test site displays significant decrease in most rural land use classes; Cropland (12.50%), Wasteland (2.07%) and Open Forest (1.28%) with a simultaneous increase in urban built-up (9.17%) which is understandably due to urbanization (Figure 1.5). *The transformation class of area under construction (5.21%) also shows significant increase indicating a continuous urbanization in future.*

As the city's population expands, it must grow spatially to accommodate more people. In addition, people's rising incomes and quality of life concerns affect urban growth because residents demand better housing conditions and more living space as they become richer over time. The greater demand for space causes the city to expand spatially as the population increase. This effect is further reinforced by the 'urban-social-aspirations' to expand and buy additional lands for their housing needs in a location where land price is cheap, mainly the peri-urban areas. Therefore, the spatial expansion due to rising incomes and quality of life concerns among the residents is strengthened by a price incentive favoring urbanization along the city's periphery.

1.3.2 Land capability and urban suitability

Poorly regulated land governance has led to unscientific urban expansions that do not conform well to the land suitability and carrying capacity of the city. Industrial areas are being built upon environmentally sensitive area; some residential areas have also encroached upon lakes and ponds and new residential areas lack open space and greenbelts. Existing infrastructure has not been integrated in the design of the layout, for eg: there is absence of logistic zones, sidewalks, bicycle lanes, parking lots, and so on. Majority of area (around 77%) in the peri-urban interface has weak or very weak suitability for future urban development primarily because of the high conservation and agriculture suitability and incompatibility of physical land use to enabling infrastructure (Figure 1.4 and Figure 1.5).

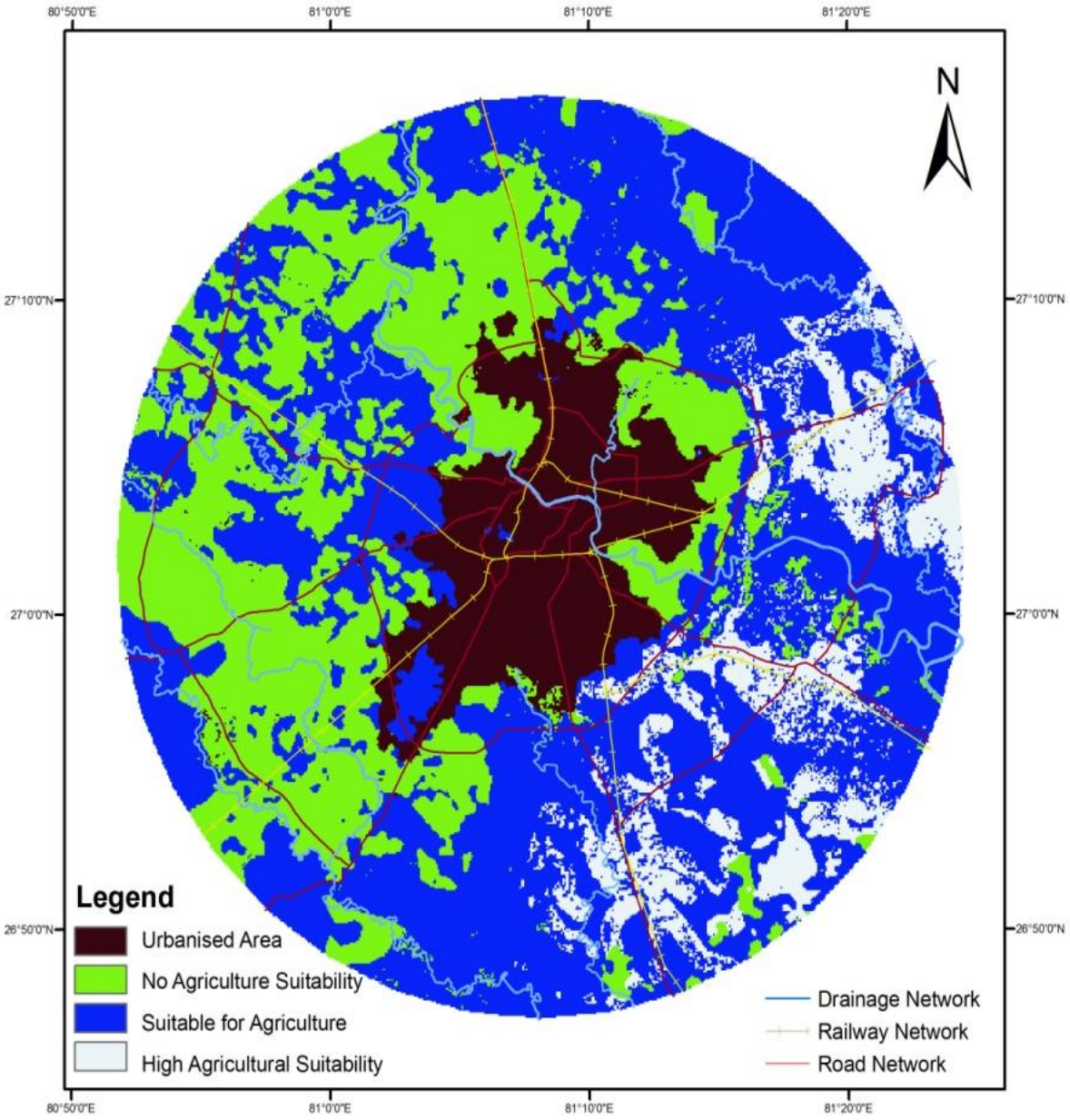


Figure 1.4: Agricultural suitability based upon Weighted Linear Combination of multiple criteria

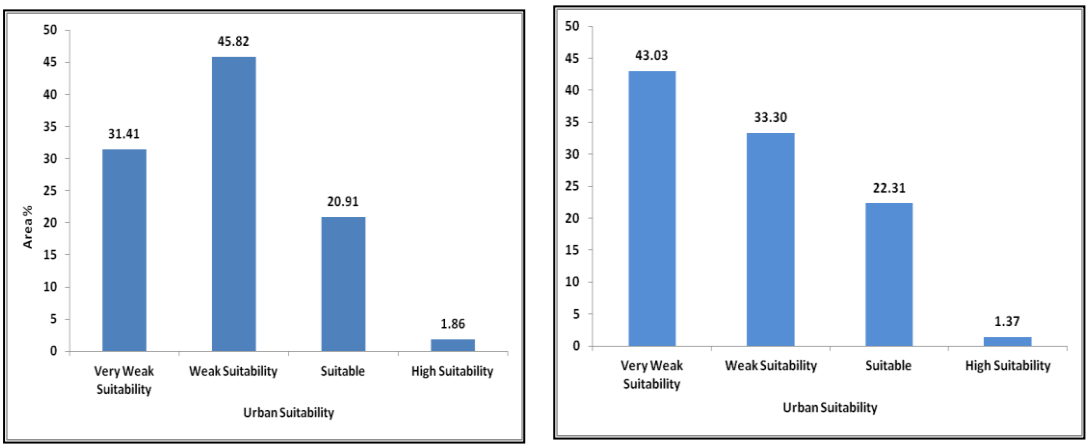


Figure 1.5: Area statistics for urban suitability using (a) traditional AHP method, and (b) Fuzzy AHP method

1.3.3 Land use conflicts

Patterns of urban growth do not follow Master Plan 2021 and even Master Plan deviate profoundly from the preferred land suitability. As per the land use statistics of 2010, high value class I agriculture land and horticulture fields constitute 57% and 15% of the area respectively. Therefore, converting them to urban land use will affect future food sustainability. Around 20% of the area, i.e. 500 sq. km. has moderate suitability whereas about 2% (50 sq. km.) of the area has high suitability for urban development. Since out of the 2500 sq. km, about 303 sq. km. has already been under active urban land use including the denser urban core, any future urban land transformation should be done very carefully taking into account the zoning regulations and importance of open space, greenbelt and class I agriculture land. It is also evident from the conflict analysis that the Master Plan 2021 is conflicting from the zoning restrictions recommended by the urban suitability analysis; the restricted/conserved areas recommended by the study are certainly in conflict with the planned future development. Of the total area of the conserved, greenbelt, reserved forests and floodplain as per the defined land suitability class, 4.18% of the area has been converted into existing built-up/settlements whereas 46.36% of the total area is proposed under residential settlements, business districts and commercial land use under the Master Plan 2021, 11.84% under transportation network and 5.11% under agriculture (Figure 1.6). Therefore, with the process of urban sprawl in the core and at the peri-urban interface, conserved area such as greenbelt, reserved forests and floodplains are threatened and will be rendered fragile.

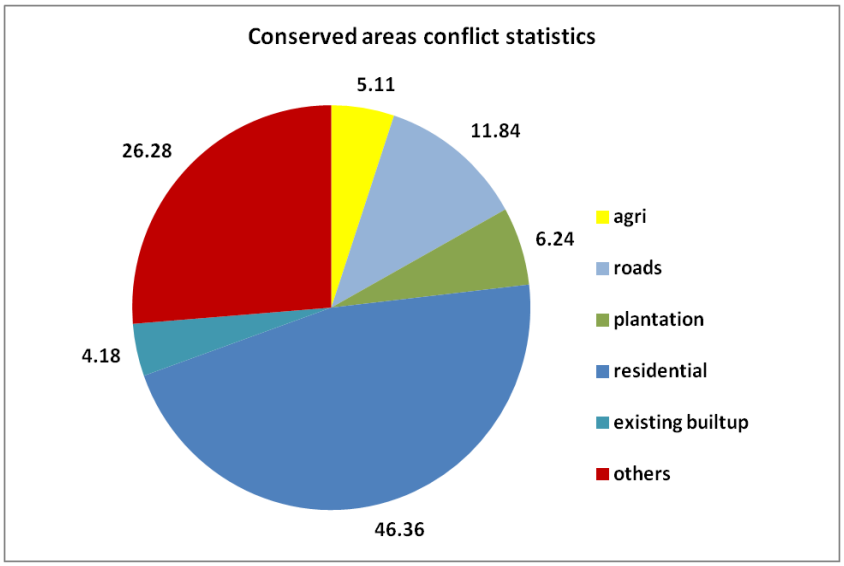


Figure 1.6: Conserved areas conflict statistics with respect to the Master Plan 2021

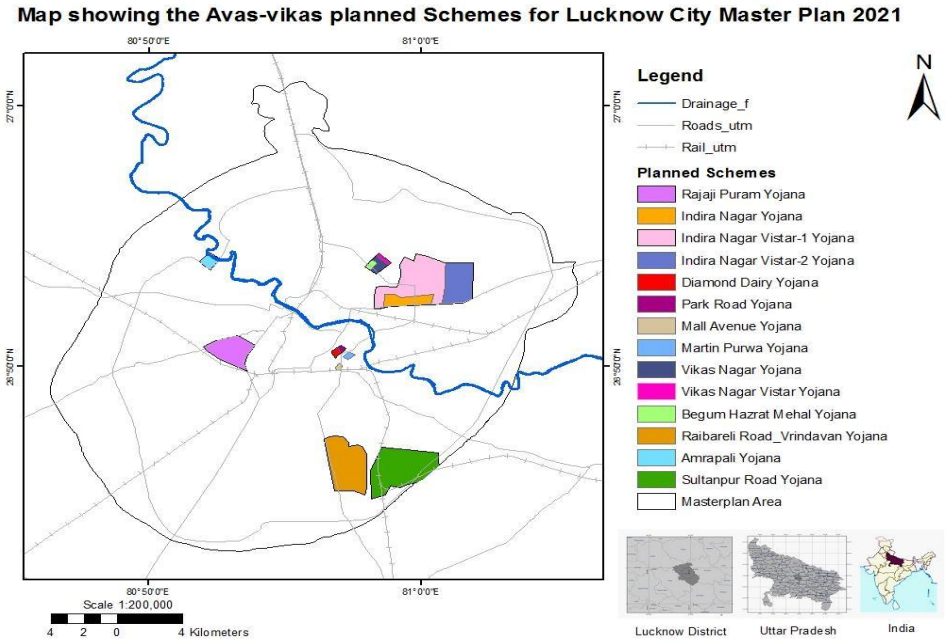


Figure 1.7: New housing schemes as planned by Avas-Vikas (Uttar Pradesh Housing Development Board) under their Master Plan 2021

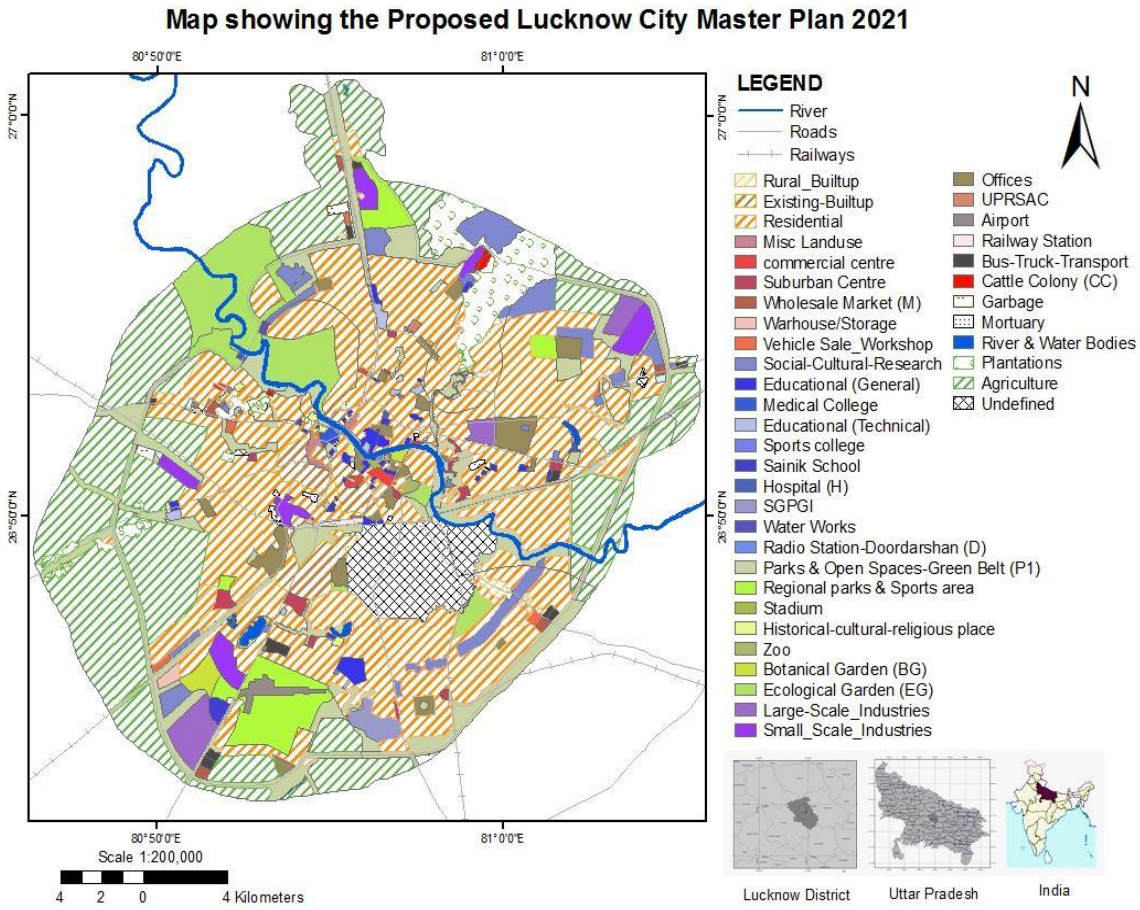


Figure 1.8: Map showing the proposed Lucknow's city Master Plan 2021

Master Plans concentrate on planning land use in isolation from other critical infrastructure and resource constraints such as water and sewerage facilities and transport network. They are not followed by local area plans and investment decisions, strategies are often inconsistent with city's spatial structure. Urban renewable schemes such as Jawaharlal Nehru National Urban Renewable Mission (JNNURM) and Rajiv Avas Yojna (RAY) are implemented as isolated projects removed from the regional policies, land use plans and their growth dynamics. Peri-urban land conversion is guided by the market's invisible hand and 'agglomeration economies' which directs resources to their highest market price ignoring the long-term environmental impacts. Multiple jurisdictions with multiple plans by the land authorities, each independent of the other, also result in fragmented development across commercial and residential areas at the micro level. Land agencies (LDA: Lucknow Development Authority and UPHDB: Uttar Pradesh Housing Development Board) do not coordinate regarding subdivision regulations creating fragmented discontinuous urban areas.

1.4 Policy implications of the study

Urban transition is a major challenge in growing cities of the developing world. Disorderly urban sprawl creates war on cities' dream to become engines of growth and threatens the future growth and vibrancy of cities' economy. Urbanization in the Indian context should be looked at beyond mega-cities like Mumbai and Delhi with a holistic view to include second-tier towns and medium size agglomerations such as Lucknow which has not been studied in detail. This paper quantitatively explores the spatio-temporal patterns of land use/land cover transformations in the core and along the city periphery of Lucknow city, the capital of India's largest state, in addition to observing nature and form of urban expansion resulting in a complicated urban landscape. Conflict analysis is carried out to explore disagreements between urban suitability, enabling infrastructure and Master plan 2021 proposed by the land authorities using satellite imageries, Fuzzy AHP and sub-models. The methodology provides a cost effective rapid land evaluation framework which may help policy makers, urban and regional planners and researchers working in developing countries to understand the dynamics of urban growth.

It is observed that due to rapid economic development, the city has expanded in size and structure, becoming increasingly more complex, heterogeneous and irregular in shape. Development has been muddled in peri-urban areas, causing natural and rural land cover to degrade over time and the trend suggests more such degradation in coming years. The land developers tend to be disconnected from the realities of resource limitations and largely inattentive to the long-term impacts of land use modifications. Natural land covers like forest and water bodies are experiencing major deterioration rendering some of the PUI sites as fragile. Each of these impacts is linked to changes in the extent of urban, agricultural, and forest lands, and (or) transportation, housing and other critical infrastructure systems. This process will continue with time if not checked through proper intervention and strict planning measures and can adversely impact the quality of life of urban and peri-urban dwellers.

Although urban sprawl cannot be stopped in a rapidly developing city, a remedy for this problem lies in strict zoning regulations based on land suitability and carrying capacity, which allow land use to be channeled toward more sustainable outcomes. Detailed observations of transformation category statistics reveal that although the pace of urbanization will grow up in the future, a significant amount of recoverable land cover presently under transformation (denoted by Critical class) can be restored and focus of development can be shifted on underutilized areas within the city development boundary. It is also suggested that older urban areas with dense horizontal urbanization can be considered for urban redevelopment using vertical urbanization methods. Primarily, unplanned and unfocussed urbanization, not considering the suitability of land cover or its environmental impacts/aesthetics should be discouraged in order to promote healthy and livable cities. Results from urban growth models can be used by land use planners and policy makers to anticipate and plan for future spatial expansion to ensure growth along the lines of city development plans and enabling infrastructure.

India's mainstream policy and planning for housing growth has been shaped to a great extent by its EIA guidelines. Mehta and Karpouzoglou (2015) note that the mainstream policy and planning for urban growth has negative implications for important natural resources like water for peri-urban areas.

It is understood that rapid, unplanned and uncontrolled urbanization is leading to disorganized growth in developing countries (Amin and Fazal, 2015). The patterns of development resulting from new urban forms are also altering natural landscapes and their dynamics in the peri-urban areas (Dutta, 2012). Unplanned urban growth is resulting in reduction in the productivity of the land and in the provision of ecosystem services (Malmir et al., 2015; Ceccarelli et al., 2015). This has necessitated understanding of spatial patterns of urbanization and their relation to post-project conflicts arising from new urban landscape. Evolution of urban land density is also a subject of great interests among researchers; however, the methodologies are arbitrary and suffer from the lack of an established foundation (Jiao, 2015; Dutta, 2012). Keeping this reality in the background, the objective of the study is to review the effectiveness of EIA systems implemented in housing projects in Lucknow city through conflict analysis based on post-project monitoring using Fuzzy AHP models and GIS. The outcome of the study would be of great importance for urban planning and decision-making communities of the city in the present and future.

Land use and land cover changes are so pervasive that, when aggregated they define the character of a city. They also define how major infrastructure such as transport, housing, commercial and market places, greenbelt etc will function in the future (Ding *et al.*, 1999). Urbanization becomes synonymous with frequent land use changes that have often negative impacts on the environment. Poorly regulated land governance which is rooted in inefficient intuitional regime leads to often unscientific urban development that do not conform well with the land suitability and carrying capacity of the region. This leads to complex policy challenges faced by planners and policymakers. Land development authorities almost always regulate land and sometimes directly provide settlement support after developing an otherwise non-urban land uses. This can also create externalities as land development agencies in the past have often neglected enabling resources and overall carrying capacity of a region in developing master plans for future growth (Frenkel & Ashkenazi, 2008).

Any future urban land transformation should be supported by a coherent urban planning policy recognizing zoning regulations and importance of open space, greenbelt, water bodies and class 1 agriculture land. Decisions made now will have a major impact on the enabling infrastructure and civic amenities. Unless more aggressive measures are taken, cities' future will be locked for decades to come. Negative externalities in terms of traffic congestion, parking, pollution, water supply and sanitation problems, solid waste disposal and lack of open space will emerge. This will also make conserved areas such as greenbelt, open spaces and floodplains fragile in times to come. Further research is required to delineate a suitable zoning development management plan to sustain a baseline for urban growth keeping in mind the carrying capacity of the city and its peri-urban areas. Furthermore, the integration of a zoning approach associated with the green belt is suggested to play a key role in a

transition to continued urbanization. The research outcome would assist planners and land developers to evaluate whether development goals are in agreement with the intended land use objectives and if yes, how the resources should best be used to optimize city's enabling infrastructure and carrying capacity.

1.4.1 EIA in housing projects

EIA certainly has a crucial role to play in addressing environmental issues surrounding project development. Most EIA processes are based on wrong assumptions and/or unclearly defined concepts, such as 'significant impacts'. There are also intractable logistical problems and challenges related to availability of resources and the necessary EIA capacities. The objective of EIA procedures, as opposed to the subjective ones that are prevalent currently, is recommended as the required first step towards addressing the challenges of EIAs. Other recommendations include making proper human resource planning and utilisation; building relevant capacity; modernizing and developing new tools and technologies; increasing budgetary allocation to the EIA function; undertaking to educate politicians and other stakeholders about the sanctity of the EIA business; communicating effectively about the EIA processes; providing the necessary political will to make the EIA administration function effectively and in a more transparent manner; and increasing investment in EIA research.

1.4.2 Assessment of Baseline (Pre-project) and Current (Post-project) environmental status

The comparative study shows the ground reality of various parameters in the selected housing projects. The housing project should have rainwater harvesting system, proper parking facilities, and adequate green area and contain the plants/trees that absorb the high level sound/noise, wastewater treatment facility and sound waste management facility.

The upcoming projects in the city of Lucknow can no doubt add to new housing areas with green spaces, gardens, constructed wetlands, permeable pavement, and integrated rainwater harvesting systems, but the situation on the ground depicts a different picture. The review of the EIA of housing projects reveal that some of the newly developed projects are characterized by severe shortage of basic services like potable water, well laid-out drainage system, sewerage network, sanitation facilities, electricity, roads and waste disposal. These in turn result in to numerous environmental and health impacts that must be addressed. The green cover and water bodies have been destroyed to give way to the rapidly developing urban settlements at the outskirts. Urban green infrastructure comprise of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales. The burden of resource use in upcoming buildings or urban housing projects can be minimized in many ways. Properly designed housing projects can provide numerous services such as purification of air and water, pollution control, mitigation of floods and droughts, re-generation of soil fertility, moderation

of temperature extremes, climate change mitigation and enhancing the landscape quality.

On comparative study of ***Air Quality*** of baseline data **(Pre project)** it was found that LDA Gomti Nagar Extension Scheme possess high PM_{10} and SO_X and parsvnath city possess low PM_{10} and $SO_{X.}$ Similarly, with respect to $PM_{2.5}$ and No_X LDA Gomti Nagar Extension Scheme possess high $PM_{2.5}$ and No_X and parsvnath city possess low $PM_{2.5}$ and $NO_{X.}$ .In comparision to current environmental data **(Post project)** was found to be high with respect to $PM_{10,}$ $PM_{2.5,}$ and NOx except SOx.

On comparative study of ***Water Quality*** of baseline data **(Pre project)** it was found that all four test sites of Lucknow city indicates poor quality of ground water this is due to lack of EIA policy implementation in all these test sites.

On comparative study of ***Water Quality*** of Current **(Post project)** environmental status it was found that all four test sites of Lucknow city shows neither good nor bad quality of Ground water and used for drinking as well as other domestic purposes. Similarly if EIA policy is strictly implemented in all these sites then in future we can maintain the ground water table otherwise we will face water crisis problems in future.

The baseline data of ***Noise Quality*** of **(Pre project)** was found that DLF garden city (shows high noise level) and LDA Gomti Nagar Extension Scheme (possess low noise level) during day and night time. This is so because the area is lying near the Amar shaheed path, sultanpur road and faizabad road.it is also a poss and crowded area. Similarly The noise level recorded in 2014 after monsoon period **(Post project)** in the study area from the graph shows that LDA Gomti Nagar Extension have high level of noise and Omaxe Residency have low level of noise quality among all the housing projects of the study area during day time while during night time DLF Garden city posses low level of noise generation and LDA Gomti Nagar Extension have high level of noise.

With respect to ***Soil Quality*** of baseline data **(Pre project)** it was found that PH, Conductivity, and available phosphorous was high in DLF garden city as compared to LDA Gomti Nagar Extension Scheme. Similarly, the bulk density, available Nitrogen and Potassium was found to be high in LDA Gomti Nagar Extension Scheme as compared to DLF garden city and also, ***Soil Quality*** of current data **(Post project)** indicates that moisture content, available phosphorous, with respect to the DLF garden city was maximum and lowest in parsvnath city. Similarly, PH, bulk density was found to be maximum in Omaxe Residency and lowest in LDA Gomti Nagar Extension Scheme. The content of zince was maximum in Omaxe residency and lowest in Parsvnath city. Also, the available Nitrogen was high in DLF garden city and minimum in LDA Gomti Nagar Extension Scheme. The electrical conductivity was found to be high in DLF garden city and minimum in Omaxe residency. The quantity of Fe and Pb was costent. The available sodium was maximum in LDA Gomti Nagar Extension Scheme but minimum in parsvnath city

On comparative study of the land use/land cover change in omaxe residency it was found that there was no built up area except green area after that there was slightly increase in green area and developments of road network, built up area but no water bodies are found (figure 5.56). With respect to DLF Garden city there is loss of water bodies in 2014 (figure 5.57), increase in road network (but in 2005 according to figure no road network were found),built up area. In parsvnath city (figure 5.58) there was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Similarly with respect to LDA Gomti Nagar Extension (figure 5.59) there was no loss of water body and too much growth was observed with respect to built up area,road network and green area. Overall from the land use/land cover change detection there was increase in built up area,road network and green area.There was no loss of water body and too much growth was observed with respect to built up area, road network and green area. Overall from the land use/land cover change detection there was increase in built up area,road network and green area.

It was observed that building bye-laws relating to the provisions of vacant areas/spaces as outlined in clause 1.3 of the building bye-laws, 2008 of UP were not adhered to. There is also non-compliance to the norm of open spaces, as the space for parks and recreational areas are limited. As per the government order in November 1999, regarding model costing plan for housing development by the land development authorities and housing boards, cost would include external development including construction of STPs and garbage disposal places. Garbage generated by these colonies is collected by private and informal groups, who ultimately dispose them in open and vacant land due to the absence of any landfills. Similarly LDA has not developed common rain water harvesting (RWH) system which is required for plots of less than 300 square meter area.

1.4.3 Effectiveness of EIA system: The effectiveness of EIA system implemented in the housing projects which was determined by the methods like Leopold matrix, land use / land cover change detection and conflict analysis.

The effectiveness can be checked by the use of Leopold matrix which is a significant method used in EIA process and provides a format for comprehensive review of the interactions between proposed anthropogenic actions and environmental factors including its characteristics and conditions. It was applied for the evaluation of impacts of housing projects in Lucknow city. The conclusions drawn from the evaluation of impacts is magnitude of LDA Gomti Nagar Extension Scheme and DLF garden city was observed medium whereas the other three housing projects have low magnitude. Similarly, the importance of all the three housing projects was observd to be medium except Omaxe Residency.

So, after analysing the Leopold interaction matrix it was found that EIA is highly effective in Parsvnath City (3.5/5.2=0.67308), and moderately effective in DLF Garden City (4.4/5.7=0.77193) and Omaxe Residency (3.2/4.4=0.72727). Similarly with respect to LDA Gomti Nagar Extension Scheme EIA is low/less effective (4.4/5.7=0.77193). The site visits also revealed that actual plantation in the

parks do not match with the plan as per the environmental clearance report and the schedule of the compliance criteria. Some of the housing projects began their construction activities before getting their prior stipulated environmental clearance.

The effectiveness of EIA was also achieved by the land use / land cover change detection. Also, analysis on the basis of land use and land cover change detection with the help of GIS and Remote Sensing from the year 2005 and 2014 it is concluded that Road network and Built up areas of the housing projects are increased. Similarly in case of Non built up areas are decreased and water bodies are lost in LDA Gomti Nagar Extension Scheme, Parsvnath City, DLF Garden City except in Omaxe Residency. Where as in the same way in case of Green areas shows increase graph in LDA Gomti Nagar Extension Scheme and Parsvnath City. Similarly with respect to Omaxe Residency green areas are decreased and in DLF garden City the green area shows no change. *The conclusion drawn with respect to Built up areas, green area and road network EIA is effective while in case of Non built up areas and water bodies, EIA is not effective. Overall EIA is effective with respect to LDA Gomti Nagar Extension Scheme and Parsvnath City while it is moderate (neither effective nor non effective) with respect to Garden City and Omaxe Residency.*

1.4.4 Effectiveness of zoning approach in EIA of housing colonies: Although urban sprawl cannot be stopped in a rapidly developing city, a remedy for this problem lies in strict zoning regulations based on land suitability and carrying capacity, which allow land use to be channelled toward more sustainable outcomes.

It is also suggested that older urban areas with dense horizontal urbanization can be considered for urban redevelopment using vertical urbanization methods. Primarily, unplanned and unfocussed urbanization, not considering the suitability of land cover or its environmental impacts/aesthetics should be discouraged in order to promote healthy and livable cities. Results from urban growth models can be used by land use planners and policy makers to anticipate and plan for future spatial expansion to ensure growth along the lines of city development plans and enabling infrastructure.

Land development authorities almost always regulate land and sometimes directly provide settlement support after developing an otherwise non-urban land uses. This can also create externalities as land development agencies in the past have often neglected enabling resources and overall carrying capacity of a region in developing master plans for future growth.Any future urban land transformation should be supported by a coherent urban planning policy recognizing zoning regulations and importance of open space, greenbelt, water bodies and class 1 agriculture land.

Further research is required to delineate a suitable zoning development management plan to sustain a baseline for urban growth keeping in mind the carrying capacity of the city and its peri-urban areas. Furthermore, the integration of a zoning approach associated with the green belt is suggested to play a key role in a transition to continued urbanization.

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