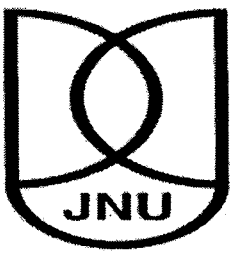
ASSESSMENT OF LAND USE LAND COVER CHANGES AND VALUING ECOSYSTEM SERVICES

(A Comparative Study of Ghaziabad and Faridabad Districts of NCR)

Dissertation submitted to Jawaharlal Nehru University in partial fulfilment of the requirements for the award of the degree of

MASTER OF PHILOSOPHY

CHANDRA PRAKASH MORYA



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July 21, 2014

DECLARATION

I, Chandra Prakash Morya, declare that the dissertation entitled, "**ASSESSMENT OF LAND USE LAND COVER CHANGES AND VALUING ECOSYSTEM SERVICES (A Comparative Study of Ghaziabad and Faridabad Districts of NCR)**", submitted at the Jawaharlal Nehru University in partial fulfilment of the requirements for the award of the degree of **MASTER OF PHILOSOPHY**, is my bonafide work. The dissertation has not been submitted for the award of any degree of this or any other university.

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CERTIFICATE

We recommend that this dissertation be placed before the examiners for evaluation.

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TO

MY PARENTS

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July 21, 2014 Chandra Prakash Morya

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ACRONYMS

CGWB	Central Ground Water Board
ES	Ecosystem Services
ESA	European Space Agency
ESV	Ecosystem Service Value
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographical Information System
GMR	Global Monitoring Report
GTB	Gautam Buddha Nagar
Ha	Hectare
IUCN	International Union for Conservation of Nature
Km	Kilometres
LQ	Location Quotient
LULC	Land Use Land Cover
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
NCR	National Capital Region
NCT	National Capital Territory
NRSC	National Remote Sensing Centre
PUI	Peri Urban Interfaces
RS	Remote Sensing
SDGs	Sustainable Development Goals
TEEB	The Economics of Ecosystems and Biodiversity
UES	Urban Ecosystem Services
UN	United Nations
UNEP	United Nations Environment Programme
UP	Uttar Pradesh
Yr	Year

CHAPTER-I

INTRODUCTION

1.1 BACKGROUND OF THE STUDY: -

Urbanization and land change are interrelated but different processes that never reflect immediate consequences over space. These have far-reaching consequences. The urban population projection signals a massive increase in urban population as well as areal expansion. This will need to re-examination of land change and urban sustainability. The process of urban expansion shrinks the benefits that we get from the urban ecosystem, directly or indirectly. These benefits are termed as ecosystem services. There is very essential need to maintain the ecological footprints in the urban areas either it will have to face severe results. The role of cities in maintaining biodiversity for functional ecosystems is becoming an important topic on the global agenda (Convention on Biodiversity, 2010). If ecological footprints are not maintained, any urban place can turn into a huge slum rather managed city. Increase in built-up area decreases urban green spaces. Consequently this limits recreational ecosystem services in a urban environment.

The process of urbanization operates at multiple scales; due to this the environment changes in the nearby landscape are also distinguished. So it is very much required to maintain the ecosystem services for balanced urbanization in and out of the urban area. For this there is need of maintaining urban green spaces like parks and forests, proper food supply, drinking water and sanitation facility in the area, implementing proper solid waste management system, etc. the urban areas affect the nearby environment and natural areas, so the urban areas are related to ecosystem services, directly or indirectly. Ecosystem services are clearly related to land use and land cover, both generally and specifically in urban areas (Breuste et al., 1996). Land use land cover not only affects climatic factors but also determines availability of ecosystem services. More open spaces regulate day and night temperatures as well as check surface water flow and increases infiltration. For the preservation of fauna, the size and nature of the urban green areas are also important. For example forest cover is more effective than a grassy land cover. The small parks and forests of cities can not sustain the biodiversity like the natural areas and natural forests have. Since land is very valuable in urban areas so there is need to try not to cover open land less with concrete as much as possible. There is strong demand to increase in green space in urban areas in order to safeguard and improve the generation of ecosystem services. If awareness for the preservation for the ecosystem services is aroused among people, resultantly we will be benefitted from the more resources and services from ecosystems.

The urban expansion significantly affects the land use types and intensity. The increasing population pressure has caused intensification of land which can be observed in every part of the world (Boserup, 1965). The conversion of high yielding agricultural land into urban places and to balance the demand of food new less productive land is incorporated for cultivating. This process significantly lowers the land use intensity. There is need to focus on urban sustainability and land change studies to understand the processes and linkages between urban and non-urban areas. To understand the drivers of land change it is necessary to know the spatial and temporal structure of land change.

In maintaining the health of a city peri-urban and its surrounding area play a very important role. Because peri-urban areas are the pathways by which rural livelihood is connected to the urban lifestyles. Due to this the rural immigrants put a huge pressure and cause degradation of the existing peri-urban environment. The peri-urban areas become less efficient in providing proper food, water and sanitation facilities as it used to be when the pressure was less. It is required to develop the peri-urban areas in such a way that it can bear multiple pressures on its environment maintaining proper access of ecosystem services to every citizen. In the developing countries the population pressure is increasing so high that it is becoming difficult to provide every facility maintaining ecological balance. The facilities are not increasing with the urban expansion.

The peri-urban areas expand over the cost of forest land, agricultural land. The fertile Northern Indian plain accounts around 43% of total geographical area of India. If compared to other nations it is very high. This land provides food, fibre, firewood etc to more than 50% population of India. These different physiographic divisions are preservers and protectors of different ecosystems. A vast range of ecosystems like Forest, Agriculture, Marine, Grassland, Wetlands, Urban, Corals, Mangroves, Deserts etc, can be observed in the territorial boundary of India. These ecosystems provide goods and services to more than 1.21 billion people in India. The biggest ecosystem all of these is agricultural ecosystem. This ecosystem provides food and fibre, one of the major basic needs for a human being. All these concerns require a great attention to protect natural as well as agricultural ecosystems.

1.2 OBJECTIVE OF THE STUDY: -

The central objective is to know the ecosystem services degradation in peri-urban areas in response to urbanization and land use land cover changes in order to maintain ecological footprints, and thus to strengthen ecosystem services to reduce vulnerability of common people.

The study of following objectives in given sequence will explain the main objective:

1. To understand levels and tempo of urbanization process in National Capital Region.
2. To study the sub-urbanization process in National Capital Region and its impact on the towns of NCR through socio-economic development.
3. To measure the land use land cover changes due to urban growth in Ghaziabad and Faridabad districts.
4. To measure the effect of changes in Land use land cover over ecosystem services and how changes in land use land cover has affected supply of benefits and services from ecosystems in Ghaziabad and Faridabad districts.
5. To study the relationship among loss of agricultural land, ecosystem services and sustainable development. It will also include evaluation of impacts of policy interventions on urbanization and ecosystem services.

1.3 RESEARCH HYPOTHESIS: -

- Due to the increasing population pressure, the urban areas are expanding and putting pressure on the land resources of the hinterland.
- The urbanization process in NCT Delhi is also impacting developmental process in peri-urban areas and towns of NCR.
- The increasing population and their increasing demands as well as industrialization and economic development are putting pressure on the resources of National Capital Region.
- These processes are leading to changes in the land use and land cover in the National Capital Region especially in the satellite towns of NCT Delhi.
- Due to this change in land use land cover the natural ecosystems are being affected severely in National Capital Region. The urban sprawl is causing shrinkages in the

agricultural as well as barren land, so the most affected ecosystem is agriculture ecosystem.

- To increase the production capacity of agricultural ecosystem we are compromising with the degradation of other ecosystems. To minimize the degradation of ecosystem services a better sustainable developmental approach is needed.

1.4 SCOPE OF THE STUDY: -

The process of urbanization and industrialization has many benefits as well as many challenges. Due to this many issues emerges before us that put challenges to the humanity. National Capital Region is a very big area to study so it is difficult to study every topic within the limited time frame. Therefore it is very necessary to determine the boundary of your research and to work only with specific cases of the interest. Here my study is limited to the impacts of urban sprawl on land use land cover in the satellite towns of the NCR region. This will explain the level and extent that how the urban sprawl is degrading ecosystem services in the urban areas. To emphasis the application of earth observation datasets and spatial techniques for development studies, a case study done by European Space Agency (*Historical Assessment of Spatial Growth of Built-Ups in Metropolitan Areas of Delhi and Mumbai in India and Dhaka in Bangladesh*) has demonstrated an empirical approach to quantify land use categories at various levels. Proposed framework has been adopted and required information for ecosystem services is extracted from available remote sensing datasets.

The major issues that will be covered are the increasing population pressure and resulting urban sprawl, changing pattern of land use and land cover due to urban growth, degradation of ecosystem services in the Ghaziabad and Faridabad districts of NCR due to the mismanagement and over-exploitation of the resources, role of human interventions and degradation of ecosystem in peri-urban areas, administrative policy and services provision to deal with the deteriorating situation of ecosystem in the peri-urban areas. The study will deal with the detailed discussion on the loss of agricultural land and resulting degradation of agricultural ecosystem services. A concern has been raised about the decreasing agricultural cover and to meet the demands of increasing population in a sustainable development approach. Apart from it the incompleteness of MDGs and implementation of SDGs in future are key areas to think.

1.5 LIMITATIONS OF THE STUDY: -

The study is mainly focused on the analysis of the satellite data. The satellite data which has been used is not of very high resolution data. It has coarse resolution of 30 meters. So to the some extent results may be varying from the other research outputs. The higher resolution data could have produced better results. The results will be analysed with the census data. But there are difficulties in studying results at micro level due to the unavailability of data and sources. The values of ecosystem services for all ecosystems are not available at micro level. The global average doesn't present a true picture before us. Apart from it the values of ecosystem services changes according the importance of the ecosystem in a particular time. It requires most recent values of ecosystem services.

1.6 METHODOLOGIES: -

1. The urban population decadal growth rate will be calculated to present the increase in population in different census years. The formula to calculate decadal growth rate is following: -

   Percentage decadal growth rate of urban population:

   $$= ((P_1 - P_0)/ P_0) * 100$$

   Where, P_1 = Urban population in the current year.

   P_0 = Urban population in the base year.

2. Level of urbanization in National Capital Region has been analyzed by calculating percentage urbanization. It refers to absolute or relative number of people living in urban Area at specific point of time.

   $$\text{Percentage Urban Population} = (P_u / P_t)*100$$

   Where, P_u = Urban population of the specific time

   P_t = Total population of that specific time

3. Further tempo of urbanization has been measured. This can be measured as the change in the rate over two different time periods or as change in the absolute values.

   $$T_A = 1/n(P_u^{t+1} - P_u^{t})$$

   Where, T_A = Tempo of urbanization

   N = number of years passed between two times.

   P_u = Percentage of urban population at the year t and t+n.

4. The district wise concentration of urban population in National Capital Region has been measured through 'Location Quotient'.

$$LQ = [p_{uj} / p_{tj}] / [P_{un}/P_{tn}]$$

Where, p_{uj} = Total urban population of j^{th} district

p_{tj} = Total population of j^{th} district

P_{un} = Total urban population of NCR.

P_{tn} = Total population of NCR.

5. The urbanization influence of NCR on the towns of NCR has been measured through 'Location Quotient'. The following procedure has been adopted to measure the influence with increasing distance.

1) Formation of Buffer Zone: -

To measure the influence on towns with increasing distance from NCT Delhi, the NCR has been divided into 4 zones. The NCT Delhi is considered as core. The distance is taken from centre of NCT Delhi. Thus four buffer zones have been identified.

I.	Ring 1	-	0 to 50 km
II.	Ring 2	-	50 to 100 km
III.	Ring 3	-	100 to 150 km
IV.	Ring 4	-	Beyond 150 km

2) Selection of Indicators: - The following indicators have been selected to measure the NCR urbanization influence on the towns of NCR.

I. Population Size,
II. Population Growth,
III. Population Density,
IV. Sex-Ratio,
V. Literacy Rate,
VI. Household Size,
VII. Work Participation Rate and

VIII. Main Workers in Non-primary activities.

The indicators are standardized through the technique of location quotient. To find location quotient of indicators the each individual figure of towns are divided by the average of individual figure of all towns of NCR. Thus all indicators are standardized first. The standardized location quotient figures are then summed and averaged to obtain a composite index.

Composite Index = $\sum$ LQ/N

This composite index represents urbanization influence of NCR on towns of NCR.

6. The Landsat images have been classified to detect land use land cover changes. Supervised Classification has been used to detect the changes of land use land cover for two time periods respectively, 2011 and 2013. Apart from it the pixel mixing has been corrected by recoding method.

7. The valuation of ecosystem services for each land use land cover category is done using the Basic value transfer aggregation method. The value of ecosystem service for each land use land cover category has been calculated for 5 years, 1991, 2003, 2010, 2011 and 2013.

$$ESV = \sum (A_k \text{ x } VC_k)$$

Where, ESV is the total estimated ecosystem service value,

A_k is the area (ha) for land use category 'k' and

VC_k is the value coefficient ($\$ha^{-1}yr^{-1}$) for land use category'k'.

The Erdas 10 and ArcMap 10 have been used to show analysis through maps and diagrams.

1.7 PROFILE OF THE STUDY AREAS: -

In this study I have taken two districts of national capital region. These two districts are Ghaziabad and Faridabad districts. The two districts Ghaziabad and Faridabad are one of the fastest developing districts of National Capital Region. The Ghaziabad district is part of the Uttar-Pradesh sub-region of National Capital Region and Faridabad district is part of Haryana sub-region of National Capital Region. The urbanization and industrialization has changed the land use land cover scenario in and around NCT Delhi. This is followed by socio-economic development and changes in the ecosystems.

1.7.1 PROFILE OF GHAZIABAD DISTRICT: -

Ghaziabad district is one of the fastest developing districts of National Capital Region. It is located in the north-eastern part of NCT Delhi and western part of Uttar-Pradesh. Apart from it is the fastest developing district of Uttar- Pradesh sub-region of National Capital Region. Ghaziabad district is named after its headquarters city 'Ghaziabad'. It is a part of revenue division Meerut. On the western side it is bounded by NCT Delhi and Baghpat district of UP state. In north it is bounded by Meerut district. The southern boundary is formed by Gautama Buddha Nagar District of UP state. Hapur district forms its eastern boundary. Earlier Hapur district was part of Ghaziabad district. Now there are only two tehsils in Ghaziabad district respectively, Ghaziabad and Modinagar (2011). Now the total area of Ghaziabad district is around 684sq.km (2011). The district is situated in the middle of Ganga- Yamuna Doab in the Upper Gangatic Plain. The region may be divided into four main divisions.

(a) Low lands (Khadar) in the East of Ganga River and West of Yamuna River
(b) Area between the river Ganga & kali Nadi
(c) Doab area of Kali river & Hindon River and
(d) Doab of Hindon and Yamuna rivers.

Except Kali River all the rivers are perennial rivers which make the region very fertile. The district is predominantly characterized by the flood plains of the perennial rivers. No significant minerals are found here except sand which is used in brick kilns for construction purpose. The hindon River flows through the Ghaziabad city from North to South and divides the city into two Halves which are Cis-Hindon Area & Trans-Hindon Area. The mean height of the region is 210 meters above sea level. So the district has plain and fertile land sloping in South. Ghaziabad falls in the Northern India so it experiences three seasons primarily, winter, summer and monsoon. According to meteorological department of India the temperatures

during summer season, remain in between 30°C to 45°C, whereas, in winter the temperature fluctuates from 5 °C to 25°C. The following table illustrates the temperature and rainfall conditions of the year 2002.

TABLE 1.1: TEMPERATUE AND RAINFALL DATA OF GHAZIABAD DISTRICT

Month	Maximum(°C)	Minimum(°C)	Rainfall(mm)
January	21.8	7.5	15.2
February	24.4	10	15.6
March	31.1	16.1	4.9
April	38	22.9	1.6
May	41	26.7	2.1
June	39.2	27.6	35
July	36.7	28.3	22
August	34	26.5	136.8
September	32.5	22.7	177.1
October	33.7	19.6	1
November	28.9	13.2	0.1
December	23.8	8.9	9.1

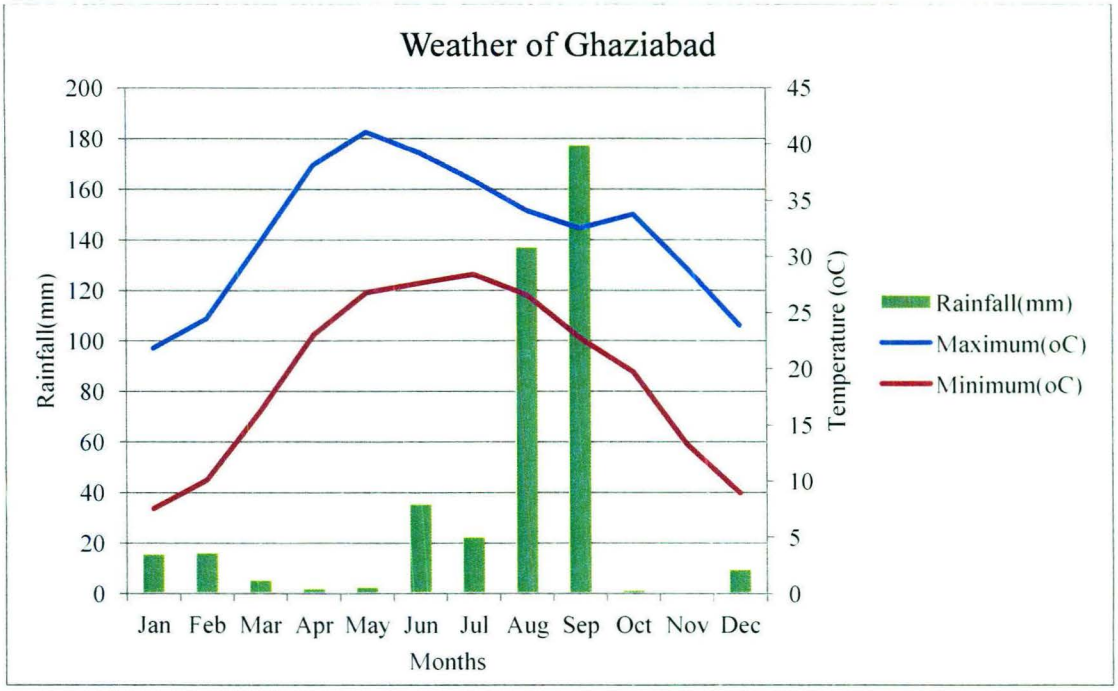
(Data Source: India Water Portal, 2002)

This district of Uttar Pradesh experiences subtropical monsoon climate. In winter cold winds blowing from Himalaya lowers the temperature in the region as low as 2°C. While in summer season dry winds (LOO) blowing from the arid and semi-arid west increases the temperature as high as 45°C.

Most of the rainfall is received in the summer season due to the south-west monsoonal winds which blows from the Bay of Bengal. Around 85% rainfall happens in the months between July to September. A very small amount of rainfall is received in winter season due to westerly disturbances. Simply the climate of the region divided into three seasons: (a) cold winter season- (December to February), (b) hot summer season- March to June, (c) warm moist season- (July to September) and (d) mild winter season- (October to November). The region experiences the extremities of the climate as the temperature ranges from 2°C to 45°C. The coldest part of the year is from mid-December to mid-January. Sometimes during this time very foggy and misty conditions prevail even till afternoon. After onwards from January to March the climate remains mild warm. The temperature gradually peaks in the months

from April to June. The warm winds called 'Loo' blows from the west causing scorching summer climate. The atmosphere gains humidity as the monsoon arrives near and climate becomes warm-humid after July. After September the average temperature decreases slowly and towards the end of October the starting of winter is signalled. The following bar-graphs illustrate the conditions clearly.

FIGURE 1.1: WEATHER CONDITIONS OF GHAZIABAD DISTRICT



(Data Source: India Water Portal, 2002)

1.7.2 PROFILE OF FARIDABAD DISTRICT: -

This is the south-eastern district of Haryana state in India. It was founded by Seikh Farid to protect the highways that pass through the district. The district headquarters is around 25kms away from Delhi. Its eastern boundary is separated by the Yamuna River with Uttar-Pradesh state. In the north it is bounded by NCT Delhi and on east it is bounded by Gurgaon. In south Palwal district makes it southern boundary. Earlier Palwal district was part of Ghaziabad district. Now there are only two tehsils Faridabad and Ballabhgarh in Faridabad district (2011). The total area of Faridabad District is around 743sq.km (2011).

The Faridabad district is also situated on the plains of the Yamuna River. It has an average elevation of 198 meters. The district is mainly drained by the perennial river Yamuna. The Aravalli tract forms its north-western boundary. It is also the source of small streams which

flow during rainy season. These factors make the district very fertile. The slope of land is generally from North-west to South-east and South.

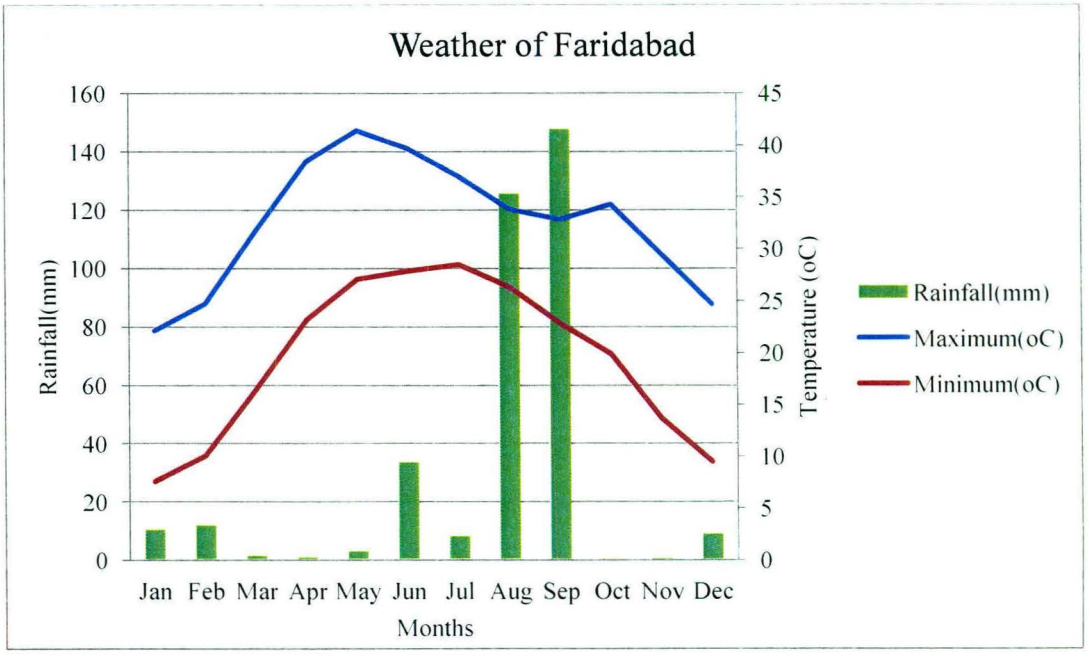
Faridabad district lies in hot and semi-arid region. The weather becomes extreme dry in months except rainy season. The temperature gradually peaks in the months from April to June. The most of the precipitation happens between June to September month. This rainfall happens due to the northward onset of south-western monsoon. This causes heavy rainfall and humidity between June to September month. The cold weather prevails last week of November to mid of March. The winters are very chilly. The fog spreads during winter season due to pollution by industrial units in the district. The following table illustrates that the temperatures during summer season, remain in between 31°C to 43°C, whereas, in winter the temperature fluctuates from 7 °C to 24°C. The following table and map illustrates the temperature and rainfall conditions of the year 2002.

TABLE 1.2: TEMPERATURE AND RAINFALL DATA OF FARIDABAD DISTRICT

Month	Maximum(°C)	Minimum(°C)	Rainfall(mm)
Jan	22.103	7.562	10.443
Feb	24.693	10.047	11.858
Mar	31.74	16.442	1.413
Apr	38.416	23.164	0.89
May	41.415	27.067	3.011
Jun	39.663	27.843	33.464
Jul	36.974	28.478	8.143
Aug	33.8	26.299	125.554
Sep	32.818	22.824	147.713
Oct	34.285	19.868	0.561
Nov	29.461	13.658	0.581
Dec	24.689	9.468	8.958

(Data Source: India Water Portal, 2002)

FIGURE 1.2: WEATHER CONDITIONS OF FARIDABAD DISTRICT



(Data Source: India Water Portal, 2002)

1.7.3 RATIONALE BEHIND THE STUDY AREA: -

Delhi is the biggest city of North India. NCT Delhi is in the last stage of urban development. It has no barriers on its expansion in any direction. It is expected that the increasing burden on NCT Delhi will be shared by the towns of adjoining districts (NCR plan, 2021). The expansion of NCT Delhi has been in those directions in which there is good connectivity. The major National Highways 8, 2 and 24 that connect Delhi to other cities like Jaipur, Mumbai, Kanpur, and Allahabad etc. passes through Gurgaon, Ghaziabad Faridabad and GTB Nagar districts. These adjoining districts Gurgaon, Ghaziabad, Faridabad and GTB Nagar of NCT Delhi are in east, south-west and south and south-east directions. Most of the urban expansion and infrastructural development has been in these districts compared to other districts of National Capital Region. The districts Ghaziabad and Faridabad are one of the most developing districts of NCR Delhi. Ghaziabad is one of the 10 fastest developing towns of the world (UN report, 2011). The urban expansion in these districts will be followed by land use land cover changes. The changes in land use land cover will affect the ecosystem functioning. The urban expansion and expected decrease in agricultural land can have negative impacts on the ecosystems of these adjoining districts. It poses challenges of environmental pollution as well as food security in the region. So there is need of a sustainable development planning to minimize environmental losses or degradation. In this study a monitoring of the environmental losses is done through GIS and remote sensing techniques.

1.8 DEMOGRAPHIC SCENARIO OF GHAZIABAD AND FARIDABAD DISTRICTS:-

1.8.1 POPULATION SIZE: -

According to the census 2011 the population of India is 1.210.193.422. An increase of 1. 831. 781. 75 persons is observed from the previous census year. According to the census 2011 the population of Ghaziabad district is 3343334. The following table illustrates the increasing scenario of population in Ghaziabad and Faridabad districts from 1981 to 2011.

TABLE 1.3: ABSOLUTE POPULATION OF GHAZIABAD AND FARIDABAD DISTRICTS, 1981-2011

Year	INDIA	NCR Region	Ghaziabad	Faridabad
1981	683329097	19883168	878681	630274
1991	846421039	27362532	1319367	859442
2001	1028737436	37100266	2184930	1364123
2011	1210193422	46049032	3343334	1809733

(Data Source: Census of India 1981, 1991, 2001 and 2011)

The population of NCR region has two and half times increased from 1981 to 2011. While the population of Ghaziabad district is four times of 1981 in 2011. A net increase of around 10 lakh people can be seen in Ghaziabad district from 2001 to 2011. A tremendous increase is observed in the population of Ghaziabad. Similarly the population of Faridabad district has tripled over the 30 years time period. In Faridabad district a net increase of around 5.6 lakh people can be measured from census 2001 to 2011.

1.8.2 DECADAL POPULATION GROWTH: -

It is the rate that indicates the % growth of population over a time period of 10 years. This change in growth may be due to natural increase or decrease and due to in-migration or out-migration. The assessment of this growth rate helps in the future regional development plans.

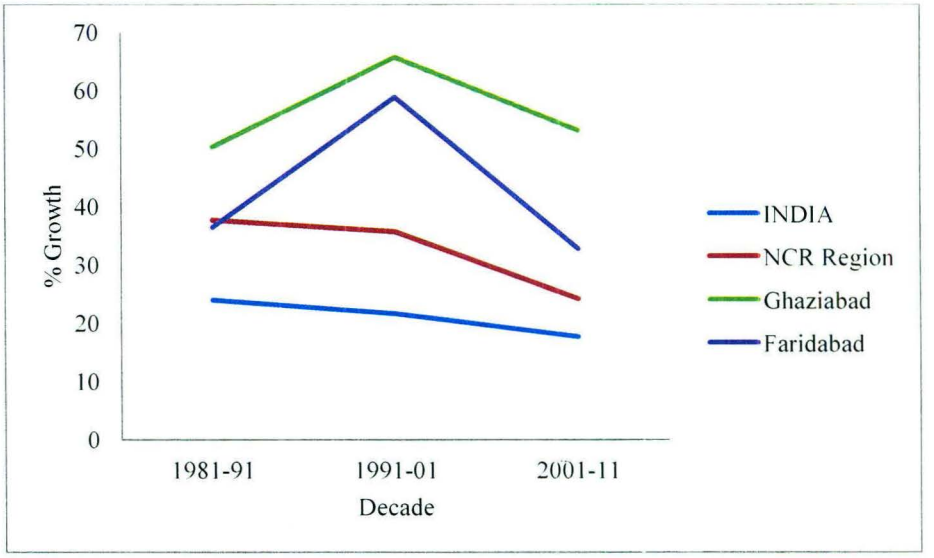
TABLE 1.4: DECADAL POPULATION GROWTH RATE OF GHAZIABAD AND FARIDABAD DISTRICTS

Decade	INDIA	NCR Region	Ghaziabad	Faridabad
1981-91	23.87	37.62	50.15	36.36
1991-01	21.54	35.59	65.60	58.72
2001-11	17.64	24.12	53.02	32.67

(Data Source: Various Census Reports)

As the table indicates above the population growth of India and NCR region shows a declining trend in the last 30 years. In the Ghaziabad district the decadal population growth rate is quite high. In the recent census data a declining trend of population growth is observed in both Ghaziabad and Faridabad districts. Although, the population growth is declining but it is still very high. A number of industrial activities are activated in Ghaziabad city so this increase in population growth may be attributed mainly to the in-migration rather than natural increase.

FIGURE 1.3: DECADAL POPULATION GROWTH RATE OF GHAZIABAD AND FARIDABAD DISTRICTS



(Data Source: Various Census Reports, 1981, 1991, 2001 and 2011)

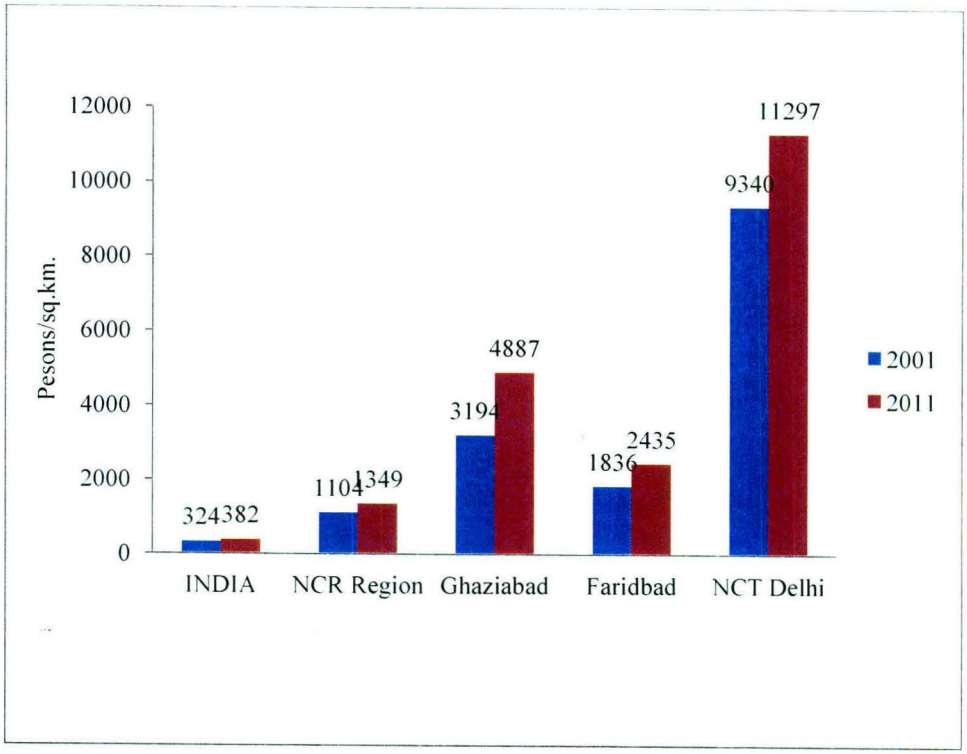
The population growth rate in Ghaziabad district in 1981-91 was around 50%. In 2001 it increased and reached up to 65.5%. In census 2011 a declining trend is observed in Ghaziabad district as the population growth was 53.02%. Yet this 53.025 population growth adds around 10 lakh people to the population of Ghaziabad district. Similarly in Faridabad district the population growth rate in 1991-1 was 58.72% which is very high. According to

the census 2011 the population growth rate of Faridabad is 32.67%. this huge increase in population in 2001 partially may be attributed to the in-migration than natural increase of population.

1.8.3 POPULATION DENSITY: -

Due to the large scale increase in population the population density has increased significantly. In Ghaziabad district the population density was 3194 persons/Km^2 in 2001 which increased to 4887 persons/Km^2 in 2011. Thus Ghaziabad is the district which has highest population density if compared to the other districts of Uttar Pradesh sub region of NCR. In Faridabad district the population density was 1836 persons/Km^2 in 2001 which increased to 2435 persons/Km^2 in 2011. In both districts population density has increased significantly.

FIGURE 1.4: POPULATION DENSITY OF GHAZIABAD AND FARIDABAD DISTRICTS

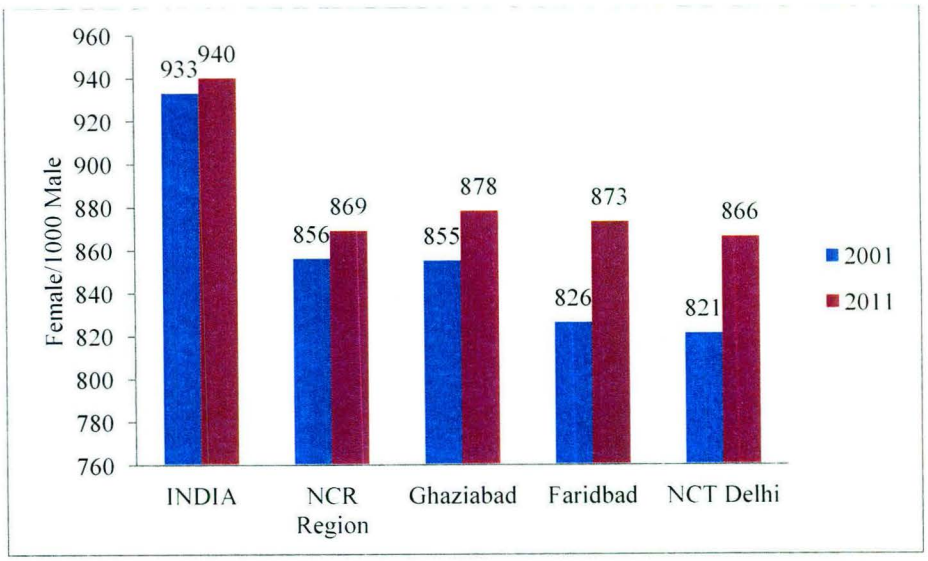


(Data Source: Various Census Reports)

1.8.4 SEX RATIO: -

If we look Sex Ratio in Ghaziabad, it stood at 881 per 1000 male in 2011 compared to 2001 census figure of 860. The average national sex ratio in 2001 was 933 now it is 940. In Ghaziabad city the sex ratio is 885 in 2011 which was 858 according to census 2001. Overall at the national level, district level and the city level we can observe increase in the sex ratio, which is a good sign for women empowerment. In Ghaziabad district urban sex ratio is 882 while rural sex ratio is 880 according to census 2011. So there is not much difference between rural and urban sex ratio.

FIGURE 1.5: SEX RATIO IN GHAZIABAD AND FARIDABAD DISTRICTS



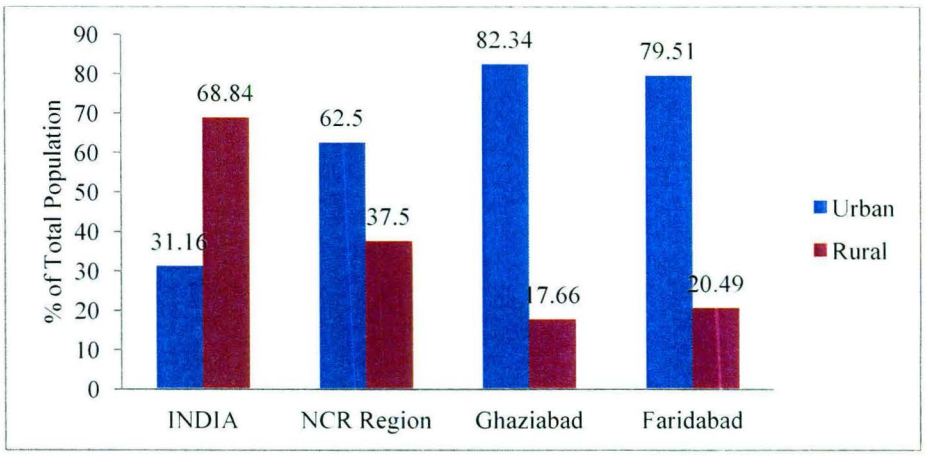
(Data Source: Various Census Reports)

Although we can observe an increasing trend in sex ratio but the sex ratio in Ghaziabad district as well as in Ghaziabad city is very low from the national average. It is a matter of great concern.

1.8.5 RURAL-URBAN COMPOSITION: -

According to the census 2011 around 31.16% population of India live in urban areas. The no. of towns has also increased from 5161 in 2001 to 7935 in 2011. In National Capital Region around 37.5% population is urbanized and 62.5% population is categorized as rural population. India currently contains three of the world's ten fastest growing cities- Faridabad, Ghaziabad and Surat, as well as three of the world's ten largest cities in terms of population (United Nations, 2011). Ghaziabad is the most urbanized district of Uttar-Pradesh sub-region in National Capital Region. According to census 2011, 82.34% population of this district is urbanized. Rest only 17.66% is rural population. While in 2001 only 68.54% population was urbanized and rest 31.45% was rural. In Haryana sub-region of NCR the most urbanized districts are Gurgaon, Rewari and Faridabad.

FIGURE 1.6: RURAL-URBAN COMPOSTION IN GHAZIABAD AND FARIDABAD DISTRICTS



(Data Source: Various Census Reports)

Faridabad is most urbanized district of Haryana sub-region after Gurgaon. According to census 2011 around 79.5% population of Faridabad district is urbanized. Only 20.5% population is rural. It is evident from the census data that the share of urban population is increasing gradually in Ghaziabad as well as Faridabad district. When compared to the 2001 census data it is clear that there is a large increase in urban population in both districts. The density has increased very much causing pressure on the resources of the region. The graph above explains the rural-urban composition of population from macro to micro.

CHAPTER II

OVERVIEW OF LITERATURE

2.1 LITERATURE SURVEY: -

All over the world population is increasing significantly booth in developed as well as developing states. The population of India has increased to 1210 million in 2011 comprising 31.16% urban and 68.84% rural population. The proportion of urban population has increased over the time in India from 27.81% to 31.16% respectively in 2001 and 2011.[1] The process of urbanization produces new opportunities and betterment of human life as well as new challenges. This simply attracts human beings to migrate to places that make their lives happier. Middle and high income category migration increase because of new opportunities of jobs, education purpose, due to the process of globalisation.[2] In India migration flows are different and slow from rest of the world.[3] The burden is continue to grow on large cities and smaller cities are not developing as needed. So in big cities pressure is extending in the adjoining peri-urban areas. The peri-urban areas are not being developed in a scientific and environment-friendly way. What is peri-urban today may be included in urban area in future. There is need to regulate the services in a better way at the peri-urban level lest the problems may not intensify when it becomes urban.

To regulate the services we have to maintain the human environment relations in urban and peri-urban areas. We are benefited from the ecosystem in many ways. These benefits are termed as ecosystem services. In urban areas also we are benefited in different ways. Typically, ecosystem services that human benefit from range from water and climate regulation functions, over biodiversity and pollination, to aesthetic and recreational services.[4] the urban ecosystem services can be ranged from local, regional to global scale. According to the Millennium Ecosystem Assessment Costanza et al. (1987), (MEA, 2005) and more recently TEEB (2011), we can define urban ecosystem services in four categories respectively; provisioning services, regulating services, cultural services and habitat and supporting services.

The process of urbanization and modernization significantly affects the relations of human to the environment. Human makes significant changes in the natural environment that have negative impacts on the ecosystem, health and livelihoods of citizens. The land use pattern

[1] Rural Urban distribution of population (provisional population totals) Census of India 2011.
[2] Kundu.A, Lopamudra R.S (2012): "Migration and Exclusionary Urbanisation in India", Economic & Political Weekly, XLVII (26/27): 219-227.
[3] Kundu,A.; Trends and Processes of Urbanization in India, sept,2011.
[4] Breuste J., Dagmar Haase D. and Elmqvist T.; (2013); Urban Landscapes and Ecosystem Services; Ecosystem Services in Agricultural and Urban Landscapes, First Edition. Edited by Steve Wratten, Harpinder Sandhu, Ross Cullen and Robert Costanza; 2013 John Wiley & Sons, Ltd.

changes with the increasing urbanization. The increasing urbanization is always a challenge for the agriculture land use because in general the demand, production factors and availability of new land determine the land use intensity.[5] The globalization, economic complexities, dynamic interrelations and commodity flows at regional and global level signifies that there are linkages between urban areas and non-urban areas.[6] The urban areas cause a lot of problems to its peri-urban areas and rural urban fringes. The increasing density in urban area cause pressure on the fringe area which leads to the corrupted use of the environment and resulting degrades the ecosystem.[7] In an urban area, UES like fresh water supply, waste management, landscape recreation, access to food etc. are very important. In developing countries urban waste management is the most significant problem. There are problems from household level to disposal level in management of urban waste. The process of urbanization in Delhi, Mumbai and other big cities in India ran so fastly that they forget to provide the facilities to combat the negative impacts of urbanization.[8] In such a degrading environment conditions for sustainable development there is need to identify and quantify the links between biodiversity and ecosystem services on the one hand, and poverty reduction on the other, while taking into account the global, regional, and local drivers of biodiversity loss in poor areas.[9] On the basis of above studies it can be said that the process of urbanization and changing land use land cover patterns are expected to pose a great risk to the environment and its services in future.

2.2 POPULATION GROWTH AND URBANIZATION: -

It is estimated that currently world population is growing at 1.2 percent annually. The world population with current rate of growth will reach to 8.1 billion in 2025 and 9.6 billion in 2050.[10] Population growth can be controlled but can't be stopped. It is inevitable characteristic of population in the current developmental process. In future the global fertility trends will determine the population growth. The developed and developing countries will

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[5] Jiang, L., Deng, X. and Seto,K.C.; (2013) ; The impact of urban expansion on agricultural land use intensity in China; Land Use Policy, no. 35 pp.33 - 39.

[6] Seto, K.C., Reenberg, A., Boone, C.G., Fragkias, M., Haase, D., Langanke, T., Marcotullio, P., Munroe, D.K., Olah, B. and D. Simon, 2012. Urban land teleconnections and sustainability, Proceedings of the National Academy of Sciences (PNAS) – Sustainability Science, published ahead of print May 1, 2012.

[7] Sancar,C., Turan, S.O. and Kadiogullari, A.H.; Land use-cover change processes in Urban fringe areas: Trabzon case study, Turkey; Scientific Research and Essay Vol.4 (12), pp. 1454-1462, December, 2009.

[8] Talyan, V., Dahiya, R.P. and Sreekrishnan, T.R.; State of municipal solid waste management in Delhi, the capital of India; Waste Management 28 (2008) 1276–1287.

[9] Sachs, J. D. and other co-werkers; Biodiversity Conservation and the Millennium Development Goals; Science, Vol, 325, 1502-1503.

[10] United Nations Department of Economic and Social Affairs/Population Division; World Population Prospects; The 2012 Revision; Key Findings and Advance Tables; United Nations, New York, 2013.

have two different patterns of population growth. From present to 2100 the population will increase more rapidly in developing countries rather than developed countries. Apart from it the overall increase will be much in the countries with high fertility rates and as well as in the countries with large population, like India.[11] United Nations reports reveal that in developed countries the number of young children and young people is high which will pose a major challenge to their countries. ; By 2050, the population of less developed countries will number over 8 billion, or 86 percent of world population.[12] The developing countries are facing and continue to face the problem of urbanization, food scarcity, drinking water, waste management and environmental sustainability etc. In India we see that the population has increased from 1028 million to 1210.2 million respectively from 2001 to 2011 accounting 17.5% of the world population.[13] Although the fertility rate has declined over the time but population is so large that even 2 percent annual growth adds a large population.

The population of India will exceed China till 2050. The current population projections show that in 2050 population of India and China respectively will be 1691 and 1311 million.[14] The decadal growth rate of population shows a declining trend 23.87%, 21.54% and 17.64% respectively in 1981-91, 1991-01 and 2001-11 but the density has increased from 325 (2001) to 328 (2011).[15] It is very difficult to meet the demands of the increasing population. The rural as well as urban areas are pressurized due to the demands of increasing population. As United Nations reports that 50 percent population of world, around 3.6 billion people live in urban areas.[16] The pressure on urban areas is likely to increase because the process of urbanization is fast in the developing countries. That will put additional pressure on the resources as well as on peri-urban resources and environment.

In past two decades the developing countries are getting urbanized rapidly. It is leading to the increase of the urban settlements, specially the slum areas which are creating many problems. Urban population of India has increased from 25.8 million in 1901 to 62.4 million in 1951 and to 285.4 million in 2001, thereby showing more than ten-fold increase in total urban population.[17] In India urban population was 25.72% and 27.78% of total population respectively in 1991 and 2001 which has increased to 31.16% in 2011 (Census 2011). The number of towns has increased from 5161 to 7935 and number of

[11] United Nations Department of Economic and Social Affairs/Population Division; World Population Prospects; The 2012 Revision; Key Findings and Advance Tables; United Nations, New York, 2013.
[12] World Population Data Sheets; Population Reference Bureau; 2012.
[13] Provisional Population Totals - India - Data Sheet; Census of India 2011.
[14] World Population Data Sheets; Population Reference Bureau; 2012.
[15] Provisional Population Totals - India - Data Sheet; Census of India 2011.
[16] Rural Urban Dynamics and the Millennium Development Goals; Global Monitoring Report, 2013.
[17] Population tables, Census of India.

metropolitan cities (+ 1 million cities) has increased from 35 to 53.[18] It means 18 new metropolitan cities have been categorized. This increase in urban population in 2011 was more due to the in-migration and reclassification of rural settlements into urban than natural increase. In past decades urbanization in India has been exclusionary, focusing mainly on the large cities and small cities cannot grow significantly.[19] It is analysed that in the process of urbanization the distribution of urban population in India has largely been focused on big cities.[20] This significantly pressurized large cities affecting the quality of life and environment in urban and peri-urban areas. In India small towns experienced slow urban growth and the low economic base which ultimately discouraged the urban growth. India has underinvested in its cities; China has invested ahead of demand and given its cities the freedom to raise substantial investment resources.[21] Instead of putting pressure on the peri-urban of big cities, small cities should be developed. In India rural migrants direct towards class 1 cities rather than other cities.[22] In India the mega cities have to face problems like slums, availability of fresh drinking water, electricity, sanitation to the poor and rural migrants.[23] It will ultimately result to the growth of all regions. Traditionally, the PUI has been defined as'the edge of the city', the 'urban fringe'or as the 'spatial transition zone between urban and rural areas'.[24] The peri urban interfaces (PUI) are the linkages that transform rural areas into urban areas.

At the global level, land use by humanity is transforming land cover at an accelerating pace.[25] Land use land cover are so important that when aggregated globally, they significantly affect the Earth system functioning.[26] There are several factors that change land cover and affects the land use capacities also. The natural driving forces of Earth and human interaction changes the land cover at different pace. The physical and socio-economic conditions of a region determine that up to what level land cover and land use will be changed. The speeding world population requires a large number of resources to meet their increasing demands. The

[18] India's Urban Demographic Transition; The 2011 Census Results (Provisional); National Institute of Urban Affairs; November 4, 2011.
[19] Kundu, A (2011); Politics and Economics of Urban Growth", Economic & Political Weekly, XLVI (20):10-12.
[20] Kundu, A. (2006); Trends & patterns of urbanization and their economic implications. India Infrastructure Report, pp. 28–41.
[21] World Population Data Sheets; Population Reference Bureau; 2012.
[22] Premi, M. K. (1991);"India's Urban Scene and Its Future Implications", Demography India, 20(1)
[23] Kundu, A., Bagchi, 5. and Kundu, D. (2010); Regional Distribution of Infrastructure and Basic Amenities in Urban India - Issues Concerning Empowerment of Local Bodies; Economic and Political Weekly, 34(28).
[24] Kölbl, R. and Haller, R.; Periurban – A Comparison Between India And Western Countries; Association for European Transport and contributors 2006.
[25] Turner II, B.L., W.B. Meyer and D.L. Skole. (1994); Global Land-Use/Land-Cover Change: Towards an Integrated Program of Study. Ambio 23 (1): 91-95.
[26] Lambin. E.F., Turner, B.L., and et al. (2001); The causes of land-use and land-cover change: moving beyond the myths; Global Environmental Change, 11: 261–269.

basic needs like food, water, shelter etc. will require land resources which will ultimately lead to the encroachment of natural areas. The increasing agricultural land demand, changing consumption patterns, urbanization and economic development intensifies the human intervention on natural areas which ultimately result to changes in Land use/land cover (LULC).[27] The increase of population and economic growth is causing expansion of megacities which causing pressure on natural resources.[28] The most direct impact of cities on biodiversity is the change in land cover associated with urban growth.[29] In year 2008 more than 50% population of world was urban and it is expected to reach by 81% in 2030.[30] Various studies explain that in developed countries the urbanization process was planned and controlled while in developing countries the urbanization process is very rapid, unplanned and uncontrolled. In India the urbanization process has been oriented towards big cities only.[31] So it is obvious that the big cities will put more pressure on natural resources of the hinterland. This ultimately will affect the land use land cover practices in the hinterland. Urban Growth in India is often nucleate, with newly urbanized land usually seen in a tight band around the older parts of the city.[32] Built-up area of Delhi witnessed an overall increment of 17% of the total area i.e. from 540.5 km^2 to 791.6 km^2 during the study period 1997 to 2008 which mainly came from agriculture land and waste land.[33] Population pressure coupled with immigration from different parts of the country in search of employment has put tremendous pressure on the natural resources—land, water, and air—of Delhi and surrounding areas, known as the NCR.[34]

In a study of Gurgaon district, the expansion of the city has altered patterns of rural natural resource use, created social, cultural and economic changes, and bred resentment among

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[27] Sharma,M.P., Archana, Prawasi,R. and Hooda, R.S. (2013); Land Use /Land Cover Change Detection in National Capital Region(NCR) Delhi: A Case Study of Gurgaon District; International Journal of Remote Sensing & Geoscience; Volume 2, Issue 5.

[28] Mohan,M., pathan, S. K., Narendrareddy, K., kandya, A. and Pandey,S. (2011); Dynamics of Urbanization and Its Impact on Land-Use/Land-Cover: A Case Study of Megacity Delhi; Journal of Environmental Protection, 2, 1274-1283.

[29] McDonald, R. I., Marcotullio, P. J. and Guneralp, b.; Chapter 3:Urbanization and Global Trends; Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities A Global Assessment A Part of the Cities and Biodiversity Outlook Project.

[30] United Nations Population Fund, "The State of World Population 2007: Unleashing the Potential of Urban Growth," United Nations Publications, Chapter 1, 2007.

[31] Kundu A.(2006); , Trends & patterns of urbanization and their economic implications, India infrastructure report 2006 pp 28-41.

[32] Nagendra, H., Sudhira, H. S., Katti, M., Tengo, M. and Schewenius, M. (2014); Urbanization and its impacts on Land Use, biodiversity and Ecosystems in India; interdisciplinia2, no.2. 305-313.

[33] Mohan,M., pathan, S. K., Narendrareddy, K., kandya, A. and Pandey,S. (2011); Dynamics of Urbanization and Its Impact on Land-Use/Land-Cover: A Case Study of Megacity Delhi; Journal of Environmental Protection, 2, 1274-1283.

[34] Kumar, P. (2009); Assessment of Economic Drivers of Land Use Change in Urban Ecosystems of Delhi, India; A Journal of the Human Environment, 38(1):35-39.

many periurban residents against urban authorities.[35] It is a great challenge for developing countries to provide shelter for the increasing population in the big cities. As from various studies it is explained that the hinterland of National Capital Region is shrinking due to land acquisition for built-up or industrial purpose. This land use land cover change due to urbanization of hinterland is causing social, cultural and economic changes. Similar a study of Bhiwani district of Haryana state explains that agricultural land has been reduced and has shifted to built-up due to rapid urbanization.[36] In Delhi urban fringe, the agricultural land is facing problems like fragmentation of land, excavation of fertile soil for brick kilns, transformation into farmhouses etc.[37] in most of the studies these types of problems have been identified in the Delhi urban fringe. Various causes of urban expansion for example population growth, economic development, migration and infrastructural innovations are resulting in transformation of villages into towns, towns into cities and cities into metro cities.[38] In Faridabad and Palwal districts also deforestation of the areas and rapid rate of urbanization have resulted marked changes in the built-up.[39] India currently contains three of the world's ten fastest growing cities- Faridabad, Ghaziabad and Surat, as well as three of the world's ten largest cities in terms of population.[40]

All the studies that have been discussed here in literature review talk about the people's negligence for agricultural land. On the basis of above studies almost every district of NCR faces the problems of land acquisition and fragmentation of fertile land. It is so because the patterns of urbanization affect patterns of biodiversity. Apart from it the overutilization of water and fertilizers is causing salinization problem in the National Capital Region. To get more production per hectare the farmer uses fertilizers beyond absorption capacity of land. This additional amount of fertilizers washed away to water sources during rainy season.

2.3 URBAN GROWTH AND ECOSYSTEM SERVICES:-

[35] Narain, V.; Growing city, shrinking hinterland: land acquisition, transition and conflict in peri-urban Gurgaon, India; International Institute for Environment and Development (IIED); Volume 21(2): 501–512.
[36] Sharma, M. P., Yadav, K., Prawasi, R. and Hooda, R.S.; Land Use /Land Cover Change Detection Using Gis Techniques: A Case Study of Bhiwani District; Journal of Environmental Science and Sustainability (JESS) 1(4): 124-128.
[37] Bentinck, J. V.(2000); Unruly urbanisation on Delhi's fringe: changing patterns of land use and livelihood; Ph.D thesis.
[38] Singh, A.L., and Mansoor, A.S.(2012); Effect of City Expansion on the Countryside: A Case Study. Punjab Geographer.4; 17-25.
[39] Yadav, K., Sharma, M. P., Prawasi, R., Archana and Hooda, R. S. (2014); Study on the pattern of land use/ land cover change in Faridabad and Palwal districts of NCR; International Journal of Innovative research and studies; Vol 3 Issue 2.
[40] United nations, World Urbanization prospects: the 2011 Revision; Department of Economics and Social Affairs: population Division, New York: United Nations Publication, 2011.

The rapidly increasing population and followed change in land use land cover advocate that urbanization is taking place. The urban growth affects the ecosystem not only in the core city but also in the periphery of the city. It is evident in many areas with the process of urbanization that urban growth significantly determines land use and land changes. There is interaction between biological and non-biological components in an urban environment. This interaction in an urban environment is termed as 'urban ecosystem'. There is now a growing understanding that human processes and culture are fundamental for sustainable management of ecosystems, and in urban planning it is becoming increasingly evident that urban management needs to operate at an ecosystem scale rather than within the traditional boundaries of the city.[41] All that we want on the Earth come from the environment in which we live. In the process of urban growth humanity is encroaching on the ecosystems of the surrounding regions of the main big cities. The demand for land, water, food and other resources is also increasing. So it is quite necessary to maintain the natural processes and functions of the surrounding environment for future benefits. If it is not so the benefits we get from the ecosystem will be diminished.

2.3.1 DEFINING ECOSYSTEM SERVICES: -

The first widely recognised and acknowledged global evaluation of ecosystem service perhaps came from Millennium Ecosystem Assessment, 2005. All the services we are provided come from ecosystems. Every ecosystem has its unique advantages and services through which humanity is benefited. Ecosystems provide us from food ,fibre , water, fuel etc. the benefits that can be measured as well as the services like recreation, pollination, pest control, fresh water etc that are difficult to be measured.[42] Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions.[43] If any ecosystem service is provided by ecosystems of an urban environment we term as Urban Ecosystem Services (UES).[44] Ecosystem goods (e.g. food) and services (e.g. waste assimilation) represent the benefits

[41] Breuste J., Dagmar Haase D., and Elmqvist T. (2013); Urban Landscapes and Ecosystem Services; Ecosystem Services in Agricultural and Urban Landscapes, Pub. John Wiley & Sons, Ltd.
[42] Millennium Ecosystem Assessment, (2005); Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
[43] Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., (1997); The value of the world's ecosystem services and natural capital. Nature 387, 253–260.
[44] Bolund, P. and Hunhammar, S. (1999); Ecosystem services in urban areas. Ecological Economics, 29, pp.293–301.

human populations derive, directly or indirectly, from ecosystem functions.[45] To be a true ecosystem service, a desirable ecosystem process has to occur near consumers of that service.[46] This definition is same as resources are defined; any material is not resources if it is not useful for human. To ensure the continued availability of ecosystem functions, the use of the associated goods and services should be limited to sustainable use levels.[47] The intensive use of the nature and ecosystems will degrade ecosystem to such level that we will no longer be benefited from the ecosystem services. Ecosystem services are clearly related to the land use and land cover.[48] Thus urban ecosystem services will be closely related to the use of land of that urban environment. Social and environmental processes and patterns influences land use and land cover. Resultantly land use affects the ecological patterns and processes. Thus it is explained that land use and land cover of an urban area determines the ecosystem services and its benefits to human.

Ecosystem services have been categorized in four parts; provisioning services like food and water availability, regulating services climate extremes like flood, heat waves and heavy rainfall & treatment and handling of waste, cultural services recreation, tourism etc., habitat and supporting services pollination, biodiversity, energy etc.[49]

2.3.2 RELEVANCE OF ECOSYSTEM SERVICES FOR PERI-URBAN AREAS: -

Peri-urban areas are transition zone, or none of interaction, where urban and rural activities intermixed, and countryside characteristics are subject to rapid modifications which are caused by human activities.[50] What makes the peri-urban environment so interesting is the complexity of political, economic and social drivers impacting locally on those biogeochemical cycles and the resulting outcomes for the health, well-being and economic

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[45] Costanza et. al. (1987); The Value of the World's Ecosystem Services and Natural Capital; Nature; Vol. 387, pp 253-260.
[46] McDonald, R. I., Forman, R. T. T., Kareiva, P., Neugarten, R., Salzer, D., & Fisher, J. (2009); Urban effects, distance, and protected areas in an urbanizing world. Landscape and Urban Planning, 93, 63–75.
[47] De Groot, R., Wilson, M.A. and Boumans, R.M.J. (2002); A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics, 41, pp. 393–408.
[48] Breuste, J. (2007); Urban soil sealing – key indicator for urban ecological functionality and ecological planning. In: 25 Years of Landscape Ecology: Scientific Principles in Practice, Proceedings of the 7th IALE World Congress, Part 1, pp. 197–198.
[49] Millennium Ecosystem Assessment, (2005); Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
[50] Douglas, I.; Peri-Urban Ecosystems and Societies: Transitional Zones and Contrasting Values; In D. McGregor, D. Simon and D. !ompson (Eds.), The Peri-urban Interface: Approaches to Sustainable Natural and Human Resource Use, pp.18-29.

survival of people in peri- urban communities.[51] Peri urban environment determines the interdependence of the rural and urban people. The land use changes which are often neglected by administration determine the ecological, hydrological, social systems etc. The scale of vulnerability or environmental risks of any ecosystem largely depends on the pressure exerted due to increasing human demands and pressure by implementing resource based economies in that particular ecosystem.[52] From an ecological and social point of view there is need to value these ecosystem services through LULC studies in a peri-urban environment for monitoring the availability of UES. The regulations of energy, water and matter budgets and also the organisation of ecological or agricultural production processes are the focal points of the indicators that regulate the availability of basic demands for human life.[53] The combination of three distinct methods: the land evaluation and identification of qualities, assessment of recreational use, and monetary assessment, gave a unique opportunity of valuing intangible services within the same limited tracts of land.[54] As the peri-urban areas develop in an urban area the degradation of the ecological benefits is natural. The construction of new roads in the peri-urban areas will increase noise and degrade the cultural values of remote wilderness areas.[55] Thus in interpreting benefits in a peri-urban environment it is very essential to measure land use land changes from ecological perspective.

2.3.3 DEGRADATION OF ECOSYSTEM SERVICES: -

Since ecosystems in urban areas are strongly influenced by anthropogenic activities, considerably more attention is currently being directed towards monitoring changes in urban land use/ land cover (LULC).[56] The advancement of urbanization in the world, particularly after 1950s coincided with global environmental change, increasing consumption of natural resources, habitat loss and ecosystem change.[57] Water bodies, including floodplains and

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[51] Douglas, I.; Peri-Urban Ecosystems and Societies: Transitional Zones and Contrasting Values; In D. McGregor, D. Simon and D. !ompson (Eds.), The Peri-urban Interface: Approaches to Sustainable Natural and Human Resource Use, pp.18-29.

[52] Ricci, L. (2012); Peri-Urban Livelihood and Adaptive Capacity: Urban Development in Dar Es Salaam; Consilience: The Journal of Sustainable Development; Vol. 7, Issue. 1 pp. 46–63.

[53] Mu¨ller, F., (2005); Indicating ecosystem and landscape organisation. Ecol. Indicat. 5 (4),pp. 280–294.

[54] Vejre, H., Jensen, F. S. and Thorsen, B. J. (2010); Demonstrating the importance of intangible ecosystem services from peri-urban landscapes; Ecological Complexity 7 ; pp.338–348.

[55] Vihervaara, P., Kumpula, T., Tanskanen, A. and Burkhard, B. (2010); Ecosystem services–A tool for sustainable management of human–environment systems. Case study Finnish Forest Lapland; Ecological Complexity 7 pp. 410–420.

[56] Stow, D. A. and Chen, D. M. (2002);Sensitivity of Multi-Tem- poral NOAA AVHRR Data of an Urbanizing Region to Land Use/Cover Changes and Misregistration; Remote Sensing of Environment, Vol. 80, pp. 297-307.

[57] McNeill,J. R.(2000); Something new under the sun, an environmental history of the twentieth- century world. New York: W.W. Norton and Company.

smaller lakes, are being converted into agricultural land and built-up areas; agricultural lands are being converted into urban uses, primarily for habitation and factories; In this process, ecosystem services, like water recharge, bioremediation, nutrient cycling, waste management, and climatic regulation, are being lost without notice and acknowledgment by planners and decision-makers. Urban Ecosystem Services Loss of Agricultural land ES Valuation of Ecosystem Services.[58] Currently 60% of the ecosystem services evaluated are being degraded or used unsustainably.[59] It is very necessary to develop strategies to cope with and adapt to long term environmental changes that will be caused by degradation of ecosystem services. In some studies urbanization is considered a problem as well as a solution to the environmental problems. Without migration to the cities, there might be less environmental impacts from cities, but perhaps more impacts in the countryside.[60] Ecosystem services evolve very slowly and it takes a long time. Once ecosystems degrade it takes a huge time to restore but not completely to original status. The loss of biodiversity is linked with irreversibility, because the restoration of ecosystems is only possible to a limited extent and with huge effort.[61] So it is very necessary to halt the loss of ecosystems and biodiversity for sustainable development to create a bright future.

2.3.4 MEASURING ECOSYSTEM SERVICES: -

To protect the ecosystems it is necessary that we know their value. Until we don't know their value we would not respect and protect the ecosystems. If we know the value of ecosystems it signals our concern for the ecosystems and biodiversity. The protection of ecosystems enriches biodiversity. Valuing the contribution of ecosystems to human well-being through economic, ecological and social accounting such as Green GDP requires demands robust methods to define and quantify ecosystem services.[62] Ecosystem services are given too little weight in policy decision because they are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured

[58] Kumar, P.(2009); Assessment of Economic Drivers of Land Use Change in Urban Ecosystems of Delhi, India; A Journal of the Human Environment, 38(1):35-39.
[59] Millennium Ecosystem Assessment, (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.
[60] McDonald, R. I., Marcotullio, P. J. and Guneralp, b.; Chapter 3: Urbanization and Global Trends; Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities A Global Assessment A Part of the Cities and Biodiversity Outlook Project.
[61] Policy paper: Human Progress within Planetary Guard Rails: A Contribution to the SDG Debate; German Advisory Council on Global Change; June 2014.
[62] Crossman, N. D. et al.(20130; A Blueprint for Mapping and modelling Ecosystem Services; Ecosystem Services; Ecosystem Services 4, 4–14.

capital.[63] In his study Costanza has used coefficient value for each type of land use land cover category. These coefficients are temporally static and global average which may differ from place to place. The close relationships of ES and LULC gives accurate measurements of ecosystem services. The GIS tools can be used efficiently and effectively to measure and estimate the impacts of land use land cover changes on the supply of ecosystem services.[64] But the goal of measuring value of ecosystem services is not to provide a precise mathematical description but to draw a mathematical framework of where particular ecosystems services would be most efficiently conserved.[65]

2.4 LOSS OF AGRICULTURAL LAND AND ECOSYSTEM SERVICES:

Agriculture is a dominant form of land management globally, which covers nearly 40% of the terrestrial surface of the Earth.[66] Agriculture is the key source of the global economy especially in developing countries as it provides basic services like food, fibre, fuel etc. It is the livelihood and subsistence of rural communities in developing world. Agriculture is one of the major drivers of environmental change.[67] Agricultural biodiversity (the biodiversity associated with agricultural ecosystems) is indispensable for plant stability, and therefore sustaining crop production, food security and livelihoods for everyone.[68] . Cover crops are used to retain soil and nutrients between crop cycles while hedgerows and vegetation along waterways reduce erosion and runoff from fields.[69] Apart from it Agriculture increases the capacity of carbon uptake and storage in soils.[70] As the rural urban composition is changing the consumption pattern is also changing. So it is a very challenging job for human beings to produce diverse diets ensuring food safety and security. For this we have to intensify agriculture in decreasing fertile land. Simplification of agro-ecosystems caused by the

[63] Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., (1997); The value of the world's ecosystem services and natural capital. Nature, 387, 253–260.

[64] Kreuter, U. P., Harris, H. G., Matlock, M. D. and Lacey, R.E. (2001); Change in ecosystem service values in the San Antonio area, Texas; Ecological Economics 39, pp. 333– 346.

[65] McDonald, R. I. (2009); Ecosystem service demand and supply along the urban-to-rural gradient; Journal of Conservation Planning Vol 5, 1 — 14.

[66] FAO. (2009) Statistics from www.faostat.fao.org, updated April 2009. Rome, Italy: FAO.

[67] Davari, M. R., Ram, M., Tewari, J. C. and Kaushish, S. (2010); Impact of agricultural practice on ecosystem services; International journal of Agronomy and Plant Production. Vol., 1 (1), 11-23.

[68] Agricultural Ecosystems Facts and Trends; World Business Council for Sustainable Development.

[69] Zhang, W., Ricketts, T. H., Kremen, C., Carney, K. & Swinton, S. M.(2007); Ecosystem services and dis-services to agriculture. Ecological Economics 64, 253– 260.

[70] Lal, R. (2008); Sequestration of atmospheric CO2in global carbon pools.Energy and Environmental Science 1, 86– 100.

intensification of agricultural practices may affect important ecosystem services via the loss of biodiversity.[71] Intensification of agriculture may affect negatively, as happening in North India. The green revolution provoked for over exploitation of ground water and more input of fertilizers and pesticides which has significantly caused land and water problems of soil degradation in north India.[72] There is need to focus on issues of collective and effective utilization of land and water data for land use planning, nutrient management, increase in productivity and enrichment of fertility of land.[73] Only than the goal of integrated and sustainable monitoring and management of agriculture and forestry can be achieved.

2.5 DEGRADATION OF ECOSYSTEM SERVICES AND SUSTAINABLE DEVELOPMENT: -

The urban sprawl is changing patterns of land use and land cover. This change in land use/cover is being followed by changes in the habits and consumption patterns of people. The current rate of use of resources is unsustainable. The future is expected to present major challenges before humanity, like availability of energy, food and fresh water. The services we get from environment are expected to be degraded. Sprawling and poorly considered patterns of urban and regional development can cause economic harm to communities by degrading fundamental ecosystem services.[74] The question arises that what to be sustained and to what quantity and quality it has to be sustained. It differs from place to place according their utility and scarcity. There is need to take into account the global, regional, and local drivers of biodiversity loss in poor areas for sustainable development, quantify the links between biodiversity and ecosystem services on the one hand, and poverty reduction on the other.[75] The developing countries like India in future are expected to face problems like access of food, water, fuel, sanitation etc. particularly to the poor section of population. The deteriorating condition of agricultural ecosystem is a point of great concern in developing countries. Unsustainable resource use can cause biodiversity loss and natural resource degradation, with the poor being disproportionally affected, so sustainable use of natural

[71] Tscharntke, T., Klein, A. M., Kruess, A., Steffan-Dewenter, I. & Thies, C. (2005) Landscape perspectives on agricultural intensification and biodiversity: ecosystem service management; Ecology Letters 8, 857–874.
[72] Singh, R. B. (2000); Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India; Agriculture, Ecosystems and Environment 82 pp. 97–103.
[73] Singh, R. B.(2000) ; Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India; Agriculture, Ecosystems and Environment 82 pp. 97–103.
[74] Deal, B. and Pallathucheril, V. (2009); Sustainability and Urban Dynamics: Assessing Future Impacts on Ecosystem Services;.Sustainability, 1, 346-362.
[75] Sachs, J. D. and other co-werkers; Biodiversity Conservation and the Millennium Development Goals; Science, Vol, 325, 1502-1503.

capital and the preservation of biodiversity and ecosystem services are vital for sustainable poverty eradication.[76] The cities in developing countries are still dependent on hinterland for food, energy, water etc. which poses threatening challenges. The Brundtland Comission defines "a sustainable development is first and foremost about ensuring that everybody both in poor and rich countries, and today as well as in future generations; can have their basic needs (food, water, clothes, shelter, work, energy and hygiene) met without jeopardizing the natural systems on which life on earth is dependent."[77] Similarly according to IUCN sustainability is improving the quality of human life while living within the carrying capacity of supporting ecosystems.[78] With changing rural-urban composition and consumption patterns it is a challenging task for humanity to protect environment while satisfying his needs.

Thus from the studies above it is very clear that the urbanization and land use land cover changes are closely associated phenomena. The land use/cover change cause degradation or up gradation of ecosystems. Depending on the negative or positive changes the ecosystems benefit us in different ways. The poor section in developing societies is significantly affected by change in the ecosystem services. Thus it requires a sustainable use of resources maintaining biodiversity in natural state and benefitting majority of the world.

[76] Lucas, P. L., Kok, M. T. J., nilsson, M. and Alkemade, R. (2014); Integrating Biodiversity and Ecosystem Services in the Post-2015 Development Agenda: Goal Structure, Target Areas and Means of Implementation; Sustainability, 6, 193-216.
[77] BRUNDTLAND COMMISSION (World Commission On Environment And Development) (1987) Our Common Future. Oxford/New York: Oxford University Press.
[78] IUCN/UNEP/WWF; Caring for the Earth: A Strategy for Sustainable Living; 1991, Switzerland: Gland.

CHAPTER III

URBANIZATION INFLUENCE OF NCR ON GHAZIABAD AND FARIDABAD DISTRICTS

(A Macro to Micro analysis)

3.1 INTRODUCTION:-

According to Oxford Dictionary of Geography, 2009, "Rapid Urbanization is the phenomenon in which, there is an increase in proportion of the population residing in towns, brought about by migration of rural or urban population into towns and cities, and higher urban level of natural increase resulting from the greater proportion of people of childbearing age in cities". It is stated that urbanization is an index of transformation in which traditional economies turn into industrial economies. Davis (1965) has stated it as the progressive concentration of population in urban unit. Thus the concentration of human settlements happens in the urban centres. Urbanization has been termed as the process which has many phases and cycles. Thus many countries are at different levels and cycles of this process of urbanization.

In recent at global level the process of urbanization can be observed from developed to developing, all types of countries. In developing countries the agricultural society and activities are transforming into industrial and service sectors, resultantly leading to the industrial development. Similarly is happening in India. The developed countries shoes higher urbanization with slow urban growth rate because in developed countries the process of urbanization started very early and systematically. So we found higher levels of urban population than rural in developed countries. But many of the developing countries like Germany are showing declining trend in urban population. While in the developing countries the situation is just opposite because in developing countries the process of urbanisation has started in 20^{th} century.

Urbanisation is termed as the increase in population and economic activities in the urban areas which further reflected through the rising population in towns and urban agglomerations. The increasing industrialization and human work force increase the economic progress in a region. In India migration is termed as the main factor for increase of urbanization but there are other factors also like, employment opportunities, educational facilities, better health services and better living standards which propellant the urban population growth in a region. The urban agglomerations are increasing. Out of the 50 largest urban agglomerations of the world five are from India respectively, Delhi, Mumbai and Kolkata, Chennai and Hyderabad. The rapidly growing urban population could not accommodate within the existing limits of the cities. In past decades urbanization in India has been exclusionary, focusing mainly on the large cities and small cities cannot grow significantly (Kundu et al., 2011). This is because the concentration of economic activities is

largely in big cities and smaller cities are unable to produce enough job opportunities for workers. This puts large pressure on the resources of cities and its peri-urban environment to sustain the living community of the city itself. Thus the peri-urban environment of big cities has been degraded significantly. Cities are expected to face economic as well as environmental pressures. It is a challenging task for cities to provide the basic services to every citizen maintaining low cost. Rapid population growth not only lessens available calorie supply from food per person but also risks the present food production with pollution. According to census 2011, there are three million plus cities in National Capital Region respectively, Ghaziabad, Faridabad and Meerut. Out of these Ghaziabad has highest population followed by Faridabad and Meerut. In past 20 years a rapid increase has been observed in the population growth as well as density of Ghaziabad and Faridabad. The analysis of population concentration shows that the National Capital Region population is highly concentrated in three cities, Ghaziabad, Gurgaon and Faridabad. Thus there is urban growth in haphazard manner in periphery of the city. In thickly populated cities like Delhi, Mumbai etc. the serious problem is air pollution and deficit of oxygen in the environment (Usha et al.). Urbanization in India has also major impacts on rural areas, reshaping lifestyles, livelihoods, consumption pattern and waste generation (Sanyal et al., 2010). The intensification of agriculture in rural areas poses risks of soil pollution as well as increase in green house gases. Deforestation and irrigation were the largest sources of human released greenhouse gasses to the atmosphere until the advent of industrial era of fossil-fuel burning (Turner et al., 2007). But in India the NCR is in Industrialization process as well as more than 35% population is still rural. Thus the fossil fuel burning and the changing patterns of agriculture are a great challenge for NCR. The establishment of industrial units on large scale in Faridabad and Ghaziabad will also further add to the degradation of the environment. This will have far reaching consequences on human well-being. The increasing slum dwellings must be maintained properly. A large number of community development initiatives should be taken in the slum areas- that would have the advantage of bringing about rapid improvement in the population's living conditions, and could even create employment (Bolay et al., 1997). There is needed to take major sustainable initiatives that can benefit each and every community minimizing the environmental degradation. There is needed to take precarious measures where people live in absolute poverty and depend mostly on environment to fulfil their needs. The urbanization in India and other developing countries require sustainable development approach. Below the analysis of level and tempo of urbanization in India, NCR and Ghaziabad and Faridabad districts provides a picture of

increasing population growth, density and concentration. It will help in understanding the process of urbanization in fastest growing districts Ghaziabad and Faridabad of National Capital Region.

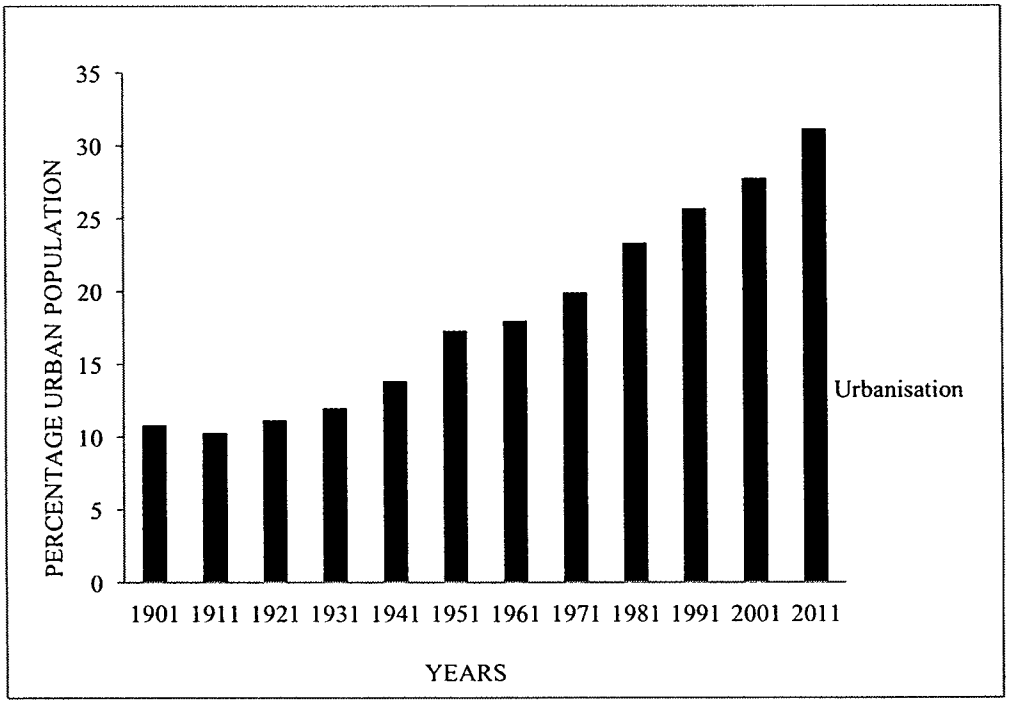
3.2 URBANISATION IN INDIA: -

In 20th century in the developing countries of Asia the population of cities is increasing rapidly. This mainly can be attributed to the increase in industrial and economic activities which leading to the fast urban development. Simply the level of urbanization can be expressed as the percentage share or urban population to the total population of a region. This can be expressed into two ways; (1) Percentage of urban population to total population (2) decadal growth rate of urban population. The two processes, level of development and level of urbanization are linked to each other as these have positive relationship to each other. It varies from region to region and within the country also.

Kingsley Davis had explained Indian population as highly immovable population. He pointed out that the main causes of immovability are the cultural aspects. There is the prevalence of caste system, joint family system, lower level of education, agriculture oriented economy, customary values, reduced transportation facility etc. all these reasons restrict migration of people from their native villages to other areas.

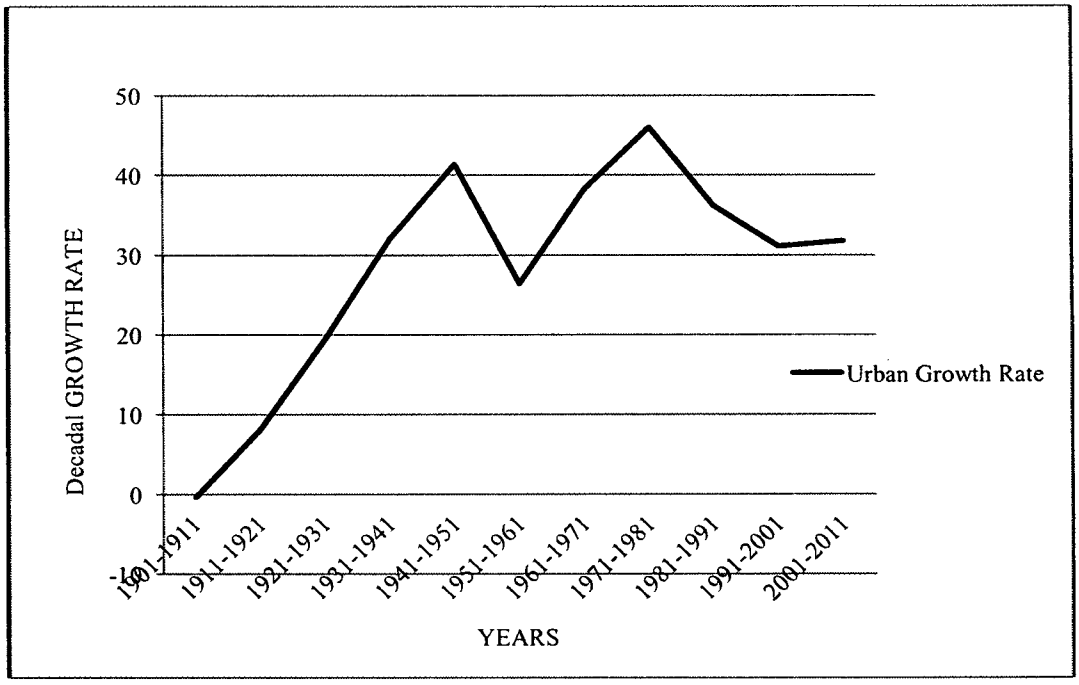
The fluctuating levels of urbanization can be viewed in India from 1901-2011. In 1991 only 10.84 percentage population of India was urban. According to census 2011 the total population of India is 1210 million; out of that 377 million people are termed as urban population. This urban population is 31.16% of the total population of 2011. In the city level scenario, the 53 million plus populated cities contain 42.6 % of total urban population of India. After independence India adopted the policy of mixed economy with development of private sector, due to which urbanization increased rapidly after 1951. The four metro cities of India, namely Mumbai, Kolkata, Delhi and Chennai together represent 15.4 per cent urban population of total urban population of India. It is clear from figure 3.1 that in 1911 the share of urban population declined; due to the famine and plague that happen in 1901-1911. The year 1931 shows slight increase in level of urbanization, with total urban population as 11.99% of total population. This census year was the period of great depression in the economy and agricultural activities.

FIGURE 3.1: URBANIZATION IN INDIA, 1901-2011



(Data Source: Census of India, 2001 and 2011)

FIGURE 3.2: URBANIZATION GROWTH RATE IN INDIA, 1901-2011



(Data Source: Census of India, 2001 and 2011)

The highest urban growth rate can be observed in the decade 1941-51 till independence. The growth rate observed in 1941-51 was 41.42% with 17.29% urbanization. This unbelievable

rise in urban population is mainly attributed to the massive migration due to partition of India. The migrated Hindu refugees settled mainly in the cities, like Delhi. Apart from it the definitions of urbanization were loose and unclear till 1951. In 1961 the decadal growth of urban population was 26.41% with 17.97% population as urban population. The decrease in the growth rate of urban population primarily can be attributed to the conceptual change of the definition of urban centers. In 1981 the urban population share of India reached to 23.34% with highest urban population growth rate (46.14%) of all decades. The number of census towns in 1981 was counted as 1054. In the decade 1981-91 in India the decadal growth rate declined but the level of urbanization continued to increase. In 1991, 25.73% population was counted as urban population. In 2001 the share of urban population reached to 27.78%, and the decadal growth rate was 31.13%, showing continues falling trend.

A net increase of 181 million people has been observed in the total urban population from 2001 to 2011. In 2011 the share of urban population to total population is 31.16% and the urban population growth rate is 31.80%. The number of towns was 5161 in 1981 which increased to 7935 in 2011 census report, showing a net increase of 2774 towns. Out of these 2774 towns, 2532 are census towns and 242 are statutory towns. Since 1951, the absolute increase in urban population was higher than absolute increase in rural population in census 2011. Out of the total increase of urban population from 2001-2011 decade, 44% can be attributed to the natural increase. The second factor is the increase of urban towns is classification of rural to urban area. It also includes the changes in the municipal boundaries and outgrowth. These two factors are primarily responsible for the speeding urbanization in India in 2011.

3.3 LEVEL OF URBANISATION IN INDIAN STATES- 1981-2011

The following table 3.1 shows the level of urbanization or share of urban population to total population in states of India. The following table clearly indicate that in census 1981, the state Maharashtra was the highest urbanized state of India with 35.03% population as urban population. In 1981 other states Tamilnadu, Gujrat and Karnataka followed it with 32.98%, 31.08% and 28.91% urban population respectively. In 1981, Arunachal Pradesh was the least urbanized state with only 6.8% urban population. Similarly the other hilly states also showed less urbanization in 1981. In census 1991, Maharashtra again grabbed first position with 38.73% population of the state as urban population. It was followed by Gujarat, Tamilnadu, Karnataka, Punjab and West Bengal with 34.40%, 34.20%, 30.91%, 29.72% and 27.39%

respectively. In 1991 the least urbanized state was Himachal Pradesh with 7.72% population as urban population followed by Assam, Arunachal and Bihar.

In 2001 census, small state showed incredible urban growth. Goa state was highest urbanized district recording the 49.77 % urbanization. It was followed by Mizoram 49.6 %. This trend continued in 2011 also as Goa was again highest urbanized state with 62.17% population of state as urban population. Again it was followed by Mizoram which recorded 51.51% urbanization. In 2011, Kerala recorded higher urbanization reaching 47.72% level of urbanization. This state also experienced emergence of 464 new towns in 2011. Most of new towns in Kerala emerged as part of urban agglomeration. In 2001 the urban growth rate of Kerala was just 15 while in 2011 it increased to 6.5%.

TABLE 3.1: LEVEL OF URBANISATION IN INDIA STATES, 1981-2011

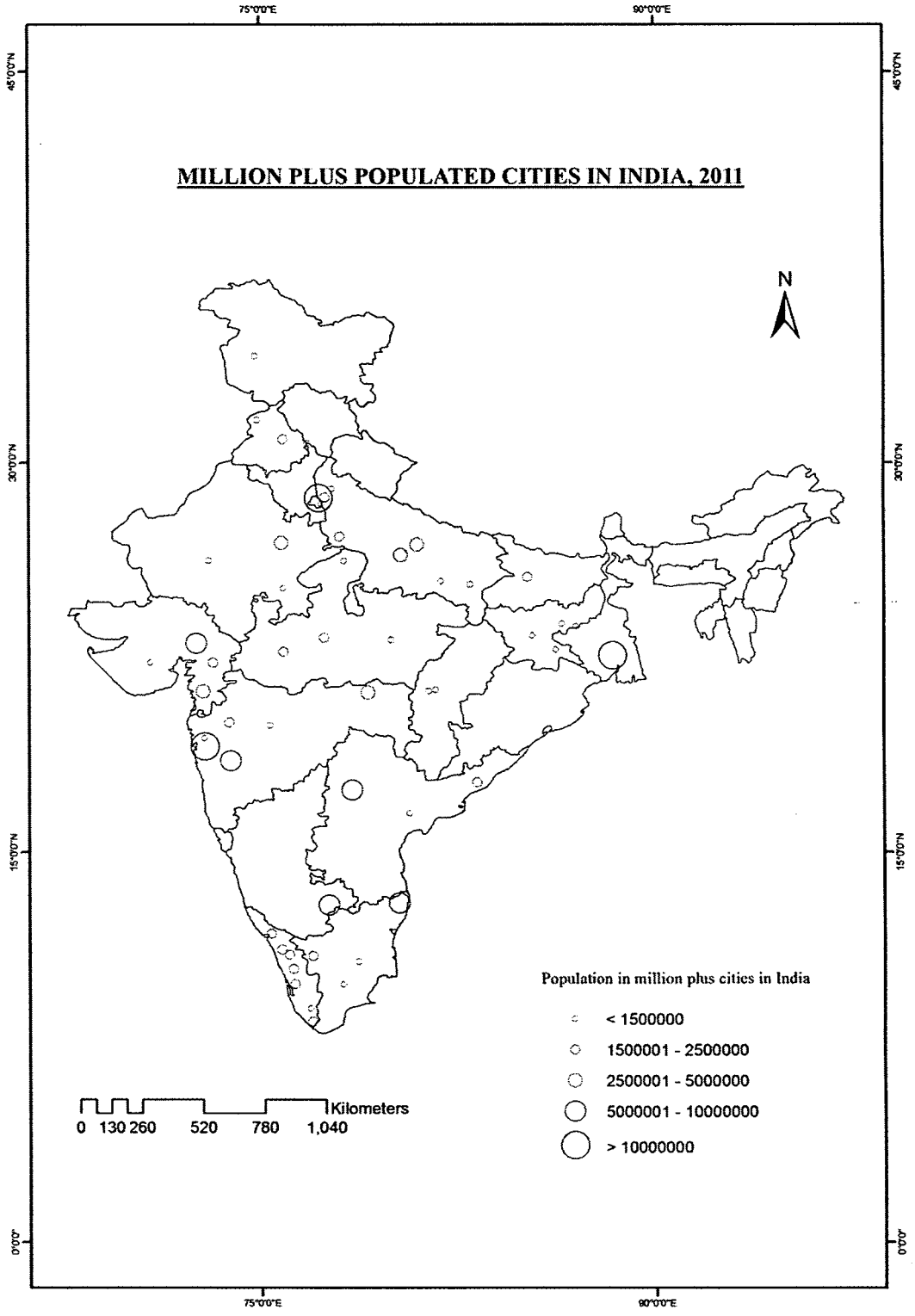
STATE of INDIA	Census Year			
	1981	1991	2001	2011
Andhra Pradesh	23.35	26.84	27.08	33.49
Arunachal Pradesh	6.32	12.21	20.41	22.67
Assam	9.88	11.08	12.72	14.08
Bihar	12.46	13.1	10.47	11.3
Chattisgarh	N.A	N.A	20.09	23.24
Delhi	92.73	89.93	93.01	97.5
Goa	32.03	41.02	49.77	62.17
Gujarat	31.08	34.4	37.55	42.58
Haryana	21.96	27.79	29	34.79
Himachal Pradesh	8.7	7.72	9.79	10.04
Jammu & Kashmir	21.05	23.83	24.88	27.12
Jharkhand	N.A	N.A	22.24	24.05
Karnataka	28.91	30.91	33.98	38.57
Kerala	18.78	26.44	35.97	47.72
Madhya Pradesh	20.31	23.27	26.67	27.63
Maharashtra	35.03	38.73	42.4	45.23
Manipur	26.44	27.69	23.88	30.21
Meghalaya	18.03	18.69	19.63	20.08
Mizoram	25.17	46.2	49.6	51.51
Nagaland	15.54	17.28	17.74	28.97
Orissa	11.82	13.43	14.97	16.68
Punjab	27.72	29.72	33.95	37.49
Rajasthan	20.93	22.88	23.88	24.89
Sikkim	9.12	16.23	11.1	24.97
Tamil Nadu	32.98	34.2	43.86	48.45
Tripura	10.98	15.26	17.02	26.18
Uttar Pradesh	18.01	19.89	20.78	22.28
Uttaranchal	N.A	N.A	25.67	30.55
West Bengal	26.49	27.39	28.03	31.89

(Data Source: Census of India, 1981, 1991, 2001 And 2011)

According to the census 2011 overall 91 million people has been added to the urban population of India. Presently 31.16% population live in urban areas which was 27.81% in 2001. While proportion of rural population to total population declined from 72.19% (2001) to 68.84% (2011). In 1901 there was only one million plus city. In 1951 there were 5 million plus cities. Subsequently the number of million plus cities increased to 12 and 23 respectively in 1981 and 1991. In 2001 the number of million plus cities was just 35 which jumped to 53 in census 2011.

Due to this process of high urbanization density of population has increased in the national capital region and its peri-urban areas. In 2001 around 55.20% population was urbanized in Ghaziabad which increased to 67.6% in 2011 recording the highest proportion of urban population in any district of Uttar Pradesh. Thus according to census 2011 Ghaziabad is the district which has highest proportion of urban population after Faridabad (79.44%) and Gurgaon (68.82%) in NCR. The following map presents the concentration of million plus cities in India.

MAP 3.1: MILLION PLUS POPULATED CITIES IN INDIA, 2011



(Data Source: Census of India, 2011)

3.4 URBANISATION IN NATIONAL CAPITAL REGION:-

3.4.1 LEVEL OF URBANISATION IN NATIONAL CAPITAL REGION:

Several factors determine the level of urbanization of cities or towns. The determinants like setting of towns, surrounding condition, population size, economic configuration of towns, transport capability, and trade and commerce relation with hinterland and nearby towns are major determinants. The level of economic development of region is reflected by the level of urbanisation of towns of that region. In 1981, around 47.40% population of total population of NCR was urban population in national capital region while at national level only 23.31% people live in urban areas. The national capital region is obviously a significant more urbanised but also experiencing rapid urbanisation than the other regions of India.

The sub regional analysis shows that there is sharp variation in level of urbanization in NCR. In 1981, Delhi recorded 92.73% urbanization, the highest urbanization in National Capital Region. This higher urbanization level may be as Delhi is capital of India. In 1981 Uttar Pradesh sub-region shows highest urbanization (27.29%) compared to other sub-regions of NCR. In Uttar Pradesh sub-region Ghaziabad shows highest urbanization (34.13%) followed by Meerut (31.22%) and Bulandshahr (19.34%). The Uttar-Pradesh sub-region is followed by Haryana sub-region in level of urbanization. In Haryana sub-region Faridabad district shows 41.46% urbanization followed by Panipat (31.34%), Gurgaon (19.92%) and Rohtak (19.83%). In 1981 only one district, Alwar of Rajasthan sub-region was included in NCR showing 11.08% population as urban population. The level of development of different sub-regions is confirmed by their level of urbanization.

In 1991, the level of urbanization was 89.93% in NCT Delhi. Thus in 1991 the level of urbanization declined 3% compared to the previous decade in NCT Delhi. The national capital region planning board decided to reduce the overburden of population in NCR through the development of nearby towns in NCR. Thus in the coming decades the nearby districts showed increase in urbanization. The Faridabad District of Haryana sub-region became highest urbanized district of NCR with 48.57% urban population. It was followed by Ghaziabad and Meerut respectively 46.16% and 37.02% urbanization. Similarly the other district of NCR has also experienced slight positive increase in urbanization. In 1991 the level of urbanization in Gurgaon district of Haryana sub-region was same as the previous year.

The NCR region is quite developed in agriculture related activities which forms its main economic base but the formation of national capital region has significant caused development in industrial and commercial sectors. Thus in NCR the districts Merrut,

Ghaziabad, Bhiwani, Rewari, Panipat, Alwar and Faridabad emerged as industrial sectors. The commercial activities has also developed along with industrial development. In 2001 Delhi again reported increasing urbanization as urbanization was measured 93.18%, which was highest in national capital region. In 2001, Faridabad was leading district of NCR with 55.65 % of urban followed by the Ghaziabad district 55.20% urban population and Meerut 48.44% urban population. Thus Ghaziabad and Faridabad experienced10% and 11.52% increase in share of urban population to total population from 1991 to 2001. In 2001 in Haryana sub-region almost all of district reported increase in the level of urbanization like, Panipat (40.53%), Rohtak (35.06%), Sonipat (25.12%), and Rewari (17.79%), (showing percentage urban population in parentheses). In 1997 three new district were added in national capital boundaries, out of which two Jhajjar and Baghpat were from Haryana sub-region and one GTB Nagar from Uttar Pradesh sub-region. Jhajjar and Baghpat were carved out of Rohtak and Meerut districts, respectively. The Gautam Buddha Nagar (NOIDA), carved out of Ghaziabad and Bulandshahr districts. In Rajasthan sub-region earlier only some tehsils of Alwar district included in NCR, later whole district included. Alwar was the least urbanised district of NCR with only 14.53% of urban population.

The urbanization gap has widened in 2001. In 2001, on one hand the 55.65% population of Faridabad district is urban population while in Alwar district of Rajasthan sub-region only 14.53% population of district is urban population in 2001. The urbanization gap was just 28.02% in 1981.

TABLE 3.2: LEVEL OF URBANIZATION IN DISTRICTS OF NCR, 1981-2011

Sr. No.	Districts	Total Population				Urban Population				% Urbanization			
		1981	1991	2001	2011	1981	1991	2001	2011	1981	1991	2001	2011
1	NCT OF DELHI	6220406	9420640	13850507	16753235	5768200	8471625	12905780	16333916	92.73	89.93	93.18	97.5
2	Faridabad	985586	1477240	2194586	1798954	408594	717513	1221344	1429093	41.46	48.57	55.65	79.44
3	Gurgaon	849598	1146090	1660289	1514085	169189	232704	369004	1042000	19.91	20.3	22.23	68.82
4	Panipat	483285	83501	967449	1202811	151459	226345	392080	552945	31.34	27.16	40.53	45.97
5	Sonipat	846765	754866	1279175	1480080	152046	178025	321375	451687	17.96	23.58	25.12	30.52
6	Rewari	345386	578301	765351	896129	51562	95200	136174	231411	14.93	16.46	17.79	25.82
7	Rohtak	1341953	1808606	940128	1058683	266094	385473	329604	444819	19.83	21.31	35.06	42.02
8	Jhajjar	-		880072	956907	-		195097	242974	-	-	22.17	25.39
9	Palwal	-		-	956907	-		-	242974	-	-	-	25.39
10	Mewat	-		-	1089406	-		-	124017	-	-	-	11.38
11	Alwar	1771173	2296580	2992592	3671999	196201	320287	434939	654288	11.08	13.95	14.53	17.82
12	Merrut	2767246	3447912	2997361	3447405	863966	1276557	1451983	1762573	31.22	37.02	48.44	51.13
13	Ghaziabad	1843130	2703933	3290586	4661452	629076	1248260	1816415	3144574	34.13	46.16	55.2	67.46
14	Bulandshar	2358270	2849859	2913122	3498507	456025	592795	674458	867791	19.34	20.8	23.15	24.8
15	Gautam Budhha Nagar	-	-	1202030	1674714		-	449415	997410	-	-	37.39	59.56
16	Baghpat	-	-	1163991	1302156	-	-	229432	274135	-	-	19.71	21.05

(Data Source: Census of India, 1981, 1991, 2001 and 2011)

In 2011 there was incredible growth of urban population in NCR. In 2011 in NCT Delhi the urbanisation was 97.50 % while at national level it was just 31.16%. There has been net addition of 29 lakh people in population of Delhi from 2001 to 2011. The urbanization level has increased in Delhi except in 1991 (89.93 %). The share of urban population NCT Delhi in 1951 was 52.815 which have increased to 97.50% in 2011.

In 2011 around 39.4% population of Haryana sub-region is urban population. In 2011 all district of Haryana sub-region has showed significant increase in the level of urbanisation. In Faridabad district the level of urbanization has increased from 55.65% (2001) to 79.44% (2011). , indicating a sharp 25% increase in the urban population from 2001 to 2011. Gurgaon district has shown enormous increase in share of urban population to total population from 19.91% in 1981 to 68.82% in 2011. This mainly may be attributed to the bifurcation of Gurgaon district in two parts, Gurgaon and Mewat district respectively. Thus the urban population of Gurgaon district has increased around 46% in the last decade. Thus Faridabad, Ghaziabad, Meerut, and Sonipat districts of Haryana sub-region have reflected soaring pace of urbanisation. On the other hand the other districts of Haryana subregion like, Rohtak, Baghpat, Rewari, Bulandshahr and Jhajjar have shown moderate speed of urbanisation.

In 2011 the Ghaziabad district of Uttar Pradesh sub-region of NCR recorded 67.46% urban population to total population which was highest in Uttar Pradesh sub-region. The level of urbanization in Meerut and Gautam Buddha Nagar was 51.13% and 59.56% respectively in 2011. In Haryana sub-region level of urbanisation is 43.10%. In Haryana sub-region four districts Faridabad, Gurgaon, Panipat and Rohtak registered higher urbanization than the national average in 2011.While in other districts the urbanization was below 30% in Haryana sub-region. In the whole NCR in 2011 the lowest level of urbanisation was recorded as 17.82% which was in Alwar District of Rajasthan sub-region. In 2008 two new districts Palwal and Mewat have been carved out of Faridabad and Gurgaon districts respectively. In 2011 Palwal and Mewat districts registered respectively, 25.39% and 11.38% urbanization. Thus Mewat was the least urbanized district in NCR in 2011. In 2012 three new districts have been added in national capital region which are Bhiwani, Mahendergarh and Hapur. Bhiwani and Mahendragarh belong to Haryana sub-region. Hapur has been carved out of Ghaziabad district of Uttar-Pradesh sub-region. Now total number of districts including Delhi in NCR is 19. The district wise analysis of trend of urbanization in NCR show increasing pattern in each decade from 1981-2011.

3.4.2 TEMPO OF URBANISATION IN NATIONAL CAPITAL REGION:-

The tempo of urbanization indicates the change in the level or degree of urbanization of a region over the time period. The tempo of urbanization can be measured either in absolute terms or in percentage urban population between two time periods. The tempo of urbanization reflects the pace of urbanisation. So through this we can measure the pace of urbanization by comparing the level of urbanization of two time periods. As it directly subtracts the values so it has the advantages and disadvantages of the while measuring the pace of urbanization.

The table 3.3 clearly explains that there is not uniformity in the pace of urbanization over the time period. The pace of urbanization is fluctuating from 1991-2011. In 1981-91 among the all districts of NCR, except Delhi (-0.280) and Panipat (-0.480) showed negative tempo of urbanization, Ghaziabad recorded highest tempo of urbanisation (1.203). While in Faridabad, Meerut, Sonipat and Alwar the tempo of urbanization was respectively 0.711, 0.580, 0.563 and 0.287. From 1981-91 the lowest level of urbanization (0.039) was measured in Gurgaon district.

From 1991 to 2001 Delhi has shown positive trend in the tempo of urbanization. While in 1981-1991 the negative trend was observed in the tempo of urbanization of Delhi. The table 3.3 shows that Faridabad district has developed fastest from 1981 to 1991 and 1991 to 2001 if compared to other districts of Haryana sub region. But, in 2001-2011 Gurgaon district shows highest positive tempo of urbanization in Haryana sub-region. In 1901-2001 the highest tempo 1.375 and 1.142 was measured in Rohtak and Meerut district of NCR. The development of industrial, commercial and trade activities lured the influx of migrants from the neighbouring areas causing highest tempo of urbanization in the above mentioned two districts. In all the districts of NCR the tempo of urbanization has increase from 2001 to 2011. In 2011 the lowest tempo of urbanization was observed in Alwar (0.059) followed by Rewari (0.133) and Sonipat (0.154). The tempo of urbanization decreased in 2011 compared to 2001 in Sonipat district.

TABLE 3.3: DISTRICTS-WISE TEMPO OF URBANISATION IN NCR 1991-2011

	Urbanization				Tempo of urbanization		
Districts	1981	1991	2001	2011	1991	2001	2011
NCT OF DELHI	92.73	89.93	93.18	97.5	-0.28	0.325	0.432
Faridabad	41.46	48.57	55.65	79.44	0.711	0.708	2.379
Gurgaon	19.91	20.3	22.23	68.82	0.039	0.192	4.66
Panipat	31.34	27.16	40.53	45.97	-0.418	1.337	0.544
Sonipat	17.96	23.58	25.12	30.52	0.563	0.154	0.539
Rewari	14.93	16.46	17.79	25.82	0.153	0.133	0.803
Rohtak	19.83	21.31	35.06	42.02	0.148	1.375	0.696
Jhajjar	-	-	22.17	25.39	-	-	0.322
Palwal	-	-	-	25.39	-	-	-
Mewat	-	-	-	11.38	-	-	-
Alwar	11.08	13.95	14.53	17.82	0.287	0.059	0.328
Merrut	31.22	37.02	48.44	51.13	0.58	1.142	0.269
Ghaziabad	34.13	46.16	55.2	67.46	1.203	0.904	1.226
Bulandshar	19.34	20.8	23.15	24.8	0.146	0.235	0.165
Gautam Budhha Nagar	-	-	37.39	59.56	-	-	2.217
Baghpat	-	-	-	21.05		-	-

(Data Source: Census of India, 1981, 1991, 2001 and 2011)

In 2011, the tempo of urbanization was 4.660 and 2.379 respectively in Gurgaon and Faridabad. The continuous increase of urban population in Gurgaon and Faridabad districts caused a high pace in the tempo of urbanization. The highest tempo of urbanization (2.217) was observed in Gautam Buddha Nagar followed by Rewari (0.803), Rohtak (0.696), Panipat (0.544) and Sonipat (0.539). In 2011 the lowest tempo of urbanization (0.165) was observed in bulandshahr district of Uttar Pradesh dub-region. The tempo of urbanization was 1.142 in 2001 which decreased to 0.269 in Meerut district. Thus the tempo of urbanization also slowed downed in Meerut district. The analysis of tempo of urbanization of 2011 show increasing tempo of urbanization mainly in the districts of Haryana sub-region. In 2011 the tempo of urbanization was faster than previous decade in all districts except Panipat, Rohtak and Bulandshahr in the national capital region.

3.4.3 URBAN POPULATION GROWTH RATE IN NCR

TABLE NO.3.4 DECADLE URBAN POPULATION GROWTH RATE IN NCR

Region/Districts	Decadal urban Population Growth Rate		
	1981-91	1991-01	2001-11
NCT Delhi	46.87	52.3	26.8
Faridabad	75.61	70.2	17.8
Gurgaon	37.54	58.6	182.5
Panipat	49.44	73.2	41.6
Sonipat	17.09	80.5	41.1
Rewari	84.63	43.0	71.4
Rohtak	44.86	-14.5	35.4
Jhajjar			24.7
Palwal			
Mewat			
Alwar	63.24	35.8	50.5
Meerut	47.76	13.7	21.2
Ghaziabd	98.43	45.5	74.1
Bulandshahr	29.99	13.8	44.5
GTB Nagar			93.0
Baghpat			19.9

(Data Source: Various Census Rports, 1981, 1991 2001 and 2011)

The table above illustrates the district or region wise growth rate of urban population in NCR region. We can see that the growth rate of urban population is decreasing in NCT Delhi. In whole NCR the Gurgaon shows highest growth rate of urban population followed by Gautam Budhha Nagar and Ghaziabad. The literature analysis shows that the massive increase in the urban population can be attributed to the in-migration in these districts. from 1981 to 2011 only Rohtak district has shown negative growth rate in urban population. In Uttar Pradesh sub-region GTB Nagar shows highest growth in urban population in 2011 followed by Ghaziabd and Bulandshahr.

3.4.4 MIGRATION PATTERN TOWARDS NCT DELHI AND NCR OF TOP 100 DISTRICTS: -

In-migration pattern in Delhi reveals that total migration from top 100 districts was 2172760 which were 73.74% of total in-migration in Delhi. It is observed that 20 districts send 31.76% migration to Delhi, out of them 11 districts are within 100-200 km distance from Delhi periphery. Out of the total in-migration in Delhi 17.32% belong to Uttar Pradesh. In Uttar Pradesh the migrators are mainly from Bulandshahr, Aligarh, Meerut, Ghaziabad, Etah, Azamgarh, Gorakhpur, Agra, Budaun and Muzaffarnagar districts. Uttar Pradesh is followed by Bihar, as 7.71% in-migration to Delhi belong to Bihar. From Bihar migratory are mainly from Madhubani, Darbhanga, Patna, Samastipur and Muzaffarpur districts.

The maps below explain the pattern of in migration towards National Capital Region including Delhi. Around 78.92% migration in NCR is from top 100 districts. Out of which Top 20 district account 18 per cent in-migration to National Capital Region. Agra, Aligarh, Azamgarh, Budaun, Mathura, Etah, Kanpur Nagar, Manipuri, Moradabad and Muzaffarnagar are the major distract from Uttar Pradesh from where people migrate to NCR. Jaipur and Bharatpur account maximum migration from Rajasthan. The map below clearly shows that most districts belong to Uttar Pradesh and Bihar state. Other districts are Nadia, Kolkata, and Medinipur from west Bengal from where people migrate to National Capital Region.

3.4.5 CONCENTRATION OF URBAN POPULATION IN NATIONAL CAPITAL REGION:-

When proportion of any characteristics in area is studied in relation to its proportion in the region, the ratio used is known as the location quotient. The used of location quotient is important because it a simple proportion of any characteristic like proportion of urban population to total population give only local picture. They do not give the position in region. Thus in a less urbanised region a pocket of 25% urban population may be consider as higher concentration of urban population than its counterpart in more urbanised region. Location quotient which gives us the relative picture of such proportion is defined as the ratio of the proportion of a particular characteristic in an area to the proportion in the region.

The district was location quotient has been explained to measure which areas bear more pressure due to increasing population concentration. In a regional context a higher or lower value of the location quotient indicates the relative concentration or dispersion of the concerned attribute.

TABLE 3.5: DISTRICT WISE CONCENTRATION OF URBAN POULATION IN NCR REGION

DISTRICTS	LOCATION QUOTIENT			
	1981	1991	2001	2011
NCT OF DELHI	2.02	1.79	1.65	1.56
FARIDABAD	0.90	0.97	0.99	1.27
GURGAON	0.43	0.40	0.39	1.10
PANIPAT	0.68	0.54	0.72	0.73
SONIPAT	0.39	0.47	0.45	0.49
REWARI	0.32	0.33	0.32	0.41
ROHTAK	0.43	0.42	0.62	0.67
JHAJJAR	N.A	N.A	0.39	0.41
PALWAL	N.A	N.A	N.A	0.41
MEWAT	N.A	N.A	N.A	0.18
ALWAR	0.24	0.28	0.26	0.28
MERRUT	0.68	0.74	0.86	0.82
GHAZIABAD	0.74	0.92	0.98	1.08
BULANDSHAR	0.42	0.41	0.41	0.40
GAUTAM BUDHHA NAGAR	N.A	N.A	0.66	0.95
BAGHPAT	N.A	N.A	0.35	0.34
NCR	1.00	1.00	1.00	1.00

(Data Source: Census of India, 1981, 1991, 2001 and 2011)

The table 3.4 explains that in 1981 the highest concentration of urban population was in NCT Delhi measuring 2.02. It was followed by Faridabad, Ghaziabad and Meerut measuring respectively 0.90, 0.74 and 0.68 in 1981.In 1981 the least population concentration was measured in Alwar which was 0.24. It was followed by Rewari and Sonipat measuring respectively 0.32 and 0.39. the least concentration in these districts is due to the higher proportion of rural population to the total population.

Due to development of the satellite towns in NCR in 2011, the concentration of urban population became periphery oriented than NCT Delhi. In Delhi the concentration of urban population is decreasing because the relative concentration of urban population is increasing in the satellite towns of NCT Delhi. The district wise analysis of urban population concentration show that Ghaziabad and Gautam Budhha Nagar (NOIDA) emerging as new centres of urban population concentration in national capital region in 2011.

3.5 NCR URBANIZATION INFLUENCE ON TOWNS OF NATIONAL CAPITAL REGION: -

In NCR region the urbanization of NCT Delhi has differently influenced the socio-economic development of towns in NCR. Some towns like Gurgaon, Faridabad, and Ghaziabad etc. are highly influenced by the urbanization of NCT Delhi. To measure the urban influence on the towns in NCR following indicators have been used for the year 1991, 2001 and 2011.

1. Population Size,
2. Population Growth,
3. Population Density,
4. Sex-Ratio,
5. Literacy Rate,
6. Household Size,
7. Work Participation Rate and
8. Main Workers in Non-primary activities.

The level of urban influence of NCT Delhi on towns in NCR is represented through composite values of all the selected indicators. The composite values were calculated through the technique of location quotient (LQ). To obtain location quotient, the individual figures of towns were divided by the NCR towns' average. The location quotient of each indicator was calculated for different census years. The location quotient values of all indicators for each year were summed up to obtain composite index. To measure the influence on towns with increasing distance from NCT Delhi, the NCR has been divided into 4 zones. The NCT Delhi is considered as core. The distance is taken from centre of NCT Delhi. The zone classification is as following.

TABLE 3.6: ZONAL CLASSIFICATION OF TOWNS OF NATIONAL CAPITAL REGION

Zone	Distance from NCT Delhi Centre	No. of Towns		
		1991	2001	2011
Ring 1	0-50 km	17	24	23
Ring 2	50-100km	58	62	60
Ring 3	100-150km	18	20	20
Ring 4	Beyond 150 km	01	01	01
Total		94	107	104

The level of urban influence has been categorized in three categories, High (More than 1), Medium (0.67 to 1.0) and Low (less than 0.67). An attempt has been made to measure the level of influence on towns in different years, whether it has increased or decreased. The following map and table depicts the level of influence on towns in different time periods.

MAP 3.2: URBAN DEVELOPMENT IN DIFFERENT ZONES OF NCR 1991-2011

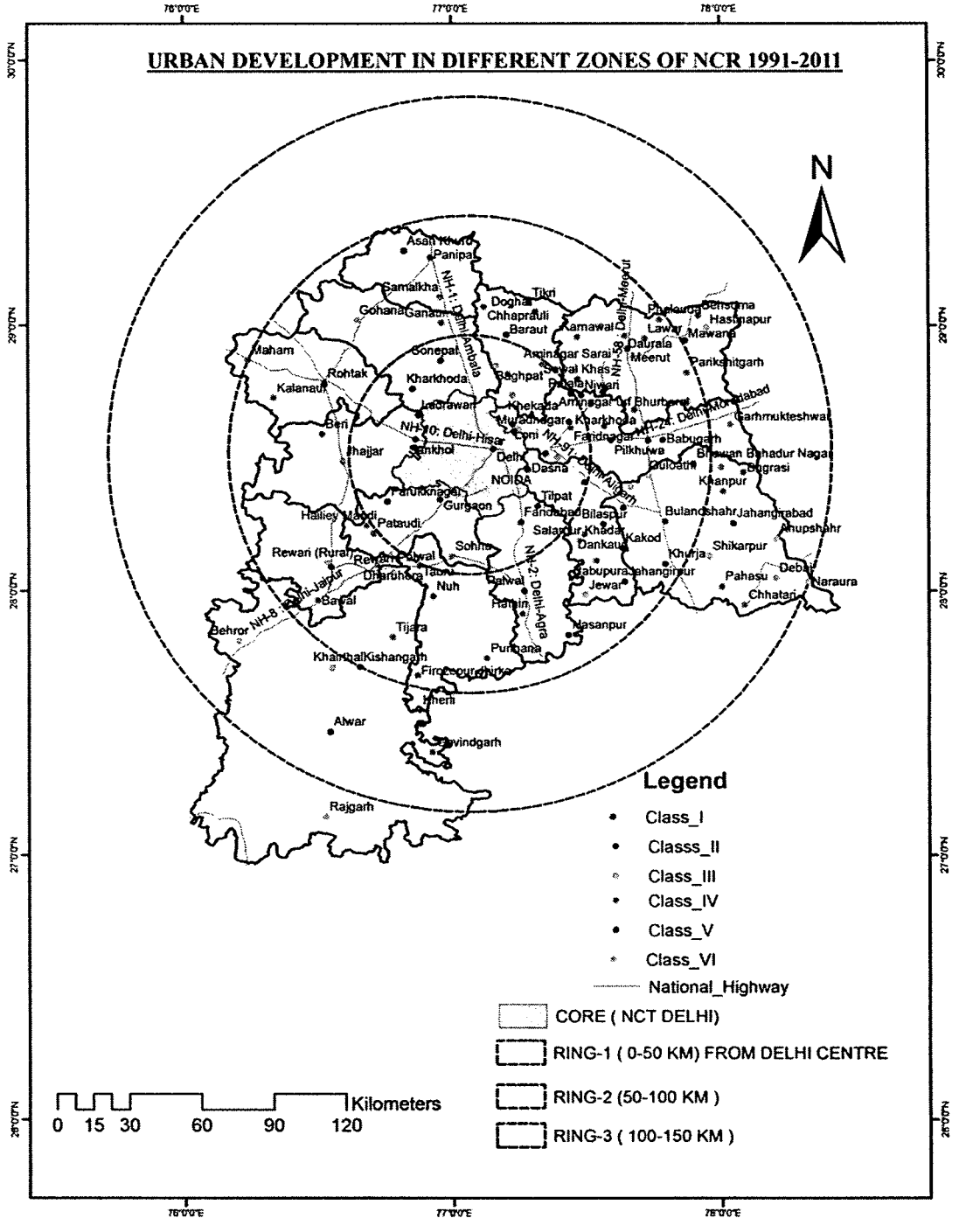


TABLE 3.7: INFLUENCE OF NCR URBANIZATION ON TOWNS OF NCR, 1991-2011

Zone	Urban Influence		1991		2001		2011
		No.	%	No.	%	No.	%
Ring 1	High (Above 1)	8	47	10	42	10	43
	Medium (0.67-1.00)	6	35	7	29	9	39
	Low (Below 0.67)	3	18	7	29	4	17
	Total	17	100	24	100	23	100
Ring 2	High (Above 1)	16	28	17	27	12	20
	Medium (0.67-1.00)	21	36	28	45	26	43
	Low (Below 0.67)	21	36	17	27	22	37
	Total	58	100	62	100	60	100
Ring 3	High (Above 1)	3	17	2	10	2	10
	Medium (0.67-1.00)	11	61	12	60	11	55
	Low (Below 0.67)	4	22	6	30	7	35
	Total	18	100	20	100	20	100
Ring 4	High (Above 1)	0	0	0	0	0	0
	Medium (0.67-1.00)	1	100	1	100	0	0
	Low (Below 0.67)	0	0	0	0	1	100
	Total	1	100	1	100	1	100
NCR	**High (Above 1)**	**27**	**29**	**29**	**27**	**24**	**23**
	Medium (0.67-1.00)	**39**	**41**	**48**	**45**	**46**	**44**
	Low (Below 0.67)	**28**	**30**	**30**	**28**	**34**	**33**
	Total	**94**	**100**	**107**	**100**	**104**	**100**

* The three towns of NCR respectively Dundahera, Patiala and Rewari (rural) have not been include in analysis of 2011, as their data was not available in PCA, 2011.

The values have been divided into three classes. These following three classes show three different levels of development.

High Developed Towns - more than 1

Medium Developed Towns - 0.7 to 1

Less Developed Towns - Below 0.7

High Developed Towns

The analysis of data shows that in 1991 high developed towns were 27 which increased to 29 in 2001 and decreased again 2011 to 24 due to reclassification of towns. The highest numbers of influenced towns are in Ring 2 in all the census years followed by Ring 1. In Ring 1 the number of developed towns in 1991 was 8 which increased to 10 in both 2001 and 2011. The towns like Gurgaon, Faridabad, Ghaziabad, Loni, Noida etc area categorized in Ring 1. These towns have highly developed socio-economic profile. It characterize that most of the towns of Ring 1 have high influence of NCT Delhi due to their nearness and better connectivity to NCT Delhi. In Ring 2 the highly influenced towns declined in 2011. In Ring 3 the highly influenced towns are just 2 while in Ring 4 even a single town is not highly influenced by NCT Delhi. It can be said that all the towns in this category have highly developed socio-economic profile due to influence from NCT Delhi.

Medium Developed Towns

In this category those town counted whose location quotient (LQ) value is between 0.67 and 1.00. In whole NCR maximum towns are in this category. In the whole NCR there were 39 towns in this category that increased to 48 and 46 respectively in 2001 and 2011. The medium influenced towns are increasing in Ring 1 gradually. There were only 6 towns in Ring 1 which increased to 7 and 9 respectively in 2001 and 2011. The maximum numbers of medium developed towns are in Ring 2. The major towns of the Ring 2 are Bhiwari, Dharuhera, Hathin, Hodal, Pataudi, Palwal, Sardhana etc. the towns of Ring 2 are under developed but have a great potential for socio-economic development. In Ring 3 also the maximum towns are in this category of development. In Ring 4 only town Rajgarh is medium developed but in 2011 it is categorised as less developed. Overall there is need to pay special attention for the towns of medium development to bring them to a proper development level.

Less Developed Towns

The towns whose location quotient value is below 0.67 are considered as less developed or influenced by NCT Delhi. In Ring 1 in 1991 there were 3 towns, namely Dasna, Muradnagar and Behta Hajipur in this category. The number of less developed towns is increasing in NCR as new areas are being incorporated in NCR. There were only 28 towns less developed in 1991 in NCR which increased to 30 and 34 respectively in 2001 and 20111. In 2001 the less developed towns were 7 but decreased again in 2011 to 4 in Ring 1. The less developed towns are maximum in Ring 2. This indicated a very slow process of socio-economic development in Ring 2 zone. It is evident in the analysis that towns which are located away from NCT Delhi and doesn't have direst connectivity are less developed.

Overall it can be said that the most of the towns in Ring 1 are developed and rest are in the process. The Ring 2 has a mix-up of medium and less developed towns. A proper attention is needed for Ring 2 for better and fast socio-economic development. In Ring 3 also most of the towns are medium developed but the similar number is of less developed towns. In whole NCR only one fourth towns are highly developed. Around 46% towns are medium developed and rest are less developed according to census 2011 data analysis.

3.6 INFLUENCE OF NCR URBANIZATION ON GHAZIABAD AND FARIDABAD DISTRICTS: -

The level of urbanization is explained in the above sections from 1981 to 2011. The census year 2001 has been taken as base to measure the influence of NCT Delhi on towns of NCR. The number of towns is considered same in 2001 and 2011. According to census 2011 the Ghaziabad and Faridabad towns are among of the 53 million plus cities of India. India currently contains three of the world's ten fastest growing cities- Faridabad, Ghaziabad and Surat, as well as three of the world's ten largest cities in terms of population (United Nations, 2011). These two district headquarters are within 25km range if we consider a central point of Delhi.

TABLE 3.8: TEMPO OF URBANIZATION IN GHAZIABAD AND FARIDABAD DISTRICTS

Districts	Urbanization				Tempo of urbanization		
	1981	1991	2001	2011	1991	2001	2011
Faridabad	41.46	48.57	55.65	79.44	0.711	0.708	2.379
Ghaziabad	34.13	46.16	55.2	67.46	1.203	0.904	1.226

(Data Source: Census of India, 1981, 1991, 2001 and 2011)

The tempo of urbanization measures how fast urbanization is taking place at a particular time at a particular region. The table 3.7 above clearly indicates that the speed of urbanization is increasing continuously in Faridabad district. In Faridabad district also the speed of urbanization is increasing. In both districts the tempo of urbanization was lower in 2001 than 1991. But in 2011 both districts show highest tempo of urbanization since 1981.

The migration pattern analysis shows that the workers concentrating more in the nearby districts of NCT Delhi. The population concentration analysis through location quotient explains that concentration of urban population is increasing in these two districts. The Faridabad district has highest value of location quotient in all districts of National Capital Region followed by Gurgaon and Ghaziabad. It indicates that urban population concentration is highest in Faridabad and then Gurgaon and Ghaziabad.

TABLE 3.9: CONCENTRATION OF URBAN POPULATION IN GHAZIABAD AND FARIDABAD DISTRICTS

Districts	Location Quotient			
	1981	1991	2001	2011
Faridabad	0.9	0.97	0.99	1.27
Ghaziabad	0.74	0.92	0.98	1.08

The influence of urbanization of NCT Delhi on districts of NCR was also measured. This analysis also indicates that in zone Ring-1 Gurgaon, Faridabad, Ghaziabad and Noida are the most influenced towns (map above). The location quotient analysis for urban influence shows an increasing trend of urban influence of NCT Delhi.

TABLE 3.10: INFLUENCE OF NCR URBANIZATION ON GHAZIABAD AND FARIDABAD DISTRICTS

District	1991	2001	2011
Faridabad	3.88	4.76	3.97
Ghaziabad	3.09	4.37	4.77

The above analyses indicate that Ghaziabad and Faridabad are one of the most influenced districts of NCR which are influenced by urbanization and industrialization of NCT Delhi. All these things supports my vision to study about the processes of urbanization, land use land cover changes and resulting impacts on the environment of the districts and surrounding regions also. The urban expansion in these districts will be followed by land use land cover changes. The changes in land use land cover will affect the ecosystem functioning. The urban expansion and expected decrease in agricultural land can have negative impacts on the ecosystems of these adjoining districts. It poses challenges of environmental pollution as well as food security in the region. So there is need of a sustainable development planning to minimize environmental losses or degradation. In this study a monitoring of the environmental losses is done through GIS and remote sensing techniques.

3.7 CONCLUSION: -

India has experienced a very fast growth rate of urbanization, especially after 1981. This chapter deals with the process, tempo, concentration and influence of urbanization. A macro to micro analysis of urbanization has been presented in this chapter. At India level urbanization has increased from 10.84% in 1901 to 31.16% in 2011. The growth rate of urbanization is declining over the time after 1981. The state-wise analysis shows that Kerala, Tamilnadu, Maharashtra, Goa, Meghalaya, Mizoram etc. are highly urbanized states than other states. In Northern India Punjab, Haryana, Delhi shows higher rates of urbanization. The number of million plus cities was just 5 in 1951 which increased to 35 and 53 respectively in 2001 and 2011. The national capital of India, Delhi and its surrounding region also experienced significant increase in urbanization. In 1981 NCR, only 45.95% population was urbanized which increased to 56.4% and 62.5% respectively in 2001 and 2011. The location, environment, economic structure and connectivity of NCT Delhi influenced the urbanization process in National Capital Region. According to census 2011 in whole NCR Uttar-Pradesh sub-region shows highest urbanization (48.3%) followed by Haryana sub-region (43.1%) and Rajasthan sub-region (17.8%). The district wise analysis of urbanization

in NCR shows that Faridabad is the most urbanized district from 1981 to 2011. In 2011 Faridabad is the most urbanized (79.44%) district followed by Gurgaon (68.42%) and Ghaziabad (67.46%). The industrial and commercial activities in these above mentioned districts have caused significant increase in urban population. The pattern of migration towards NCR is explained to show that which states or districts send more people in NCR. It's observed that 20 districts sending 31.76 per cent migration to Delhi, out of them 11 districts within 100-200 km distance from Delhi periphery. Most of the people migrate from Uttar Pradesh followed by Bihar in NCR. Further an attempt has been made to explain the concentration of urban population in NCR through location quotient (LQ). The location quotient analysis explains that highest concentration of urban population in Districts of NCR is in Faridabad followed by Gurgaon and Ghaziabad in 2011. The influence of urbanization of NCT Delhi on the towns is also measured through location quotient. The results came out that Faridabad and Ghaziabad are one of the most influenced towns of NCR. A zone development analysis of towns is also calculated. It explains that in within 50km periphery of NCT Delhi the NCR towns are most influenced. The district wise analysis shows that Faridabad, Gurgaon and Ghaziabad are the most urbanized districts in NCR. The town wise analysis shows that same Faridabad, Gurgaon and Ghaziabad are the most influenced towns of NCR All these explanations make a strong argument that Faridabad, Ghaziabad and Gurgaon are the most influenced districts of NCR by urbanization process in National Capital Region.

CHAPETR IV

LAND USE AND LAND COVER CHANGES IN GHAZIABAD AND FARIDABAD DISTRICT

4.1 INTRODUCTION: -

Over the last few decades, dramatic land-use changes have occurred throughout India. Especially in the North India due to changes in the agricultural patterns. The grazing areas and semi-natural areas have been converted into irrigated or rain-fed agriculture, followed by the large spread of the urban settlements. A variety of human derived processes has caused changes on the biophysical cover and pattern on the surface of the Earth. Land-use, on the other hand, is human activity on the land, influenced by economic, cultural, political, historical, and land-tenure factors. The proper management, planning and monitoring of natural resources will require knowledge of spatial land cover information. Remotely-sensed data Land-use maps provide more details for agricultural and urban land-use classes than for others. A current land-use information data base must be created for the utilization by planners, scientists, and decision makers for better policies. It is explained in the previous chapter that the increasing demand of increasing urban population is posing pressure on land. This pressure is causing changes in land use land cover of mega cities, like Delhi. The changing land use land cover will affect the production patterns and the environment of the region. The LULC analysis is required for projecting changes so that natural environment can be preserved and enhanced. This will ultimately increase the quality of life in urban environment. Thus land use land cover studies will help in strengthening the concepts of urban planning. As it is clear that to sustain large urban agglomerations there is needed a prosperous hinterland because all the needs a city cannot fulfil itself. The National Capital Region of India depends largely on fertile land of Ganga and Yamuna basin. The natural sources are finite and are being used at much faster rate. The intensification of agriculture, higher input of fertilizers and contamination of groundwater with hazardous chemicals will seriously degrade this fertile land on which a large population survive.

It is required to maintain economic development, conserving and developing natural environment in a sustainable ecological framework. It makes compulsory to regulate and monitor the land use land cover so that natural land cover can be maintained.

Land use land cover is a desired input for many agricultural, geological, hydrological and ecological models. Also, any natural hazard study such as landslide hazard zonation highly depends on the availability of accurate and up-to-date land cover information. In recent technological advancement the remote-sensing (RS) data are a viable source of data from which land-use maps could be created and updated efficiently. The satellite images provide synoptic view in map like format and the multi-temporal availability of datasets

cause better mapping and monitoring of land use land cover from local to global scales. The remote sensing data gives a synoptic view of large areas for different times. Remote sensing data is very useful when we incorporate large areas and inaccessible areas in our study. This is one of the best suited methods for mapping land use land cover in precise time. In this study I have used 30 meters resolution data which is good for land use land cover mapping for urban areas. The accurate assessment of land use land cover large depends on the resolution of the data available. The coarse resolution will give less reliable results while fine resolution data will give precise details of land use land cover. Apart from it the urban areas are generally heterogeneous that cause mixing of pixels ultimately affecting the accuracy of results. To resolve this problem information from secondary sources or from available people participation information on Google earth can be used. Apart from ground knowledge and limited field observation, Google Earth and Wikimapia images have also been used to correctly map land use land cover. Combination of this ancillary information can make remote sensing data more reliable for land use land cover mapping, however there is no alternative to sound and well thought of field work.

4.2 DATABASE FOR LAND USE - LAND COVER CHANGES: -

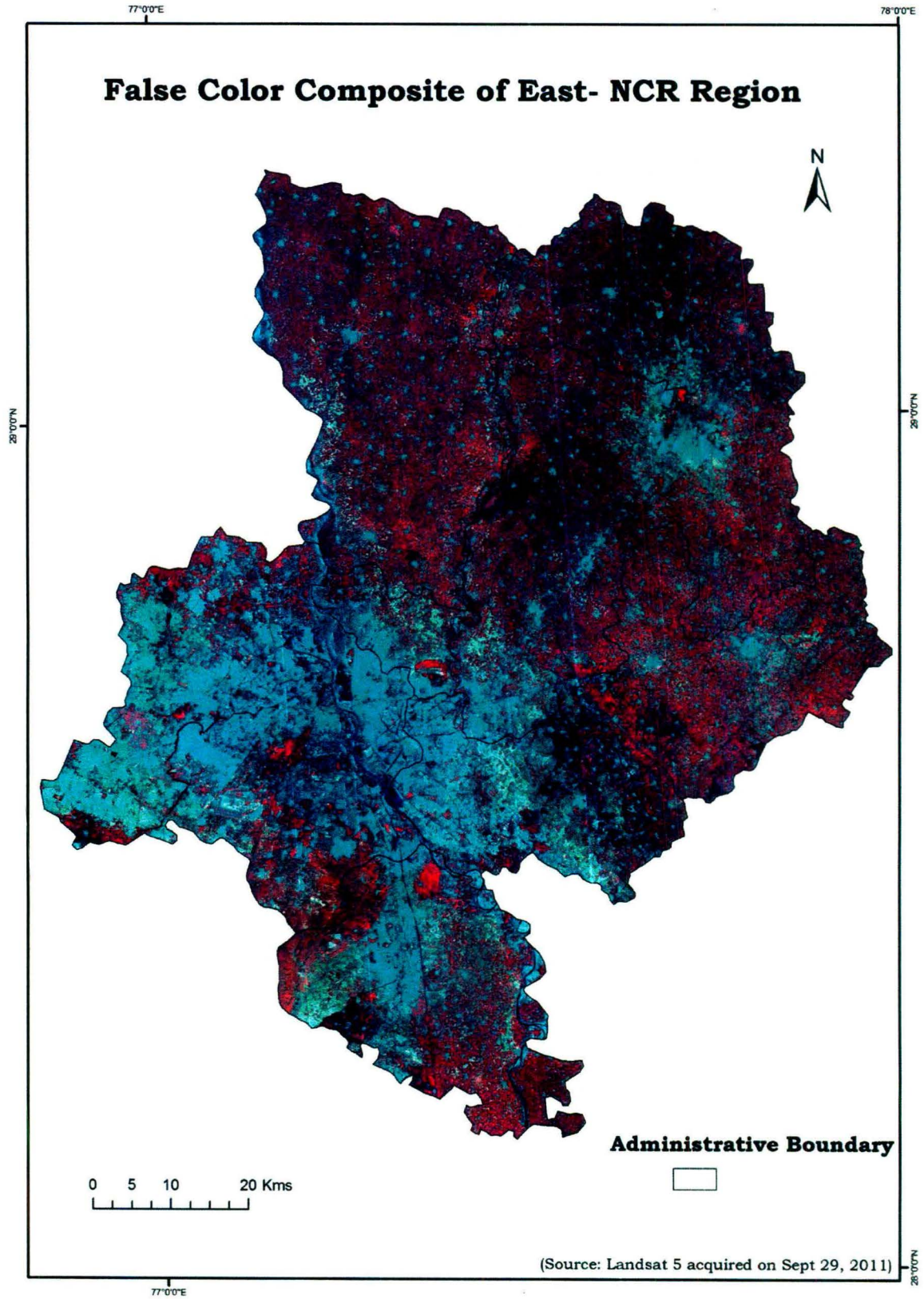
The data used for the analysis is for 5 time periods of 1991, 2003, 2010, 2011 and 2013. The LULC data for the year 1991, 2003 and 2010 has been taken from the study conducted by ESA on "*Historical Assessment Of Spatial Growth Of Built-Ups In Metropolitan Areas Of Delhi And Mumbai In India And Dhaka In Bangladesh*" in the framework of the "eoworld" initiative supported by the European Space Agency (ESA). The LULC data for the year 2011 and 2013 has been derived by analyzing satellite images. The description of the satellite images is given below.

TABLE 4.1: DESCRIPTION OF LANDSAT IMAGES

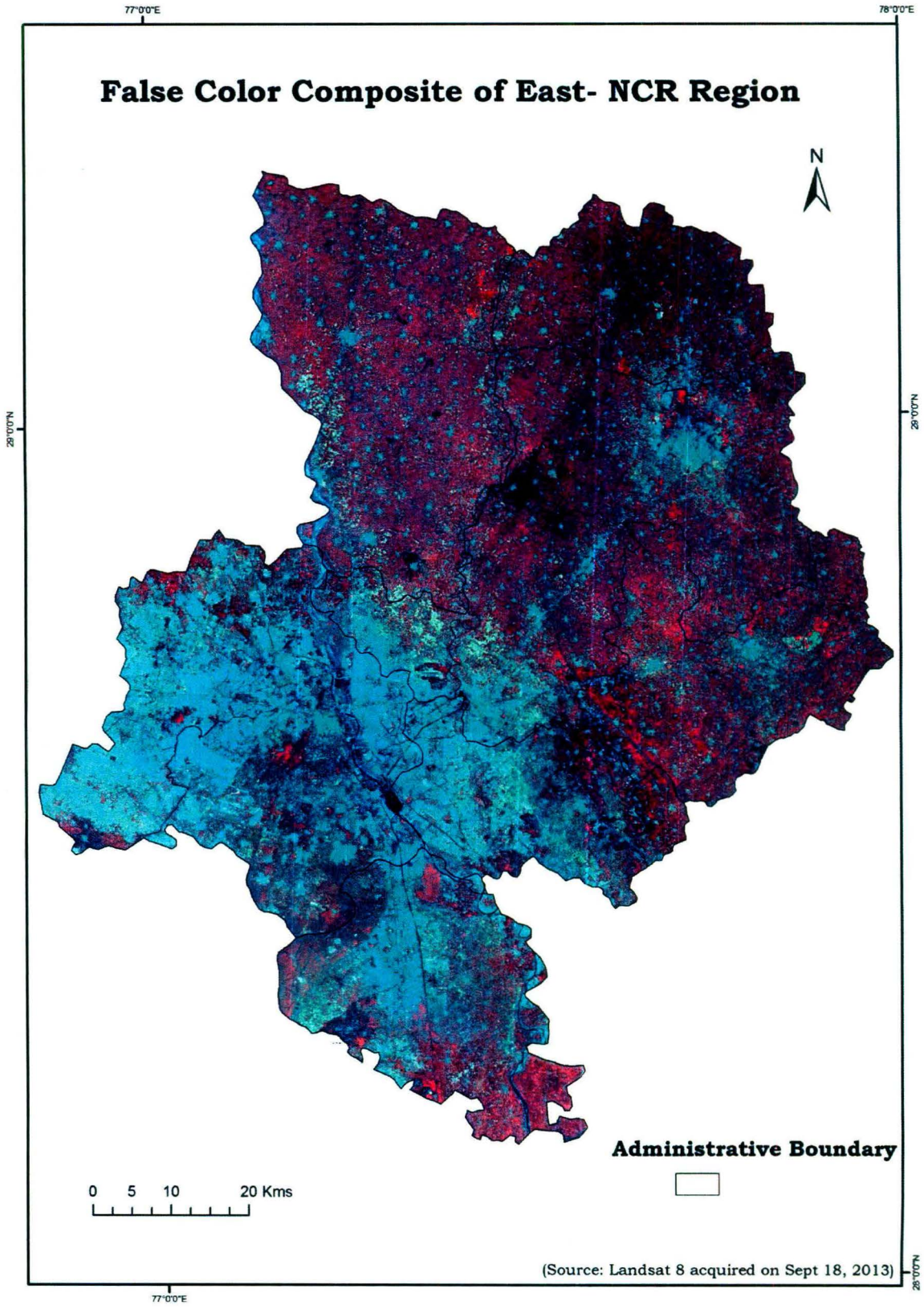
S.N.	Satellite	Sensor	Path/Row	Date Acquired
1	Landsat 5	TM	146/040	29-09-2011
2	Landsat 8	OLI-TIRS	146/040	18-09-2013

The following image is the eastern part of National Capital Region. The false color composite of sattelite images is created. The surrounding administrative units of Ghaziabad and Faridabad districts have also been taken to compare results with the surrounding environment. Following are the false color composte images of East NCR region of India for 2011 and 2013.

MAP 4.1: FALSE COLOR COMPOSITE OF EAST NCR REGION, 2011



MAP 4.2: FALSE COLOR COMPOSITE OF EAST NCR REGION, 2013



4.3 LAND COVER AND LAND USE CLASSIFICATION: -

The increasing pressure of human population and uncontrolled development is causing loss & deterioration of natural areas. Thus to overcome the problems of environmental degradation and to maintain the habitat quality the knowledge about land use and land cover has become increasingly important (Anderson et al. 1976). Land use is what people do on the earth surface like, agriculture, commerce, settlement etc. while land cover is the material on the land surface like, crops, water, forest, building etc. Many land use land cover classifications schemes have been used according to purpose. The land use land cover mapping requires interpretation of colour, texture, shadow, pattern, association, shape, size etc. elements of the image. When details beyond the capacity of remote sensor are needed, other data like topographic maps, road maps, field studies are also used. With the help of interpretation of above elements and according to purpose land use land cover lasses are identified. Anderson has identified two levels of land use land cover classification. The level I comprises 9 major land use land cover classes. These 9 major LULC classes have been subdivided into level II which includes 37 classes. The level I classification in Anderson scheme is done for global or continental purpose. The level II classification by Anderson probably is most appropriate for statewide and regional land use land cover mapping. The classification system used for National Land Cover Dataset (NLCD), USA, 92 is modified from the Anderson land-use and land-cover classification system. The Michigan Resource Information System (MIRIS) for land cover and land use mapping is also modified from Anderson classification. In MIRIS classification an attempt has been made to maintain clear distinction between natural land cover types and man-made land use activities. The National Remote Sensing Centre (NRSC), Hyderabad defines seven primary classes of land use land cover classification. The seven primary categories identified by NRSC are sub-divided into 24 classes. The World Bank study has identified several land use land cover categories. The main purpose of my study is to measure the benefits we derive from the ecosystems of the study area. An attempt has been done to classify land use land cover according ecosystems of study area. The eight major ecosystems have been identified in the study area. According to the ecosystems based assessment eight categories of land use land cover have been identified. The above false colour composite images have been used to analyze the land use land cover in the study area for 2011 and 2013. The satellite images taken for study belong to the time when Kharif crop is at its peak. This situation makes better measurement of prominent land use land cover classes. Apart from it during this season the sky is also cloud free. In this study the purpose of

LULC mapping is the valuation of the ecosystem services. An attempt has been made to analyze whether LULC changes in the study area has impacted the value of ecosystem services. So to fulfil this purpose the Land Use Land Cover (LULC) has been broadly classified into 8 broad categories. The 8 categories identified for land use land cover area as following: -

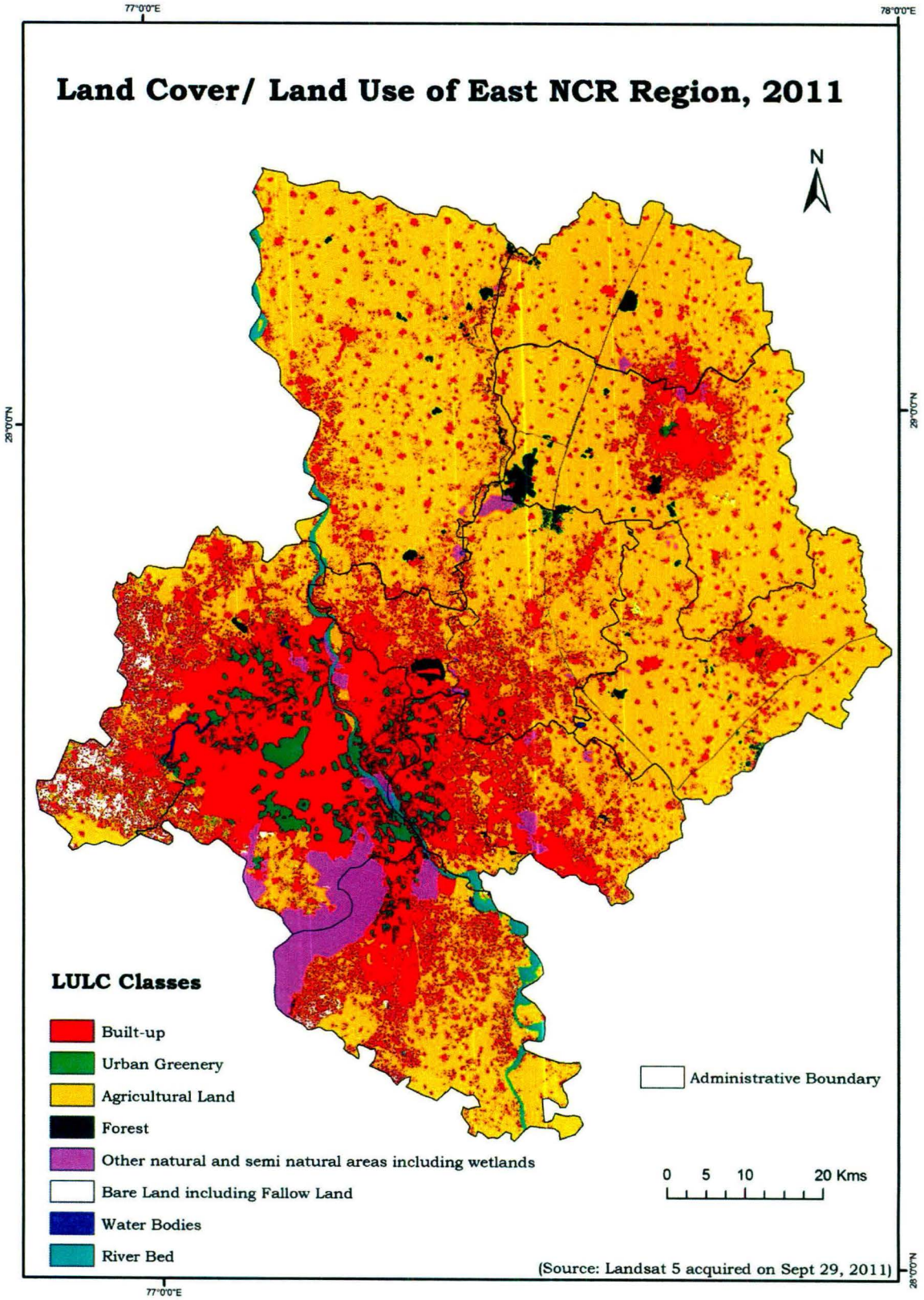
I. Built-up (Urban& Rural settlements),
II. Agricultural Land,
III. Forest,
IV. Urban Greenery,
V. Other Natural and Semi-natural Areas including Wetlands,
VI. Bare Land (including Fallow Land),
VII. Water Bodies and
VIII. River bed.

The major ecosystems identified in the study area are represented by the above land use land cover categories. Secondary information like Google Earth, Wikimapia etc. has been used to clearly identify the land use land cover categories in the study area.

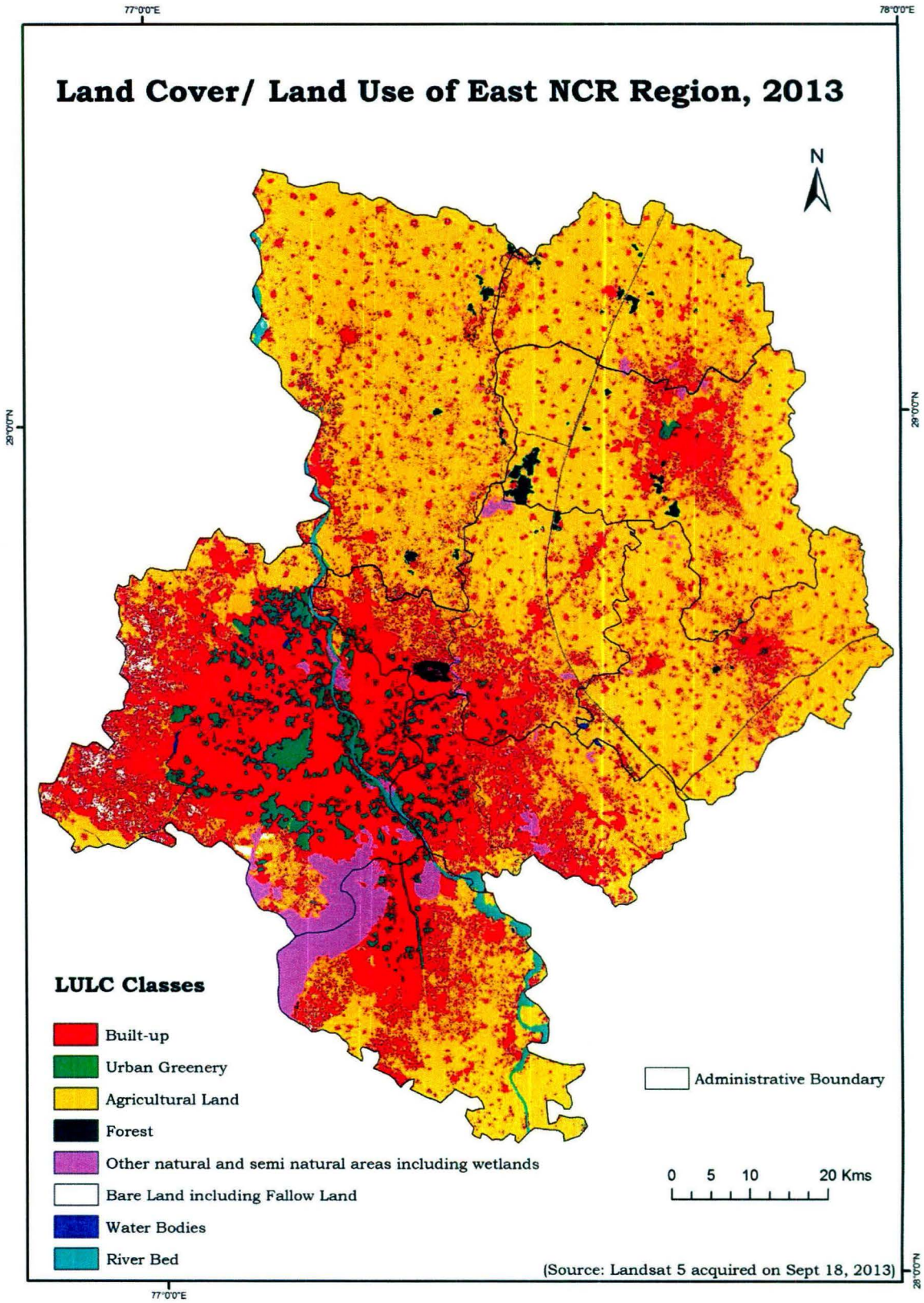
4.4 LULC STATUS IN GHAZIABAD AND FARIDABAD DISTRICTS IN RELATION TO ITS SURROUNDING REGIONS: -

If we look the NCR predominantly is an urban region. The maps below indicate that the built-up in increasing and the area under agricultural activities is shrinking. The urban growth affects the ecosystem not only in the core city but also in the periphery of the city. In Delhi urban fringe, the agricultural land is facing problems like fragmentation of land, excavation of fertile soil for brick kilns, transformation into farmhouses etc. The bare land is also being transformed into settlement areas. Apart from this the high economic value of land in the NCR region evokes farmers to sell the fertile agricultural land. There are several natural and semi- natural areas that are necessary to be preserved in the process of urban sprawl. In the NCR significant improvements have been observed in forest cover and urban greenery. The increase in urban greenery may be attributed to the transformation of agricultural land into recreational areas. The increase in forest cover is may be attributed to the implementation of forestation scheme in whole NCR region. The agricultural land is continuously decreasing in the whole National Capital Region (NCR). To measure the influence of urbanization on land use land cover in Ghaziabad and Faridabad, it is also necessary to compare these LULC changes with surrounding region.

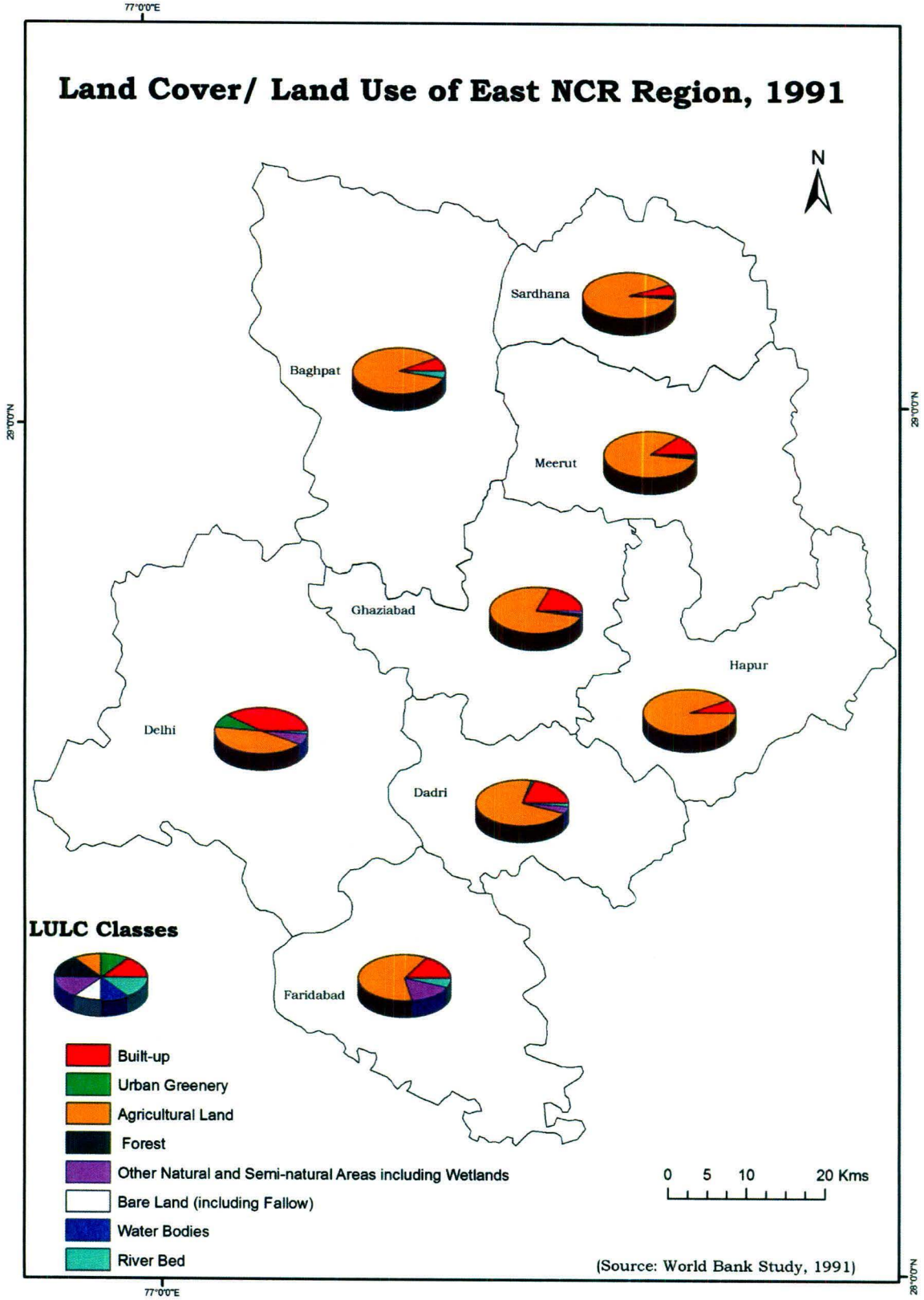
MAP 4.3: LAND COVER/ LAND USE OF EAST NCR REGION, 2011



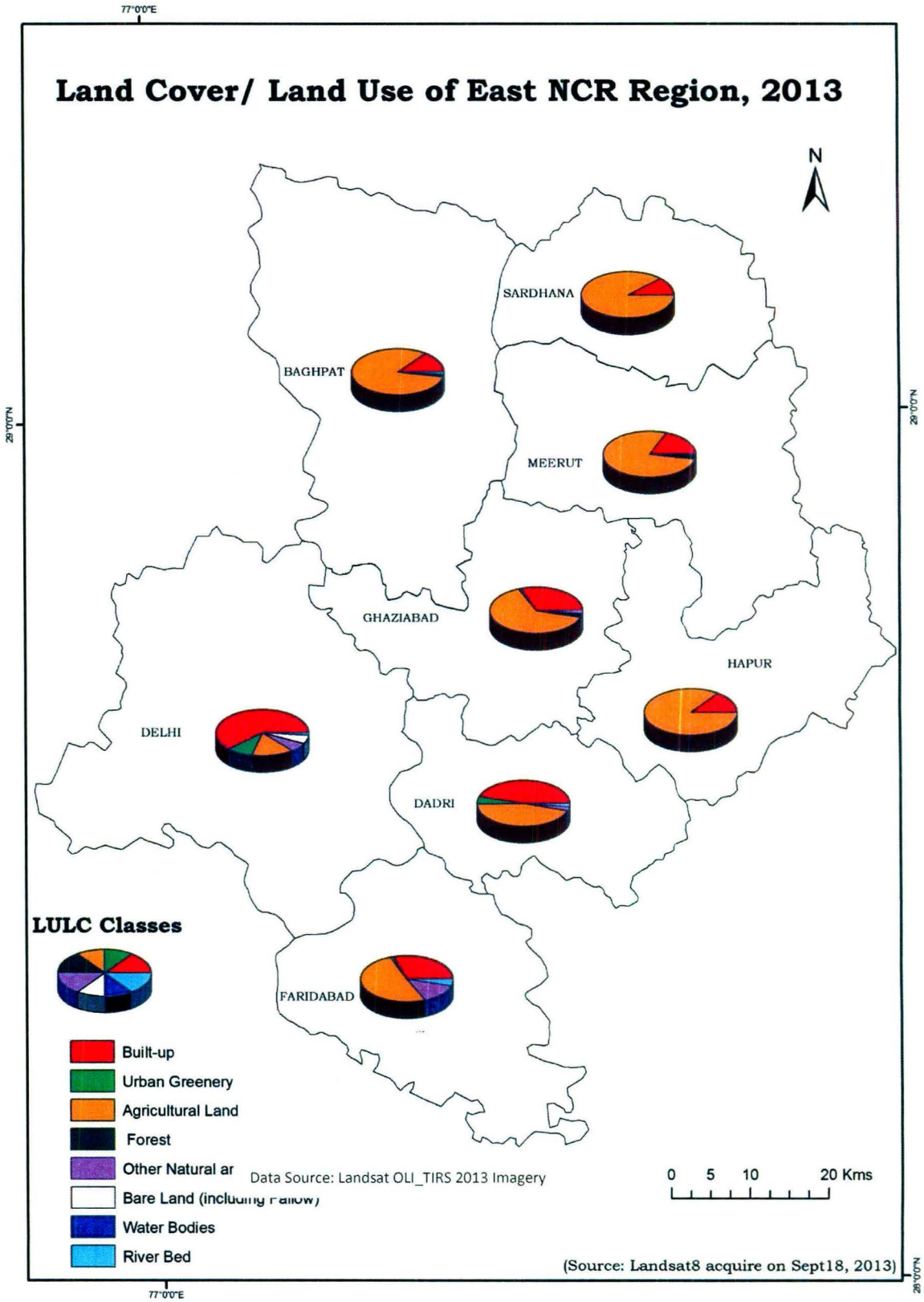
MAP 4.4: LAND COVER/ LAND USE OF EAST NCR REGION, 2013



MAP 4.5: LAND COVER/ LAND USE STATUS OF EAST NCR REGION, 1991



MAP 4.6: LAND COVER/ LAND USE STATUS OF EAST NCR REGION, 2013



4.4.1 BUILT-UP AREA (SETTLEMENTS): -

This category includes residential, non-residential built-up, industrial sites, airport, yards, landfill sites etc. This category constitutes the second largest use of land in national Capital Region. Haryana sub-region has the highest concentration (35.46 %) of the area under "built up" category in NCR followed by U.P. (33.29%), NCT-Delhi (22.43%) and Rajasthan sub-regions (8.82%) (NCR revised Draft, 2021). The report from World Bank indicates that the built up area was 18.2%, 21% and 23.4% respectively in the years 1991, 2003 and 2010. The agricultural and barren land is continuously being turned into built-up area. In the graph below it can be observed that in Ghaziabad district also the built up area is increasing and agricultural area is decreasing. The high selling price of land is attracting farmers to sell their fertile land. The forest cover is increasing continuously in the district. The data collected from World Bank research also explains that the forest cover is increasing gradually in the whole NCR region. In rest of the LULC categories no significant improvements have been observed in Ghaziabad district. The figure 4.1 illustrates the area covered by different LULC class in different time periods in Ghaziabad district.

The table shows that the built up area in Ghaziabad district in 1991 was 18.2% which increased and reached up to 20.96% in 2003 and 23.4% in 2010. The analysis of satellite images shows that the built up area increased to 29.4% and 31.6% respectively in 2011 and 2013. It is clear that the share of built –up increased around 13.36% from 1991 to 2013.Thus the area covered by built up in 1991 was just 13516.7 ha which increased up to 9922.6 ha and reached up to 223438.52 ha in the year 2013 in Ghaziabad district. The map 4.5 & 4.6 shows the built up continuously increasing and the area under cultivation is continuously decreasing. The table 4.2 & 4.3 explains that the fertile agricultural land as well as bare land is continuously being covered by built-up areas.

TABLE 4.2: LULC CLASS WISE AREA (HECTARE) IN GHAZIABAD AND FARIDABAD DISTRICTS

		Ghaziabad					Faridabad				
SN	LULC Class	1991	2003	2010	2011	2013	1991	2003	2010	2011	2013
1	Built-Up	13516.7	15549.7	17376.1	21843.9	23438.52	12145.3	14342	16974.3	23752.08	26163.72
2	Urban Greenery	628.9	759.3	793.7	861.93	899.64	727.7	960.9	965.8	1074.06	1196.55
3	Agricultural Land	56869	54424	52473	47879.73	46285.83	53250	50971	48529	43012.51	42835.6
4	Forest	1009.5	1257.2	1264.3	1230.12	1377.81	10.29	10.29	8.05	20.99	28.59
5	Other Natural and Semi-natural Areas including Wetlands	990.2	1005.6	991.2	1107.45	1048.95	13555	13254	12817	10976.85	10396.08
6	Bare Land (including Fallow land)	95.25	114.4	210.4	662.85	457.92	217.5	357.6	587.2	1968.93	304.83
7	Water Bodies	498.2	498.2	499.7	309.42	319.32	71.36	76.48	89.9	108.81	45.8
8	River Bed	590.3	590.3	590.3	321.75	389.16	4055.2	4055.1	4055	3117.06	3060.36
	Total	74198.05	74198.7	74198.7	74217.15	74217.15	84032.35	84027.37	84026.25	84031.29	84031.53

TABLE 4.3: LULC CLASS WISE PERCENTAGE AREA IN GHAZIABAD AND FARIDABAD DISTRICTS

		Ghaziabad					Faridabad				
S.N	LULC Class	1991	2003	2010	2011	2013	1991	2003	2010	2011	2013
1	Built-Up	18.22	20.96	23.42	29.43	31.58	14.45	17.07	20.2	28.27	31.13
2	Urban Greenery	0.85	1.02	1.07	1.16	1.21	0.87	1.14	1.15	1.28	1.42
3	Agricultural Land	76.64	73.35	70.72	64.51	62.37	63.37	60.66	57.75	51.1	50.85
4	Forest	1.36	1.69	1.7	1.66	1.86	0.01	0.01	0.01	0.11	0.15
5	Other Natural and Semi-natural Areas including Wetlands	1.33	1.36	1.34	1.49	1.41	16.13	15.77	15.25	13.06	12.37
6	Bare Land (including Fallow land)	0.13	0.15	0.28	0.89	0.62	0.26	0.43	0.7	2.34	0.36
7	Water Bodies	0.67	0.67	0.67	0.42	0.43	0.08	0.09	0.11	0.13	0.05
8	River Bed	0.8	0.8	0.8	0.43	0.52	4.83	4.83	4.83	3.71	3.64

Data source: Study by European Space Agency and Landsat images

TABLE 4.4: PERCENTAGE CHANGES IN AREA OF LAND USE LAND COVER CLASSES OF GHAZIABAD DISTRICT

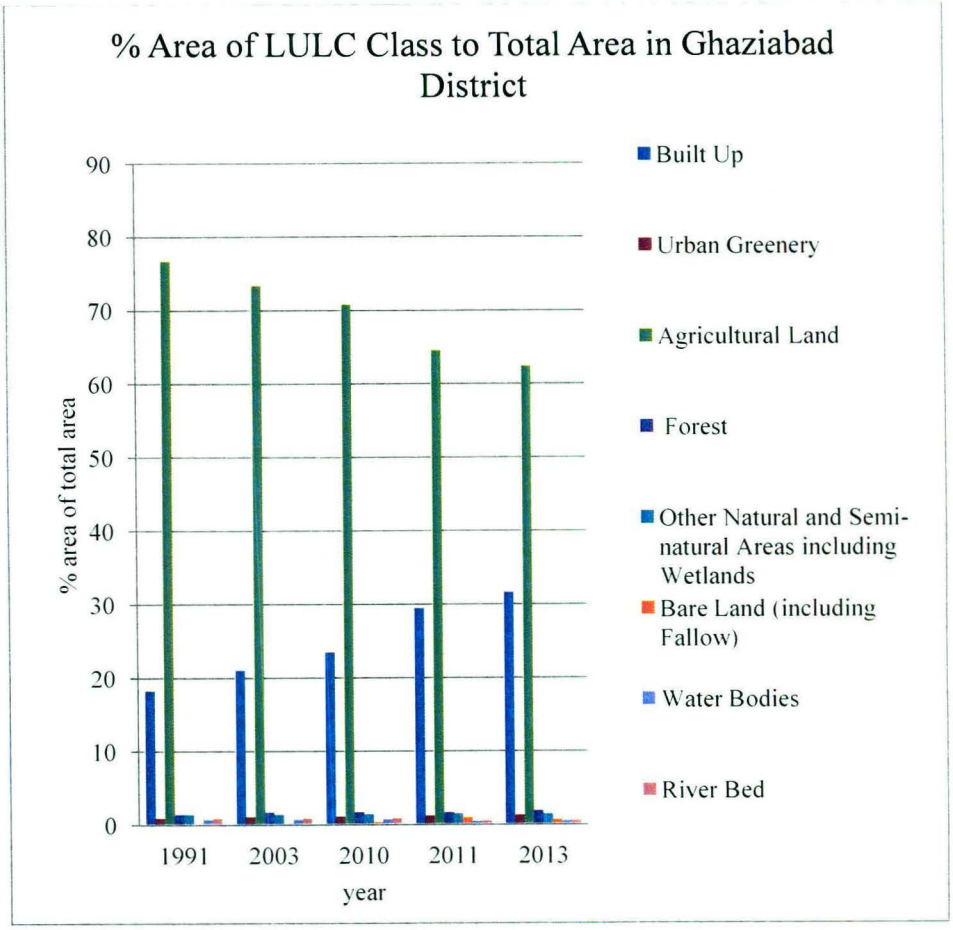
	1991-03			2003-10			2010-11			2011-13			1991-13		
LULC Category	Ha	%	%/yr	Ha	%	%/yr	Ha	%	%/yr	ha	%	%/yr	ha	%	%/yr
Built-up	2033	15	1.5	1826.4	11.7	1.7	4467.8	25.7	25.7	1594.6	7.3	3.7	9921.8	73.4	3.3
Urban Greenery	130.4	20.7	2.1	34.4	4.5	0.6	68.2	8.6	8.6	37.7	4.4	2.2	270.7	43	2
Agricultural Land	-2445	-4.3	-0.4	-1951	-3.6	-0.5	-4593.3	-8.8	-8.8	-1593.9	-3.3	-1.7	-10583.2	-18.6	-0.8
Forest	247.7	24.5	2.5	7.1	0.6	0.1	-34.2	-2.7	-2.7	147.7	12	6	368.3	36.5	1.7
Other Natural and Semi-natural Areas including Wetlands	15.4	1.6	0.2	-14.4	-1.4	-0.2	116.3	11.7	11.7	-58.5	-5.3	-2.6	58.8	5.9	0.3
Bare Land (including fallow land)	19.2	20.1	2	96	83.9	12	452.5	215	215	-204.9	-30.9	-15.5	362.7	380.8	17.3
Water Bodies	0	0	0	1.5	0.3	0	-190.3	-38.1	-38.1	9.9	3.2	1.6	-178.9	-35.9	-1.6
River Bed	0	0	0	0	0	0	-268.6	-45.5	-45.5	67.4	21	10.5	-201.1	-34.1	-1.5

TABLE 4.5: PERCENTAGE CHANGES IN AREA OF LAND USE LAND COVER CLASSES OF FARIDABAD DISTRICT

	1991-03			2003-10			2010-11			2011-13			1991-13		
LULC Category	ha	%	%/yr	ha	%	%/yr	Ha	%	%/yr	ha	%	%/yr	ha	%	%/yr
Built-up	2196.7	18.1	1.8	2632.3	18.4	2.6	6777.8	39.9	39.9	2411.6	10.2	5.1	14018.4	115.4	5.2
Urban Greenery	233.2	32	3.2	4.9	0.5	0.1	108.3	11.2	11.2	122.5	11.4	5.7	468.9	64.4	2.9
Agricultural Land	-2279	-4.3	-0.4	-2442	-4.8	-0.7	-5516.5	-11.4	-11.4	-176.9	-0.4	-0.2	-10414.4	-19.6	-0.9
Forest	0	0	0	-2.2	-21.8	-3.1	12.9	160.7	160.7	7.6	36.2	18.1	18.3	177.8	8.1
Other Natural and Semi-natural Areas including Wetlands	-301	-2.2	-0.2	-437	-3.3	-0.5	-1840.2	-14.4	-14.4	-580.8	-5.3	-2.6	-3158.9	-23.3	-1.1
Bare Land (including fallow land)	140.1	64.4	6.4	229.6	64.2	9.2	1381.7	235.3	235.3	-1664.1	-84.5	-42.3	87.3	40.2	1.8
Water Bodies	5.1	7.2	0.7	13.4	17.5	2.5	18.9	21	21	-63	-57.9	-29	-25.6	-35.8	-1.6
River Bed	-0.1	0	0	-0.1	0	0	-937.9	-23.1	-23.1	-56.7	-1.8	-0.9	-994.8	-24.5	-1.1

Data source: Study by European Space Agency and Landsat images

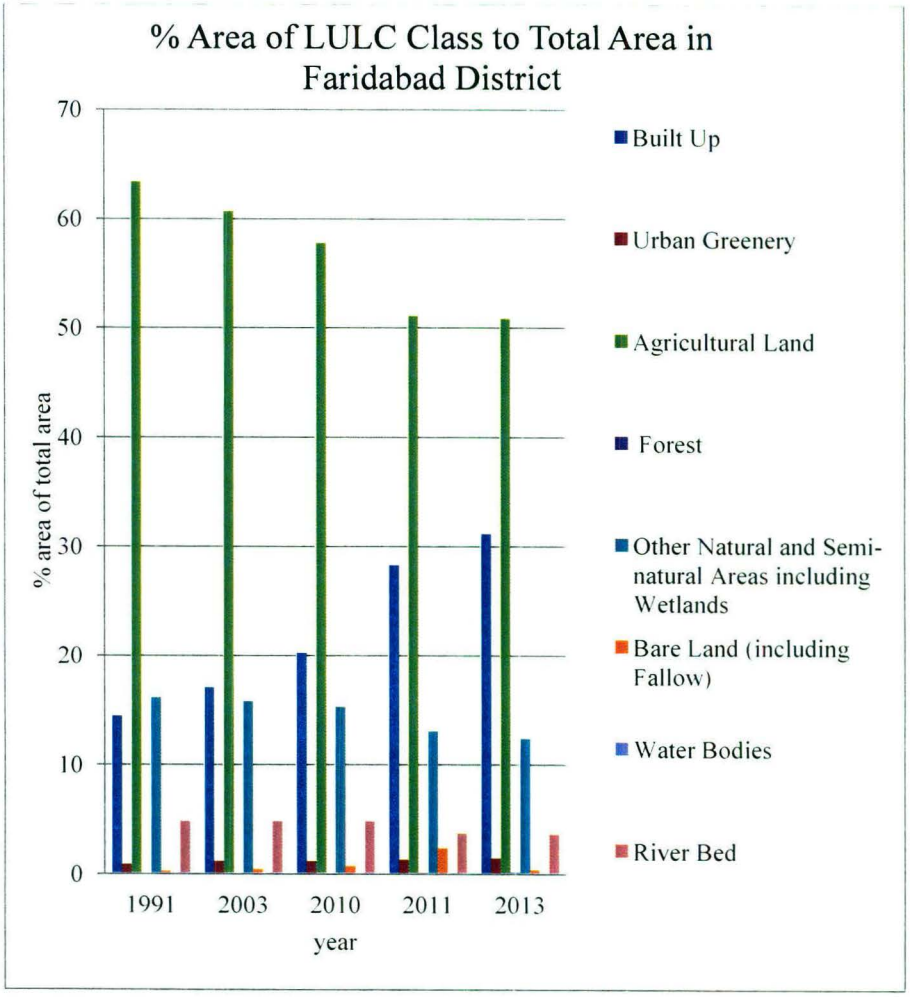
FIGURE 4.1: PERCENTAGE AREA COVERED BY LULC CLASS IN GHAZIABAD DISTRICT



(Data Source: Study by European Space Agency and Landsat Images)

In the graph 4.2 it can be observed that in Faridabad district also the built up area is increasing and agricultural area is decreasing. The high selling price of land is attracting farmers to sell their fertile land. The forest cover is increasing continuously in the district. The data collected from World Bank research also explains that the forest cover is increasing gradually in the whole NCR region. In rest of the LULC categories no significant improvements have been observed in Faridabad district. The table4.4 & 4.5 illustrates the area covered and changes by different LULC class in different time periods in Ghaziabad district.

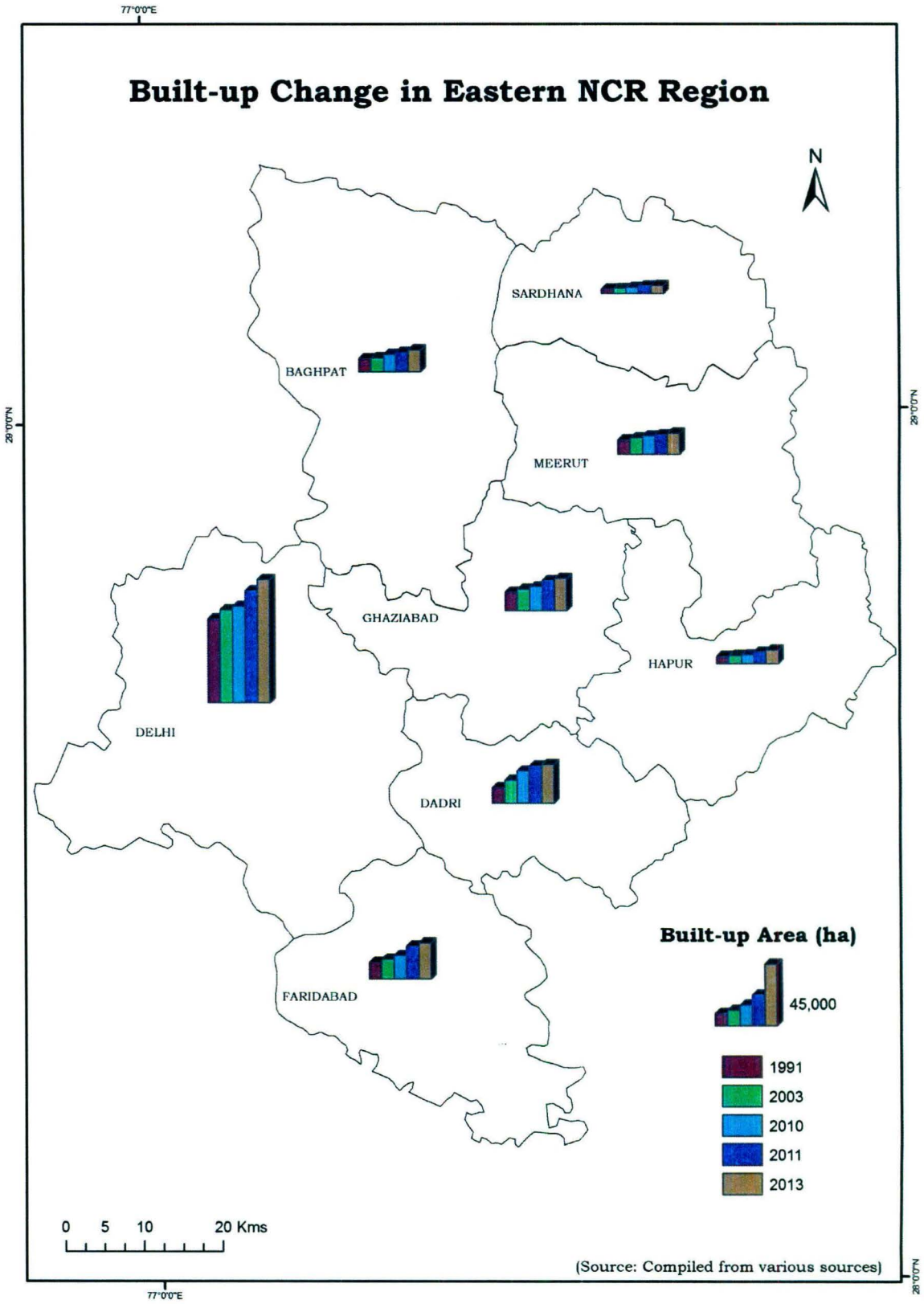
FIGURE 4.2: PERCENTAGE AREA COVERED BY LULC CLASS IN FARIDABAD DISTRICT



(Data Source: Study by European Space Agency and Landsat Images)

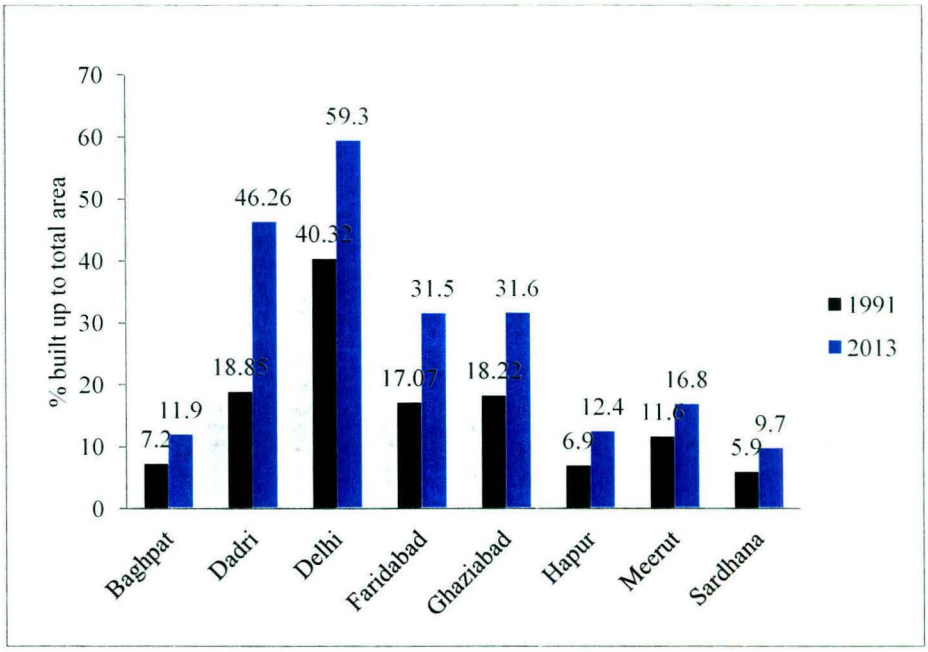
The table 4.3 shows that the built up area in 1991 was 14.45% which increased and reached up to 17.07% in 2003 and 20.2% in 2010 in Faridabad district. The analysis of satellite images shows that the built up area increased to 28.27% and 31.13% respectively in 2011 and 2013. It is clear that the share of built –up increased around 16.7% from 1991 to 2013.Thus the area covered by built up in 1991 was just 12145.3ha which increased up to 14018ha and reached up to 26163.72ha in the year 2013. The figure 4.2 shows that the built up continuously increasing and the area under cultivation is continuously decreasing. The data explains that the fertile agricultural land as well as bare land is continuously being covered by built-up areas.

MAP 4.7: BUILT-UP CHANGE IN EASTERN NCR REGION



If we look the change in the built up scenario of the nearby districts and NCT Delhi we found that Ghaziabad district is one of the fastest urbanizing districts. In Delhi in 1991 the built up area was 40.32% of total area which increased to 59.3% in 2013. Ghaziabad district is very near to Delhi and has good connectivity. So it has high influence of NCT Delhi. In its surrounding districts Ghaziabad district is one of the fastest growing districts.

FIGURE 4.3: PERCENTAGE BUILT-UP AREA TO TOTAL AREA IN EAST NCR REGION



(Data Source: Study by European Space Agency and Landsat Images)

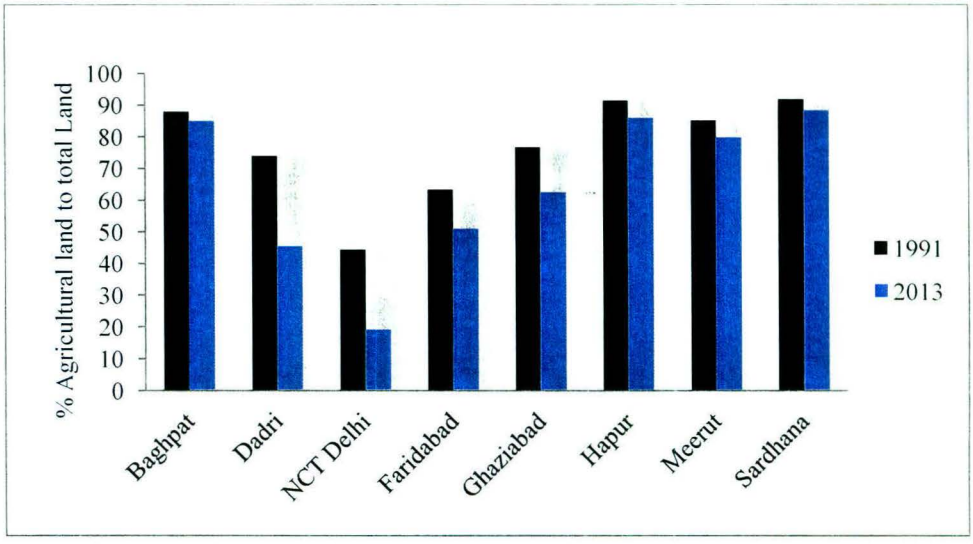
The figure 4.3 explains that built up has significantly increased in the NCT Delhi. The built up area was 40.32% in 1991 which became 59.3% in 2013. This is a tremendous increase as well as it will put high pressure on the resources of the region itself and on the peri-urban area also. In this flow of industrialization and urbanization the nearby regions also have to bear the huge direct and indirect pressure that will be thrust upon by increasing resource utilization. In Faridabad and Ghaziabad districts the area covered by built up is almost same. The tehsil Dadri shows a very high % increase in built-up area from 1991 to 2013. In 1991 just 18.85% land was under built-up category which increased to 46.26% in 2013. In other tehsils like Baghpat, Hapur, Meerut and Sardhana the built-up area has increased nominally. Actually it is the fertile agricultural land or bare land which has been sold to the big contractors to built multi-story buildings. The high prices paid by the contractors to the owner of land. Thus the owner of land is lured by the high prices and sells his land for any commercial type use apart from agricultural activities.

4.4.2 AGRICULTURAL LAND: -

In the study area and in surrounding tehsil the predominant use of land is in this category. This category includes cultivated land, plantation agriculture and horticulture. The fertile land and adequate supply of water makes this region most suitable for agriculture. If we analyze the World Bank data we found that the agricultural area is continuously decreasing on the cost of urban sprawl. If we compare the agricultural land use with surrounding districts and NCT Delhi we found that all the districts are showing a declining trend in the agricultural land use. It is clear from the data that in nearby districts of NCT Delhi the land under agricultural activities has declined significantly. The NCT Delhi itself experienced a significant loss of agricultural land from 1991 to 2013. In 1991 around 44.36% land of Delhi was under agricultural activities which remained only around 19% in 2013. The total area under agricultural activities in Delhi in 1991 was 66733 ha which remained around 28673ha in 2013. A net loss of 38059 ha is experienced in NCT Delhi during these 22 years.

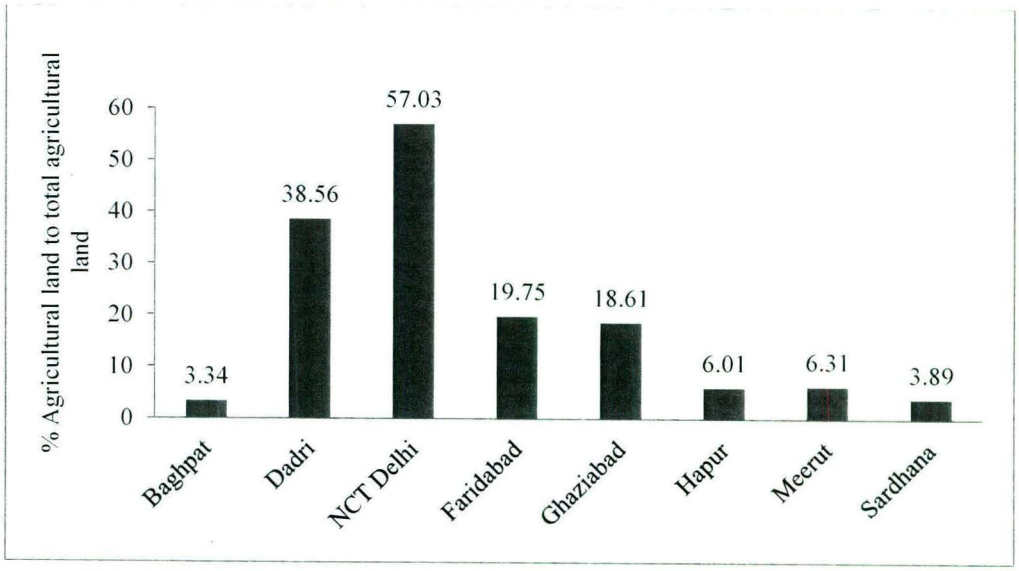
The data explains that nearby districts of NCT Delhi, the land under agricultural activities is transforming fastly in other land use. In 1991, Dadri and Faridabad had 74% and 63% agricultural land which remained only 45.4% and 50.8% in 2013. It is clear from the figure 4.4 that apart from NCT Delhi in tehsils Dadri, Faridabad and Ghaziabad the agricultural land transformed significantly into other land use categories. In tehsils Baghpat, Hapur, Meerut and Sardhana not so much agricultural land was transformed into other land uses.

FIGURE 4.4: PERCENTAGE AGRICULTURAL AREA TO TOTAL AREA IN EAST NCR REGION



(Data Source: Study by European Space Agency and Landsat Images)

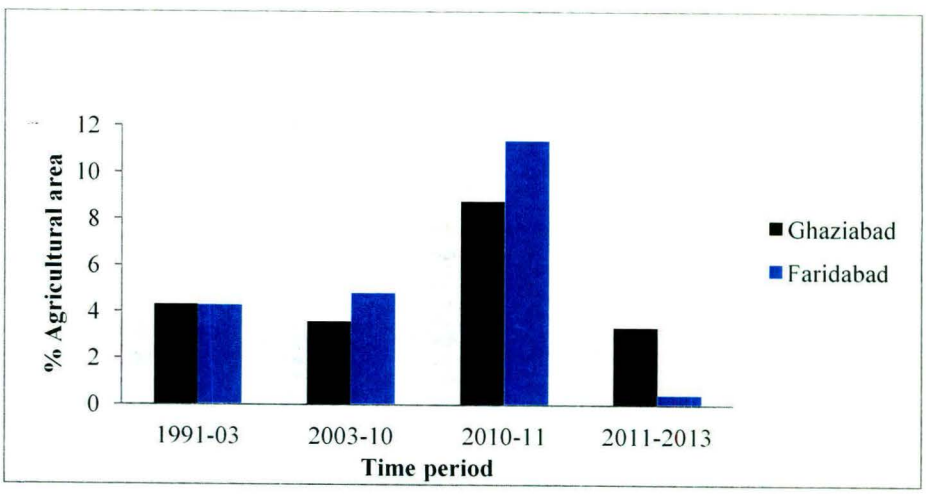
FIGURE 4.5: PERCENTAGE DECREASE IN AGRIULTURAL LAND IN EAST NCR REGION 1991-2013



(Data Source: Study by European Space Agency and Landsat Images)

In Ghaziabad district in 1991 the agricultural area was 76.64% of total area. It continuously decreased and remained 73.35% and 70.7% respectively in 2003 and 2010. The data analyzed from satellite also shows a decreasing trend in agricultural land use. In the district it remained only 64.5% and 62.4% in 2011 and 2013 respectively. It is estimated that from 1991 to 2013 the agricultural land declined around10583 hectares. It means around 481 hectare land /year was transformed into other land use. The graph above shows clearly the declining trend of agriculture.

FIGURE 4.6: PERCENTAGE DECREASE IN AGRICULTURAL LAND IN GHAZIABAD AND FARIDABAD DISTRICTS



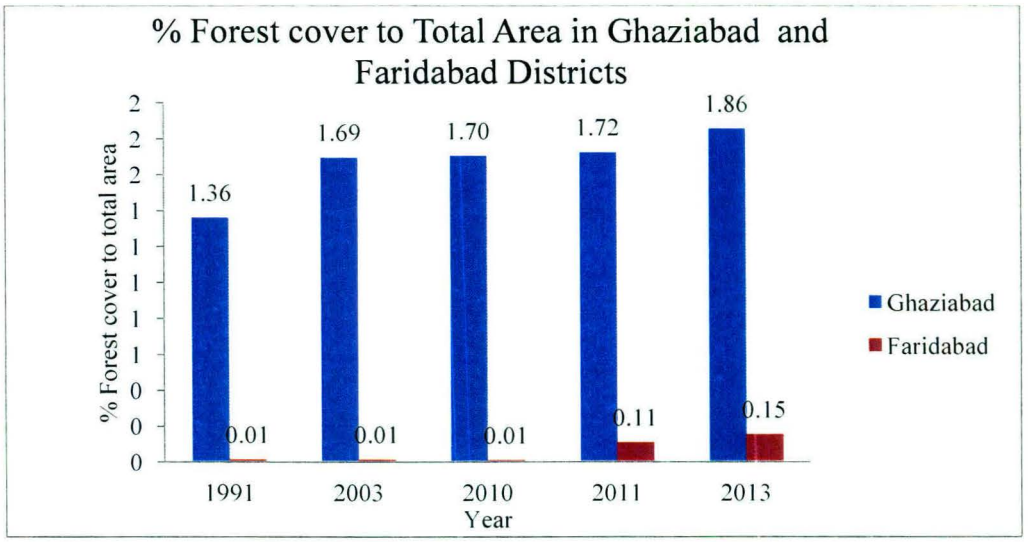
(Data Source: Study by European Space Agency and Landsat Images)

In Faridabad district in 1991 the agricultural area was 63.37% of total area. It continuously decreased and remained 60.66% and 57.75% respectively in 2003 and 2010. The data analyzed from satellite also shows a decreasing trend in agricultural land use. In the district it remained only 51.1% and 50.85% in 2011 and 2013 respectively. It is estimated that from 1991 to 2013 the around10414 hectares agricultural land declined. It means around 473 hectare land /year was transformed into other land use. The decrease in agricultural land happened at higher rate in Faridabad district if compared to Ghaziabad district. From the ecological and biological point of view the declining agricultural land is a point of great concern. It is because the pattern of urban growth affects the patterns of biodiversity. The urban sprawl can be used as a solution if in the same proportion the urban greenery is maintained to avoid the ecological imbalance. If urban sprawl continues the city will continue to spread. Thus a big city will have big population. It will increase the consumption of the resources which will cause pressure on the natural resources of the region and in the surrounding peripheral area also.

4.4.3 FOREST: -

This land use category includes non- agricultural naturally or artificially forested cover away from the urban or rural settlements. This includes both types of forest cover: reserved or unreserved. Due to the afforestation scheme in National Capital Region the forest cover is increasing gradually in the Ghaziabad district as well as in the whole NCR. The study by World Bank explains that in 1991 around 1009.5 ha land was under forest cover in Ghaziabad district. Later on it was measured as 1257.2 ha and 1264.3 ha respectively in 2003 and 2010. The analyses of satellite imageries show that in 2011 the forested cover was 1280.12 ha and in 2013 it was 1377.81 ha. Overall an increasing pattern of forested cover can be observed in the study area. The figure 4.7 explains scenario of percentage land covered by forests in different years in Ghaziabad and Faridabad districts.

FIGURE 4.7: PERCENTAGE FOREST COVER IN GHAZIABAD AND FARIDABAD DISTRICTS



The study by World Bank explains that in 1991 around 10.29 ha land was under forest cover in Faridabad district. Later on it was measured as 10.29ha and 8.05 ha respectively in 2003 and 2010. It means from 1991 to 2010 the changes in forest cover were negligible. The analyses of satellite imageries show that in 2011 the forested cover was 20.99 ha and in 2013 it was 28.59 ha. Through the above graph it can be observed that the forest cover is increasing in Faridabad as well as in Ghaziabad. But it is still very less if we see from the ecological point of view in semi-arid climatic region. According to national forest policy 1988 the forest cover should be at least one third of the total land area. The analysis above shows that very less area is forested. Actually in this study the urban green cover has been categorised separately as urban Greenery.

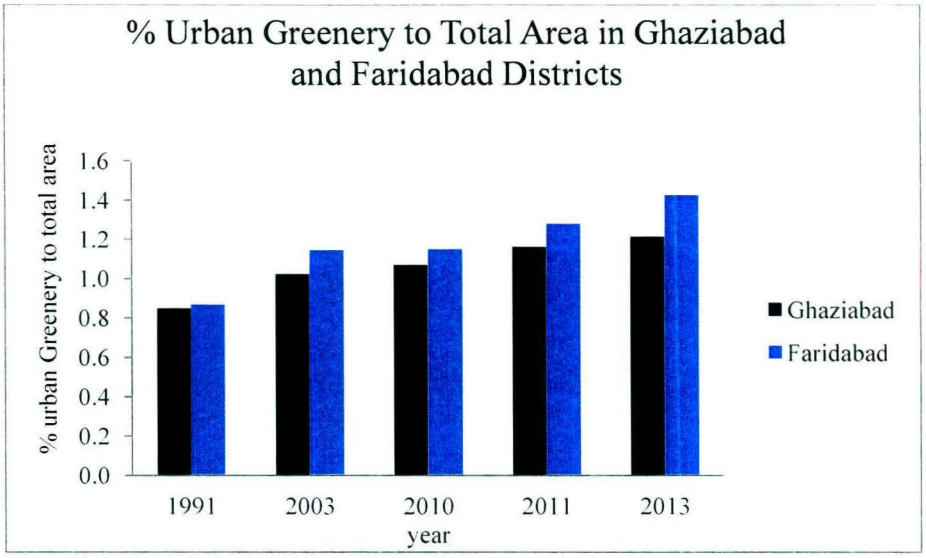
4.4.4 URBAN GREENERY: -

This category includes urban parks, urban gardens, urban forests, tree cover along the roads and railway lines, zoological parks, forest reserves, commercial and industrial green belts, avenues and boulevards etc. for a city to be a liveable city it should have sufficient amount of green cover. It is very necessary from climatological as well as ecological point of view. These urban green spaces provide recreational services to residents. These places have lesser economic value than forests but very important to improve the living conditions in big cities. The urban greenery acts as a natural cooling system of the city. Apart from it act as noise absorbers, improve microclimates and the quality of natural resources including soil, water, vegetation & wildlife in the urban area. Urban green cover helps in improving the aesthetic

beauty of the cities. This benefits the inhabitants of the city by maintaining their psychological health.

Urban greenery absorbs the pollutants of the city which are generated due to industrial activities or transportation. Thus helps in keeping the air clean and breathable. Trees shrubs etc in urban areas modifies the solar radiation and thus controls temperature extremes. This reduces the increasing temperature in the urban area which increases due to urban built up covers. Urban green covers are a source of employment as well as education for the inhabitants. These enhance outdoor recreation, especially for the low income people who can't afford distant recreational areas. Thus these areas develop as meeting points for people that strengthens neighbourhood and enhance community building.

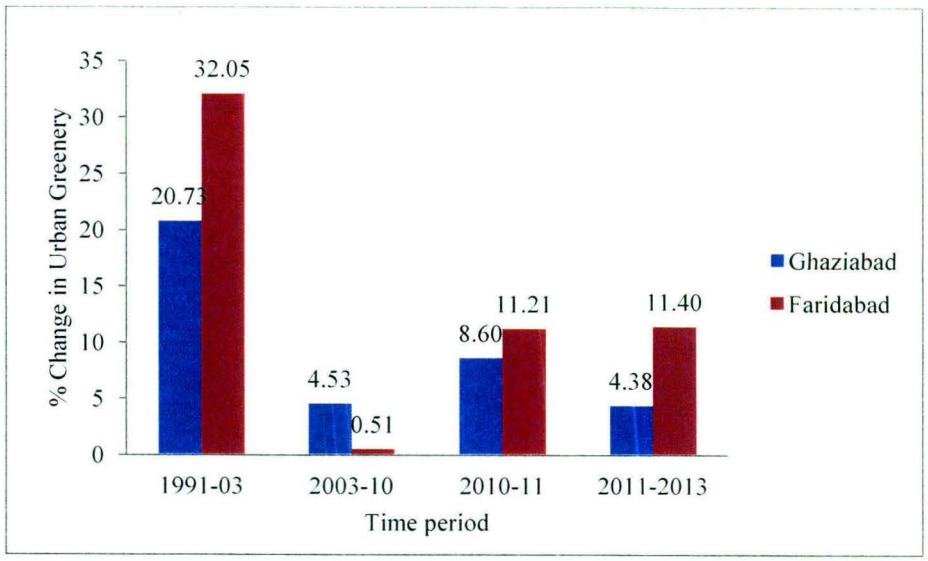
FIGURE 4.8: PERCENTAGE URBAN GREENERY IN GHAZIABAD AND FARIDABAD DISTRICTS



(Data Source: Study by European Space Agency and Landsat Images)

The data from World Bank study shows that urban greenery is increasing in the National Capital region with urban sprawl. The urban greenery is increasing with urban built-up. In NCT Delhi the urban greenery has continuously increased over the time. In 1991 around 10900 ha land was under this category which was 7.25% of the total area. In 2003 and 2010 it was measured respectively 11483ha and 11313ha in NCT Delhi. The satellite imagery classification show that later on it increased much. As in 2011 and 2013 it was measured respectively as 13525ha 14919ha in NCT Delhi. Thus in NCT Delhi the urban greenery was 8.99% and 9.2% of total area respectively in 2011 and 2013.

FIGURE 4.9: PERCENTAGE CHANGE IN URBAN GREENERY IN GHAZIABAD AND FARIDABAD DISTRICTS



(Data Source: Study by European Space Agency and Landsat Images)

In Ghaziabad the area under urban greenery has becomes 1.5 times from 1991 to 2013. In 1991 around 629ha land was in this category. In 2003 and 2010 it was measured as 759ha and 793ha in the World Bank study. The classification of satellite imagery shows that it increased in 2011 and 2013. In 2011 around 1.16% area and in 2013 around 1.21% area of total area was in this category. In Faridabad also the area under urban greenery has becomes 1.5 times from 1991 to 2013. In 1991 around 727ha land was in this category. In 2003 and 2010 it was measured as 961ha and 965.8ha in the World Bank study. The classification of satellite imagery shows that it increased in 2011 and 2013. The area under green cover was 1074ha and 1196ha respectively in 2011 and 2013. Thus in 2011 around 1.28% area and in 2013 around 1.48% area of total area were in this category. In other surrounding tehsils Dadri has around 3.49% area in urban green cover in 2013 which amounts 2140ha in absolute terms. Other tehsils like Baghpat, Sardhana, Meerut and Hapur has urban green area below 1% of total area. The figure 4.9 explains changes in urban greenery in different time periods.

4.4.5 OTHER NATURAL AND SEMI-NATURAL AREAS INCLUDING WETLANDS: -

In this category the rocky, hilly tracts, gullied land, scrub land, saline land, water logged areas or wetlands, semi-arid pastures and rangelands have been included. The 'Delhi Ridge' which is northern extension of Aravalli Range contributes largest part in semi-arid natural areas. It is extended from Alwar district of Rajasthan to NCT Delhi and Faridabad district of Haryana state. The urban sprawl may cause many problems to this biodiversity hotspot. The semi-arid forest of this tract is being utilized, apart from this it is being used as dumping site of construction activities. These will cause serious problem to this area which are being neglected. The mining activities which were running earlier now have been stopped to protect this ecological niche. This is a biodiversity hotspot of NCR so to protect biodiversity parks have been developed. Now a stable condition can be measured in this category. There have been found some wetlands also in the study area. These wetlands are concentrated on the banks of Yamuna River and Hindon River. In the outer National Capital Region the other natural and semi-natural areas and wetlands are showing a declining trend. The area covered by this category is decreasing gradually over the time. More or less the area in this category has remained same with negligible increase or decrease.

In NCT Delhi in 1991 around 8428ha area was in this category that constituted 5.60% of the total area. In 2013 it was around 5.61%. Throughout from 1991 to 2013 it has remained same but the land has been degraded. According to the surveys the land is being used for dumping zone of construction materials. Public parks developed for amusement are also a threat for the many endangered species of this region.

In Ghaziabad district in 1991 around 990 hectare area was in this category that was 1.33% of total area till 2013 it increased marginally and was measured 1.41% of total area. In Faridabad district the opposite view has been observed as the area in this category has declined significantly. In 1991 around 13555ha land was in this category which remained 10396ha in 2013. So a net loss of 3.76% has been measured from 1991 to 2013. This may be due to the conversion of this land into built-up cover. Thus the area in this category in 1991 was 16.13% which remained 12.37% in 2013. In nearby tehsils Dadri in 1991 had 1995ha land in this category which remained 1203ha constituting only 1.96% of total area of tehsil. In other nearby tehsils like Baghpat, Sardhana, Meerut and Hapur very less increase or decrease has been observed over the time.

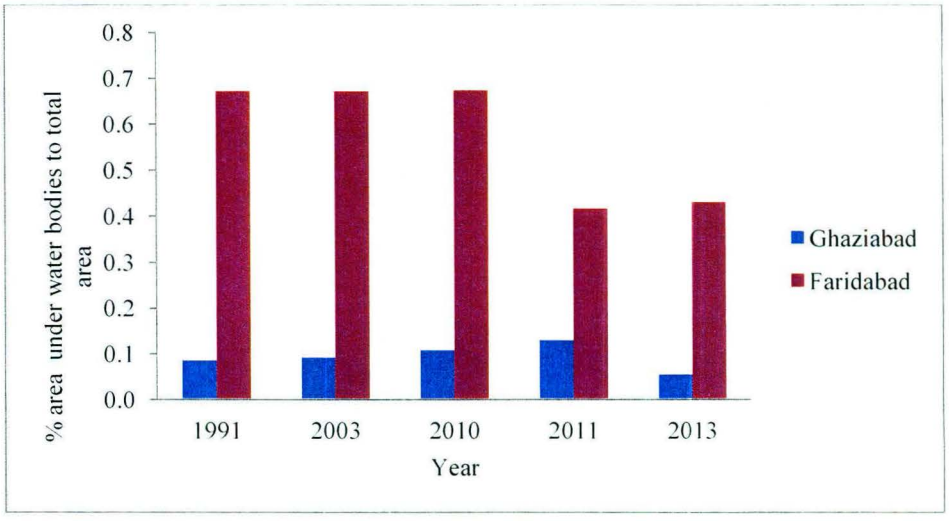
4.4.6 BARE LAND (INCLUDING FALLOW LAND): -

This category includes land which is not occupied by cultivation, built-up, scrub land or any type of grass cover. Though this land may be fertile but currently it is not in any use. This category also includes fallow land: the land which is cultivated but is not under cultivation in the reference year. The bare land as well as the fallow land has same productivity if not in any use. So both have been categorised in a single category. It also includes the barren land. In the NCT Delhi itself the ratio of bare land to total land has irregularity over the time period. For NCT Delhi the bare land was around 708ha in 1991. In 2003 and 2010 it shows a declining pattern. In 2011 it shows a very high ratio of land in bare land category. In Ghaziabad and Faridabad districts as well as in surrounding tehsils the ratio of bare land in the year 2011 is very high compared to the other time periods. In Faridabad district in 2011 around 1968 ha land was in this category while in 2013 it was just 304ha. Similarly in Ghaziabad district also in 2011 the ratio of bare land to total land was very high. In surrounding tehsils of Ghaziabad and Faridabad districts the similar irregular pattern of bare land has been observed over the time period.

4.4.7 WATER BODIES: -

The flowing water bodies like river, canal etc and stagnant water bodies like ponds, lakes etc have been included in this category. The water bodies, especially the flowing water is considered as veins of any region. In agriculture dominant area the water plays a main role in the productivity of the crops. The fresh water sources are very necessary in an urban area as it provides drinking water facility. Similarly the urban ponds are not just pools of water. Ponds are important part of ecology. Ponds are benches to sit & relax beside and place for aesthetic satisfaction for the inhabitants in urban areas. In National Capital Region which is agriculture dominant region requires sufficient water resources.

FIGURE 4.10: % AREA OF WATER BODIES IN GHAZIABAD AND FARIDABAD DISTRICTS



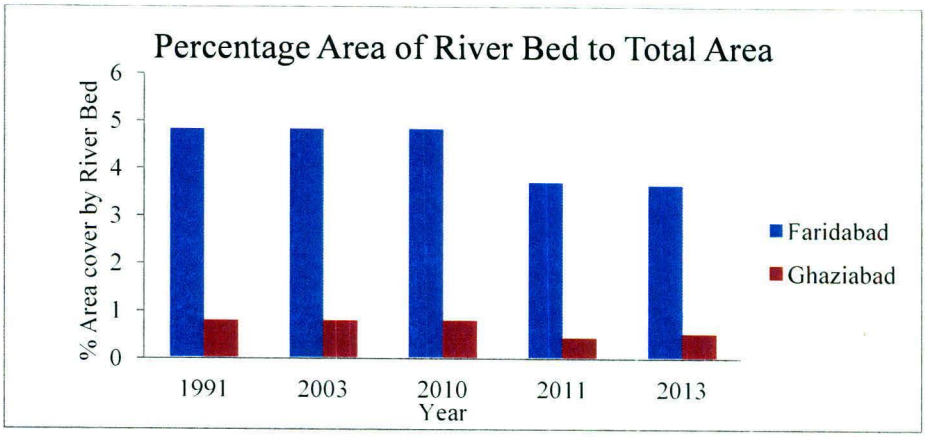
(Data Source: Study by European Space Agency and Landsat Images)

The figure 4.10 explains the area under water bodies in different time periods in Ghaziabad and Faridabad districts. It is clear that availability of water bodies in Ghaziabad district is consistent in different time periods. The area under water bodies increased gradually till 2011 but declined marginally in 2013. While in Faridabad district there was no change in area covered by water bodies in 1991, 2003 and 2010. The area covered by water bodies was consistent till 2010. But in 2011 the area of water bodies declined and it remained about 0.4% of total area in 2011 and 2013.

4.4.8 RIVER BED: -

The channel area occupied by a river or stream is included in this category. The river bed is found only in those tehsils or administrative divisions through which river Yamuna flows. The river flows through NCT Delhi, Baghpat, Ghaziabad, Dadri and Faridabad districts.

FIGURE 4.11: PERCENTAGE AREA OF RIVER BED IN GHAZIABAD AND FARIDABAD DISTRICTS



(Data Source: Study by European Space Agency and Landsat Images)

From the above graph we can say that till 2010 both districts Ghaziabad and Faridabad experienced no change in river bed area. Later in year 2011 and 2013 it declined significantly. In Faridabad district around 4055ha land was under river bed category in 1991 which remained only 3060 ha in 2013. Similarly in Ghaziabad district the area under river bed category was around 590ha which remained 390ha in the year 2013. In NCT Delhi negligible changes are observed in area of river bed. The river Yamuna doesn't flow through Sardhana, Meerut and Hapur tehsils. So no area in river bed category is distinguished in these above mentioned tehsils.

4.5 CONCLUSION: -

This chapter deals with the explanations of changes of land use and land cover in Ghaziabad and Faridabad districts. The urbanization process within the districts also affects the surrounding regions. So the land use land cover changes of these two districts have been compared with the Eastern part of National Capital Region. The data for the year 1991, 2003 and 2010 has been taken from the World Bank study mentioned earlier. To obtain data for the year 2011 and 2013, Landsat datasets have been used. After studying several classifications schemes like USGS classification scheme, Anderson classification scheme, NRSC classification scheme, an objective orient classification has been adopted. The land use land cover has been classified into eight categories. Further land use land cover category wise analysis has been done. The first LULC category identified is 'Built-up', the area occupied by settlements. The built-up area has increased in both districts. In Ghaziabad the built-up area in 1991 was 18.2% which increased to 31.6% in the year 2013. Similarly in Faridabad district the built-up area in 1991 was 14.45% of total area which increased to 31.13% in 2013. The data explains that the fertile agricultural land as well as bare land is continuously being covered by built-up areas. In all the surrounding regions of Ghaziabad and Faridabad districts except Dadri, the built-up is increasing but at lower speed than Ghaziabad and Faridabad. The second category is 'Agricultural Land' which has been identified to measure changes in agricultural land over the time. The analysis of data shows that whole Eastern part of NCR faced significant loss of agricultural land from 1991 to 2013. In Ghaziabad district the land and agricultural activities was 76.64% in 1991 which remained just 62.4% in the year 2013. Similarly in Faridabad district also in 1991 the land under agricultural activities was 63.37% which remained 50.85% in 2013. Both districts Ghaziabad and Faridabad lost respectively 10583ha and 10414ha agricultural land from 1991 to 2013. Actually it is the fertile agricultural land or bare land which has been sold to the big contractors to built multi-story buildings. The high prices paid by the contractors to the owner of land. Thus the owner of land is lured by the high prices and sells his land for any commercial type use apart from agricultural activities. The 3rd LULC category deals with the analysis of forest cover. The analyses of forest cover by national capital region planning board measures that due to the afforestation scheme the forest cover has increased in the whole NCR region. Our analysis also shows increase in forest cover. In Ghaziabad district 1009.5 ha land was under forest cover in which increased to 1264.3 ha in 2013. In Faridabad district also the forest cover in 1991 was 10.29ha which increased to 28.59 ha in 2013. The 4rd category of LULC is 'Urban

Greenery' which includes urban parks, urban gardens, urban forests, tree cover along the roads and railway lines, zoological parks, forest reserves, commercial and industrial green belts, avenues and boulevards etc. It is very necessary from climatologically as well as ecological point of view. In Ghaziabad the area under urban greenery has becomes 1.5 times from 1991 to 2013. Similarly in Faridabad has happened. In Ghaziabad district in 1991 around 628.9ha area was occupied by urban greenery which increased to 899.64ha in 2013. In Faridabad district also in 1991 around 727.7ha area was occupied by urban Greenery which increased to 1196.55ha in 2013. Thus urban greenery has increased with the increase in the built-up area.

The next LULC category 'other natural and semi-natural areas including wetlands' includes the rocky, hilly tracts, gullied land, scrub land, saline land, water logged areas or wetlands, semi-arid pastures and rangelands. The opposite scenario has been observed in Ghaziabad and Faridabad districts. In Ghaziabad district the area under other natural and semi-natural areas has increased marginally. While in Faridabad district a net loss of 3159ha has been measured. These areas are the biodiversity hotspots of National Capital Region. In the LULC category 'Bare Land including Fallow Land' an irregular pattern has been observed. The area covered by LULC category 'Water Bodies' is consistent over the time except a slight fall in 2011. The last category of LULC classification deals with the 'River Bed'. Till 2010 both districts Ghaziabad and Faridabad experienced no change in river bed area. Overall the river bed area in Ghaziabad district in 1991 was 0.80% of total area which decreased to o.52% in 2013. Similarly in Faridabad district also in 1991 around 4.83% area of total area was occupied by river bed which remained to 3.64% of total area in 2013. Overall analysis explains that built-up has increased significantly on the cost of losing agricultural and bare land. The forest cover is increasing gradually but the semi-natural areas and wetlands have decreased causing a threat to natural ecosystems. In rest of the LULC categories no significant changes have been observed over the time period.

CHAPTER V

LULC CHANGES AND ECONOMICS OF VALUING ECOSYSTEM SERVICES

5.1 INTRODUCTION: -

All that we want on the Earth come from the environment in which we live. In the process of urban growth humanity is encroaching on the ecosystems of the surrounding regions of the main big cities. The demand for land, water, food and other resources is also increasing. It is estimated that the ecosystems that provide these services are degrading over the time. So it is quite necessary to maintain the natural processes and functions of the surrounding environment for future benefits. If it is not so the benefits we get from the ecosystem will be diminished. The equatorial forests are the greatest sink of carbon. They are degrading due to human interventions and thus losing their originality. The increasing size of cities largely affects the hinterland also. The ecological footprint of a city, the area required to supply resources and services from the environment, is much larger than the area itself (Wackernagel et al., 1996). It enforces us to study the surrounding environment also of the city itself. Thus the larger cities will have more impact on the surrounding environment as their population is large. In India the expansion of National Capital Region is putting more pressure in the adjoining areas. In 2001 the population density was 1104 persons/km^2 which increased to 1349 persons/km^2. It means the limited resources of ecosystems of the NCR now have to sustain more people. This will lead to the changes in the ecosystems and their functioning also due to human interventions. As large slum population concentration near Yamuna River has deteriorated the bank environment of Yamuna River. The changes of ecosystems will be reflected by the changes in the land use land cover. The current practices of land use are not environmental friendly, so pressure will be on the environment. The fertile agricultural land is being transformed into built-up cover. The dual pressure is on agricultural land as it has to increase its production capacity with reducing area. The built environment also affects the other environments, as causes increase in the air temperature causing heat island effect etc.

The problem is that we are underestimating the ecosystem degradation. We are not aware that in what quantities the services and benefits we derive. It must be known to every common man. It is necessary to quantify the services we are provided. We must know the value of the services and benefits of ecosystems. Several attempts have been made to measure the services in monetary terms. Some have argued that valuation of ecosystems is unwise as we cannot place a value on such 'intangibles' as human life, environmental aesthetics or long term ecological benefits (Costanza et al., 1997). The value of ecosystem increase when the supply is decreasing and the demand is increasing constantly. So it is necessary to know the real price of ecosystems and protect ecosystems on purely moral and aesthetic reasons.

5.2 LAND USE LAND COVER CHANGES AND ECOSYSTEMS: -

In the previous chapter we discussed about the processes and results of land use land cover changes in and around Ghaziabad and Faridabad tehsil. The LULC change has significantly affected the humid and sub-humid areas in the world (Bai et al. 2008). The rapidly changing human population densities and land cover manifests that urbanization is taking place at global level. The four forces which are responsible for growth of cities are as following (UN Habitat, 2011).

- Natural Growth,
- Rural to Urban Migration,
- Massive migration due to extreme events and
- Redefinition of administrative boundaries.

These processes are leading to the sprawl and large formation of urban areas especially in developing countries. From the census 2011 it can be observed that India's population is rapidly urbanizing. Around 31.6% population is urban population of India (census, 2011). The population is being concentrated in urban areas. A large number of activities in cities require a large input of resources such as food, water, fuels, building materials, minerals etc. the cities are expanding physically. These requirements put a huge pressure on the resources of hinterland. The rate of utilization of resources to meet the increasing demands of the urban areas. The high rate of resource utilization disturbs the natural environment. Cities are moving closer to the protected areas especially in developing countries. Especially the biodiversity hotspots of natural environment are being affected.

These processes disturb the environment of natural areas. Natural areas whether they are near or far regulate the environment of nearby as well as far areas. For example a slight change in the gaseous composition of atmosphere may have large scale climate change impacts affecting the whole world. To meet the increasing demands human have done modifications to natural ecosystems. The growth of city and the urbanization process are essentially linked with biophysical and ecological processes. Scientific researches show that in the history of the Earth biodiversity changes have come due to the changes in the physical environment of the Earth. After industrial revolution the major changes in the physical environment are being done by the anthropogenic activities. The functioning of ecosystems is being disturbed by human. The ecosystems flows energy and cycles materials naturally. The change in the functioning of any ecosystem does not mean that it will affect only that region. It may have

small scale to large scale impacts. For example changes in rain forests in tropical region will significantly affect the rainfall distribution all over the world. The physical extension of cities is encroaching agricultural land. The increasing population demand more food production which has to be met with decreasing agricultural land. Due to this the pressure intensifies on agricultural land. In India in NCR, the land which is being utilized for construction activities is very fertile. The natural and semi-natural areas which are reserves of the biodiversity are being encroached. The conversion of urban forest covers into parks or gardens also affects the ecosystem of urban areas. So a detailed discussion is given below about quantifying and valuing ecosystem services and goods in the study area.

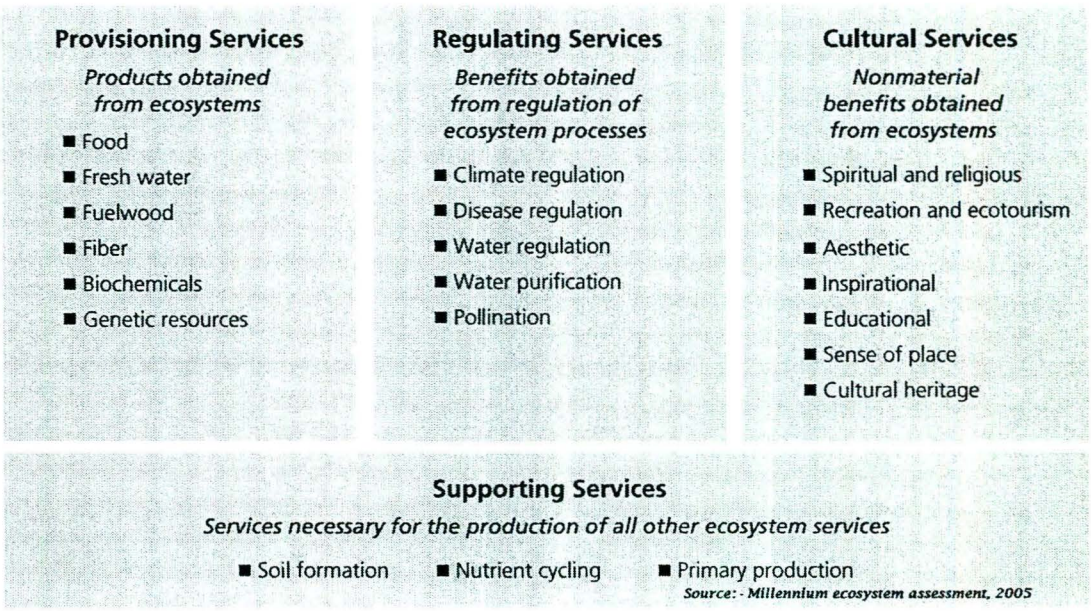
5.2.1 ECOSYSTEM SERVICES: -

We are one of the living creatures on the Earth. Like other creatures, animals or micro-organisms, we also depend on living or non-living things of ecosystems. We are dependent on the food, fibre and fuel provided by nature. Directly or indirectly all resources or facilities we get from the ecosystems. There are different types of ecosystems which benefit us in different ways. Like tropical forest ecosystem works as a climate control system. Forests provide us wood and food. Thus by different ecosystems we are benefitted in different ways. An ecosystem has specific capacity to benefit humanity. We receive many goods and services from the ecosystems. These services and goods combined termed as ecosystem services. Ecosystem services are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services e.g. clean air, water, and food (Constanza et al. 1997). Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human (MEA, 2005). We are benefited from ecosystem services in direct and indirect ways. Direct benefits like food, fresh water etc. and indirect benefits like climate regulation, fresh air etc. According to the Millennium Ecosystem Assessment (MEA, 2005) ecosystem system services can be categorized within four categories. The four categories of ecosystem services (ES) are following: -

a) Provisioning services, such as food and water,
b) Regulating services, such as flood and disease control,
c) Cultural services, such as spiritual, recreational, and cultural benefits and
d) Supporting services, such as nutrient cycling, that maintains the conditions for life on Earth.

The following table gives a detailed description of products and services obtained from ES.

TABLE 5.1: PRODUCTS AND SERVICES OBTAINED FROM ECOSYSTEM SERVICES



5.2.2 VALUING ECOSYSTEM SERVICES: -

The first step towards valuing ecosystem services is to prepare a land use land cover data sheet. Costanza in his valuation model (1997) has measured the value of 17 ecosystem services for 16 major biomes of the world. In this study in order to obtain ecosystem services values the 8 LULC categories were compared with the 16 biomes identified in Costanza et al's (1997) ecosystem services valuation model. The most similar and equivalent biome was used as a proxy for each land use land cover category. Costanza in 1997 valued ecosystem services according to 1994 US$ prices. Due to various changes in land use land cover the importance of various ecosystems has decreased or increased. It is estimated that average value of global ecosystem services is $33 trillion/yr (Costanza et al., 1997). Land use has changed significantly in last two decades. This has also changed the supply of ecosystem services. The ecosystem services' value has been adjusted according to 2014 Dollar prices. The following table represents the equivalent biome and the corresponding ecosystem services values.

TABLE 5.2: AVERAGE GLOBAL VALUES OF ECOSYSTEM SERVICES

AVERAGE GLOBAL VALUES OF ECOSYSTEM SERVICES (Costanza et al., 1997*)			
LULC Category	**Equivalent Biome**	**Unit Values**	
		1994 US$/ha/yr	**Adjusted (2014 prices) US$/ha/yr**
		1997	**2014**
Built-up	Urban	0	0
Urban Greenery	Temperate/Boreal Forest	302	441
Agricultural Land	Cropland	92	134
Forest	Tropical Forests	969	1415
Other Natural and Semi-natural Areas including Wetlands	Grass/Rangelands	232	339
Bare Land (including Fallow land)	Cropland	92	134
Water Bodies	Lakes/Rivers	8498	12407
River Bed	Floodplains	19580	28587

* Costanza et al. (1997); The value of the world's ecosystem services and natural capital; NATURE, Vol-387, 15 May 1997.

In this study the biomes used as proxy are not perfect matches but an attempt has been made in assigning most similar, representative and equivalent biome. The Bare land has been equalled with cropland because in the study area it has similar level of productivity. The forest in the study area has been equalled with tropical forests. The tropical forests have high value of ecosystem services than temperate or boreal forest. Similarly it is assumed that forest cover in study area has high value of ecosystem services than urban greenery. So Urban Greenery has been equalled with temperate or boreal forest because urban greenery cannot be valued equal to the tropical forest area.

5.2.3 ASSIGNMENT OF ECOSYSTEM SERVICE VALUES: -

To obtain ecosystem services value for each category the Basic value transfer aggregation method is used. The table above summarises the per hectare aggregate annual global monetary value of each land use land cover category according to 1994 $US prices. The annual global values have been adjusted according to current dollar prices. The value of ecosystem services is estimated by multiplying the land area of each biome by the value coefficient of the equivalent biome which has been used as the proxy for that land use land cover category. The value of ecosystem service for each land use land cover category has been calculated for 5 years, 1991, 2003, 2010, 2011 and 2013.

$$\mathrm{ESV} = \sum (A_k \times VC_k)$$

Where ESV is the total estimated ecosystem service value, A_k is the area (ha) and VC_k is the value coefficient ($\$ha^{-1}yr^{-1}$) for land use category 'k'. The changes in values of ecosystem services have been calculated by the difference between the estimated values of ecosystem services for each land use land cover category in 1991, 2003, 2010, 2011 and 2013.

5.3 ESTIMATION OF CHANGES IN ECOSYSTEM SERVICES: -

5.3.1 ESTIMATION OF CHANGES IN ECOSYSTEM SERVICES IN GHAZIABAD DISTRICT: -

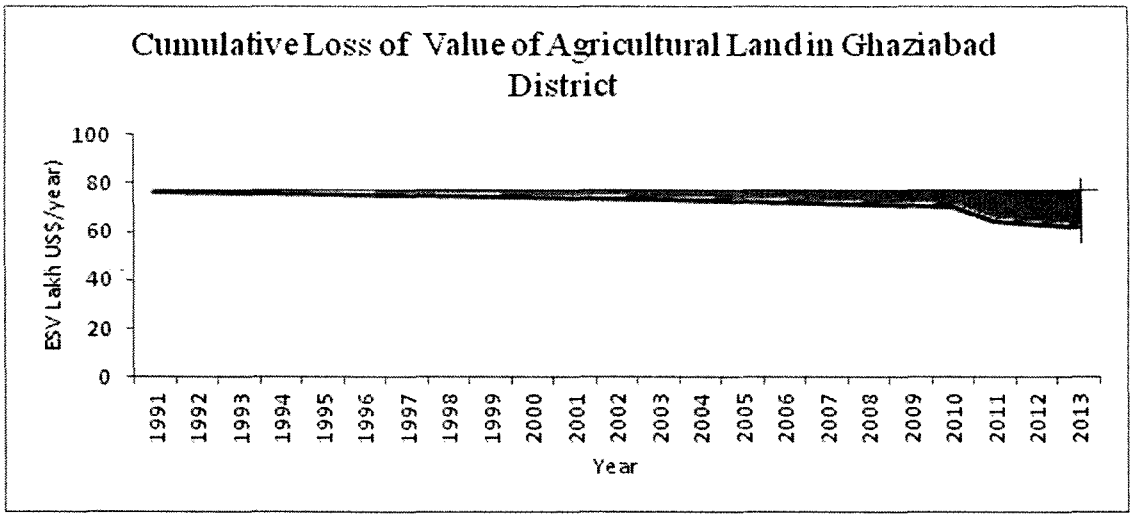
The coefficient of the equivalent biome suggested by Costanza et al. 1997 has been used to estimate the value of ecosystem services in Ghaziabad District. We found that land-use changes in the 74217 ha of our study area resulted in an average net decrease of $86.82 lakh/ year in ecosystem services between 1991 and 2013 (Table 5.3). Assuming a linear decrease in ecosystem services, this represents a cumulative decrease of $955 lakh in ecosystem services over the 22 year period of the study. However, this cumulative estimate must be regarded with caution because ecosystem services may fluctuate somewhat, our analysis detected decrease in the value of ecosystem services from 2003 to 2011. Our analysis detected that the rate of decline was highest from 2010-2011. The ecosystem services must be measured at regular intervals in order to accurately estimate the cumulative loss of ecosystem services (Kreuter et al., 2001). By adding the ecosystem service increase or decline during the time periods, we obtained a net loss of 194.12 lakh US$ in value of ecosystem services. The actual value of decline is very low from the linear value of decline. The data analysis in the table 5.3 reflects the actual loss of ecosystem service value over the 22 years time period in different land use land cover categories. No ecosystem services value has been assigned to the settlements. If a value is assigned it may have had a significant effect on our estimate, because settlements covered a very large portion of the study area. The settlements may underestimate the actual ecological value derived from plants in residential and urban areas in Ghaziabad district. Total ecosystem service value (ESV in US$ x 10^6 per year) estimated for each land cover category in the study area using Costanza et al. coefficients (1997), and the overall change and rate of change between 1991 and 2013 in Ghaziabad District, UP. Settlements covered a very large portion of the study area. The cropland is assigned US$ 134/ha/yr, a value lower than the forest cover. The significant part of agricultural land has been converted into built-up (table 4.2).

TABLE 5.3: TOTAL ECOSYSTEM SERVICE VALUE (ESV IN US$ X 10^6 PER YEAR) ESTIMATED FOR EACH LAND COVER CATEGORY IN THE STUDY AREA USING COSTANZA ET AL. COEFFICIENTS (2014), AND THE OVERALL CHANGE AND RATE OF CHANGE BETWEEN 1991 AND 2013 IN GHAZIABAD DISTRICT, HARYANA.

LULC Category	**ESV (US$ x 10^5 per year)**					1991-03		
	1991	2003	2010	2011	2013	$ x 10^5	%	%/ year
Built-up	0	0	0	0	0	0	0	0
Urban Greenery	2.77	3.35	3.50	3.80	3.97	0.57	20.73	1.73
Agricultural Land	76.39	73.10	70.48	64.31	62.17	-3.28	-4.30	-0.36
Forest	14.28	17.79	17.89	17.40	19.49	3.50	24.54	2.04
Other Natural and Semi-natural Areas including Wetlands	3.35	3.41	3.36	3.75	3.55	0.05	1.56	0.13
Bare Land (including fallow land)	0.13	0.15	0.28	0.89	0.62	0.03	20.10	1.68
Water Bodies	61.81	61.81	62.00	38.39	39.62	0.00	0.00	0.00
River Bed	168.75	168.75	168.75	91.98	111.25	0.00	0.00	0.00
Total	**327.48**	**328.36**	**326.25**	**220.52**	**240.67**	**0.87**	**0.27**	**0.02**

2003-2010			2010-2011			2011-2013			1991-2013		
$ x 10^5	%	%/ year	$ x 10^5	%	%/ year	$ x 10^5	%	%/ year	$ x 10^5	%	% /year
0	0	0	0	0	0	0	0	0	0	0	0
0.15	4.53	0.65	0.30	8.60	8.60	0.17	4.38	2.19	1.19	43.05	1.96
-2.62	-3.58	-0.51	-6.17	-8.75	-8.75	-2.14	-3.33	-1.66	-14.22	-18.61	-0.85
0.10	0.56	0.08	-0.48	-2.70	-2.70	2.09	12.01	6.00	5.21	36.48	1.66
-0.05	-1.43	-0.20	0.39	11.73	11.73	-0.20	-5.28	-2.64	0.20	5.93	0.27
0.13	83.92	11.99	0.61	215.04	215.04	-0.28	-30.92	-15.46	0.49	380.76	17.31
0.19	0.30	0.04	-23.61	-38.08	-38.08	1.23	3.20	1.60	-22.19	-35.91	-1.63
0.00	0.00	0.00	-76.77	-45.49	-45.49	19.27	20.95	10.48	-57.50	-34.07	-1.55
-2.10	**-0.64**	**-0.09**	**-105.73**	**-32.41**	**-32.41**	**20.14**	**9.13**	**4.57**	**-86.82**	**-26.51**	**-1.21**

FIGURE 5.1: CUMULATIVE LOSS OF AGRICULTURAL LAND ES IN GHAZIABAD DISTRICT



The decrease in agricultural ecosystem services is measured around 14.22 lakh US$ per year during 22 years time period. The ecosystem service value of agricultural land decreased around 18.16%, i.e. a net decrease of 0.85% per year is observed in agricultural ecosystem services. The coloured area in the above graph shows the cumulative loss of agricultural land in million US$. Thus the net loss of agricultural ecosystem services is around 35.5 lakh US $ during 22 years time period. The conversion of ecologically fertile and valuable agricultural area and fallow land into built-up is apparent in the study area. The net effect of the huge loss of agricultural ecosystem on ecosystem services can be observed in the table 5.3. If built-up is assigned any value then instead of decreasing pattern of values of ecosystem services in the study area it will show increasing scenario. This ecological conversion is consistent with the increase in distribution and density of built-up. The average decline in ecosystem services during 22 years time period was -26.51%. It means the value of ecosystem services declined around 1.21% per year. The estimated 10582 ha loss of cropland to other land uses in 22 years and the associated loss in ecosystem services appeared to have resulted in a massive decrease in the annual value of such services within our study area.

5.3.2 ESTIMATION OF CHANGES IN ECOSYSTEM SERVICES IN FARIDABAD DISTRICT: -

The coefficient of the equivalent biome suggested by Costanza et al. 1997 has been used to estimate the value of ecosystem services in Faridabad District. We found that land-use changes in the 84032 ha of our study area resulted in an average net decrease of US$ 309.81 lakh/ year in value of ecosystem services between 1991 and 2013 (Table 5.4). Assuming a linear decrease in ecosystem services, this represents a cumulative decrease of $3408 lakh in ecosystem services over the 22 year period of the study. However, this cumulative estimate must be regarded with caution because ecosystem services may fluctuate somewhat, our analysis detected decrease in the value of ecosystem services from 2003 to 2011. Our analysis detected that the rate of decline was highest from 2010-2011. In order to accurately estimate the cumulative loss of ecosystem services, it would be necessary to measure ecosystems' services at regular intervals, preferably annually (Kreuter et al., 2001). By adding the ecosystem service increase or decline during the time periods, we obtained a cumulative ecosystem services loss of 599.14 lakh US$. The actual value of decline is very low from the linear value of decline. The Decline is not constant, if it had been there has been more loss of ecosystem services.

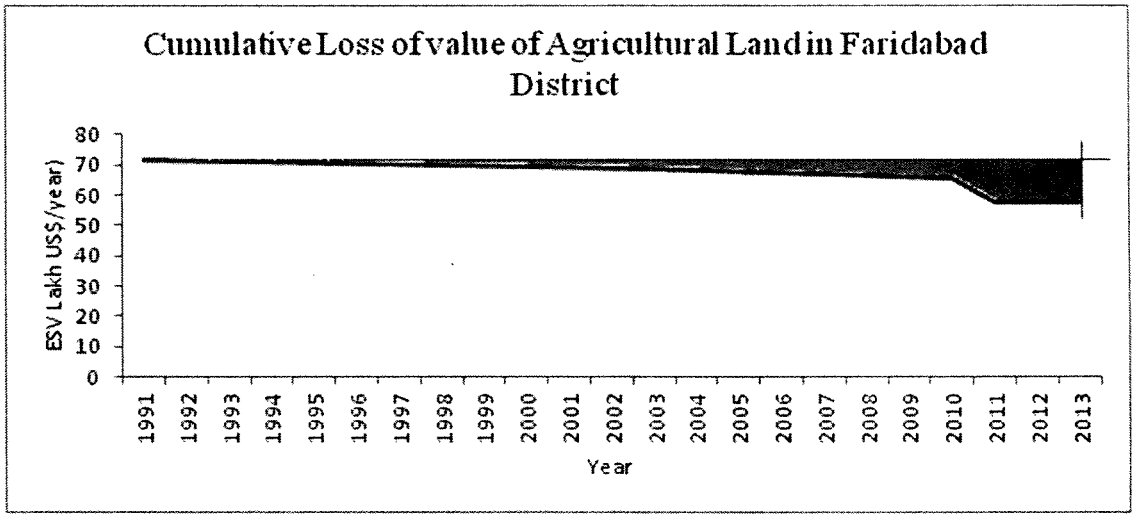
The data analysis in the table 5.4 reflects the actual loss of ecosystem service value over the 22 years time period in different land use land cover categories. No ecosystem services value has been assigned to the settlements. If a value is assigned it may have had a significant effect on our estimate, because settlements covered a very large portion of the study area. The settlements may underestimate the actual ecological value derived from plants in residential and urban areas in Faridabad district. The cropland is assigned US$ 134/ha/yr, a value lower than the forest cover. The estimated 22 years 10414 ha loss of cropland to other land uses and the associated loss in ecosystem services appeared to have resulted in a massive decrease in the annual value of such services within our study area. The significant part of agricultural land has been converted into built-up (table area ch 4). The decrease in agricultural ecosystem services is measured around 14.08 lakh US$/year during 22 years time period. In monetary terms it was -24.03% losses in the value of all ecosystem services of Faridabad. The ecosystem service value of agricultural land decreased at the rate of 1.09% per year.

TABLE 5.4: TOTAL ECOSYSTEM SERVICE VALUE (ESV IN US$ X 10^6 PER YEAR) ESTIMATED FOR EACH LAND COVER CATEGORY IN THE STUDY AREA USING COSTANZA ET AL. COEFFICIENTS (2014), AND THE OVERALL CHANGE AND RATE OF CHANGE BETWEEN 1991 AND 2013 IN FARIDABAD DISTRICT, HARYANA.

LULC Category	**ESV (US$ x 10^5 per year)**					1991-03		
	1991	2003	2010	2011	2013	$ x 10^5	%	% /year
Built-up	0	0	0	0	0	0	0	0
Urban Greenery	3.21	4.24	4.26	4.74	5.28	1.03	32.05	2.67
Agricultural Land	71.53	68.46	65.18	57.77	57.54	-3.06	-4.28	-0.36
Forest	0.15	0.15	0.11	0.30	0.40	0.00	0.00	0.00
Other Natural and Semi-natural Areas including Wetlands	45.91	44.89	43.41	37.18	35.21	-1.02	-2.22	-0.19
Bare Land (including fallow land)	0.29	0.48	0.79	2.64	0.41	0.19	64.41	5.37
Water Bodies	8.85	9.49	11.15	13.50	5.68	0.64	7.17	0.60
River Bed	1159.25	1159.22	1159.19	891.07	874.86	-0.03	0.00	0.00
Total	**1289.19**	**1286.93**	**1284.11**	**1007.20**	**979.38**	**-2.26**	**-0.18**	**-0.01**

2003-2010			2010-2011			2011-2013			1991-2013		
$ x 10^5	%	%/ year	$ x 10^5	%	% /year	$ x 10^5	%	% /year	$ x 10^5	%	%/ year
0	0	0	0	0	0	0	0	0	0	0	0
0.02	0.51	0.07	0.48	11.21	11.21	0.54	11.40	5.70	2.07	64.43	2.93
-3.28	-4.79	-0.68	-7.41	-11.37	-11.37	-0.24	-0.41	-0.21	-13.99	-19.56	-0.89
-0.03	-21.77	-3.11	0.18	160.75	160.75	0.11	36.21	18.10	0.26	177.84	8.08
-1.48	-3.30	-0.47	-6.23	-14.36	-14.36	-1.97	-5.29	-2.65	-10.70	-23.30	-1.06
0.31	64.21	9.17	1.86	235.31	235.31	-2.24	-84.52	-42.26	0.12	40.15	1.83
1.67	17.55	2.51	2.35	21.03	21.03	-7.82	-57.91	-28.95	-3.17	-35.82	-1.63
-0.03	0.00	0.00	-268.13	-23.13	-23.13	-16.21	-1.82	-0.91	-284.39	-24.53	-1.12
-2.83	**-0.22**	**-0.03**	**-276.91**	**-21.56**	**-21.56**	**-27.82**	**-2.76**	**-1.38**	**-309.81**	**-24.03**	**-1.09**

FIGURE 5.2: CUMULATIVE LOSS OF AGRICULTURAL LAND ES IN FARIDABAD DISTRICT



The decrease in agricultural ecosystem services is measured around 13.99 lakh US$ per year during 22 years time period. The supply of agricultural ecosystem services decreased around 19.56%, i.e. a net decrease of 0.89% per year is observed in agricultural ecosystem services. The coloured area in the above graph shows the cumulative loss of agricultural land in million US$. Thus the net loss of agricultural ecosystem services is around 37.17 lakh US $ during 22 years time period. The coloured area in the above graph shows the cumulative loss of agricultural land in million US$. The conversion of ecologically fertile and valuable agricultural area and fallow land into built-up is apparent in the study area. The net effect of the huge loss of agricultural ecosystem on ecosystem services can be observed in the table 5.4. If built-up is assigned any value then instead of decreasing pattern of values of ecosystem services in the study area it will show increasing scenario. The estimated 10414 ha loss of cropland to other land uses in 22 years and the associated loss in ecosystem services appeared to have resulted in a massive decrease in the annual value of such services within our study area. This ecological conversion is consistent with the increase in distribution and density of built-up.

The scenario of degradation or up gradation of ecosystem services has been analyzed above through land use land cover statistics. The built up is assigned no value, so there is no valuation of built-up environment. The agricultural land covers maximum area of the district and this ecosystem has experienced significant decrease in ecosystem services. The forest

ecosystem shows up-gradation of ecosystem services in both districts, Ghaziabad as well as Faridabad.

TABLE 5.5: STATUS OF ECOSYSTEM SERVICES IN GHAZIABD AND FARIDABAD DISTRICTS

S.N.	Ecosystem	Status of Ecosystem Services	
		Ghaziabad	Faridabad
1	Built-up (Urban& Rural settlements)	-	-
2	Agricultural Land	⬇	⬇
3	Forest	⬆	⬆
4	Urban Greenery	⬆	⬆
5	Other Natural and Semi-natural Areas including Wetlands	⬆	⬇
6	Bare Land (including Fallow Land)	⬆	⬆
7	Water Bodies	⬇	⬇
8	River bed	⬇	⬇
	Total	⬇	⬇

The table 5.5 clearly summarizes the status of ecosystem services, whether they have degraded or up-graded. The up-arrow signals up-gradation of the ecosystem services of a particular ecosystem and the down arrow signals degradation of ecosystem services of a particular ecosystem.

5.4 CONCLUSION: -

This chapter explains that how land use land cover changes degrade the different ecosystems of a region. The changes of land use and land cover causes changes in natural cover of land. Apart from it the increasing population pressure is also affecting ecosystems. In previous

chapter we understand that how built-up is affecting the other land uses and land covers. Thus natural functioning and flow of energy and matter in ecosystem is being disturbed. This chapter starts explaining relation of land use land cover changes with ecosystems and biodiversity. Further the chapter advances defining ecosystem services as defined by Millennium Ecosystem Assessment, 2005 and other researchers. More or less everyone has defined ecosystem services as the goods and services we obtain from ecosystems. Broadly four types of ecosystem services have been identified by MEA, 2005 respectively, Provisioning services, Regulating services, Cultural services and Supporting services. In literature review it has been discussed that if we want to maintain supply of goods and services from ecosystems, we have to maintain and enhance natural ecosystems. Until we understand the value of ecosystem services, no significant attention is paid. A monetary value assessment has been done in this study. The method of valuing ecosystem services has been adopted from Costanza et al. 1997. Thus for each land use land cover category the representative equivalent biome and the corresponding ecosystem services values has been identified. To obtain ecosystem services value for each category the Basic value transfer aggregation method is used. The value of ecosystem services is estimated by multiplying the land area of each biome by the value coefficient of the equivalent biome which has been used as the proxy for that land use land cover category. In Ghaziabad we found that land-use changes in the 74217 ha area resulted in an average net decrease of $86.82 lakh/year in ecosystem services between 1991 and 2013. Assuming a linear decrease in ecosystem services, this represents a cumulative decrease of $955 lakh US$ in ecosystem services over the 22 year period of the study while the net loss was 194.12 lakh US$ in value of ecosystem services in Ghaziabad district. Thus actual value of decline is very low from the linear value of decline. The average decline in ecosystem services of Ghaziabad district was around 1.21% per year. Similarly in Faridabad district assuming a linear decrease in ecosystem services, a cumulative decrease of 3408 lakh US$ was observed over the 22 year period of the study while net cumulative ecosystem services loss was just 599.14 lakh US$. One explanation for the apparent huge net effect of land use conversion on the value of ecosystem services in the study area is that the loss of ecosystem services on land being developed was offset by the apparent conversion of ecologically fertile and valuable agricultural area and fallow land into built-up. If built-up is assigned any value then instead of decreasing pattern of values of ecosystem services in the study area it will show increasing scenario. The valuation is not for marketing purpose but this is done so that common man can understand the importance of ecosystems and aesthetically and morally protect ecosystems.

Chapter VI

LOSS OF AGRICULTURAL LAND AND ECOSYSTEM SERVICES & SUSTAINABILITY

6.1 INTRODUCTION: -

India is a country with diverse landscape. The country is bounded by Indian Ocean to highest mountain range Himalayas. India has a very rich topographic diversity. This includes from Great Himalaya, Northern Plain, Thar Desert, Southern Plateau, Coastal Plains and Islands. These different topographies have different climatic patterns. This gives birth to different types of ecosystems. The interaction of different climates makes it a biodiversity rich country. In the process of urbanization and development India is facing degradation of ecosystems and biodiversity (Sudhira et al., 2014). The Millennium Development Goals are difficult to be achieved till 2015. The middle and poor class is expected to suffer most in this unsustainable development process (MDGs, 2013). Although measures have been taken for sustainable development but they seem insufficient with the speedily increasing population and urbanization in India.

Similarly a large chunk of world population is still in absolute poverty, especially in developing countries. By analyzing the status of the Millennium Development Goals it comes out that only 4 goals have been achieved so far and there are regional disparities in the achievements as developing nations of Asia and Sub- Saharan African countries are lagging far behind in the achievements (MDGs, 2013). The following section deals with the detailed description of agricultural ecosystem. So Millennium Development Goals are supposed to be replaced by new Sustainable Development Goals (SDGs) after 2015. The German Advisory Council on Global Change (WBGU) goals towards the key message of the 1992 Earth Summit: that development and environmental protection must be considered together and do not contradict each other. The Rio Earth Summit also proposed that environmental protection is prerequisite for sustainable development and poverty eradication. The WBGU talks about the six planetary guard rails that mean that the development should be in limit of the planetary boundaries. The SDGs talks about limiting global temperature increase and ocean acidification, land and soil conservation, decreasing use of phosphorous and other harmful substances. The increasing demand of goods and services is causing pressure on natural ecosystems. The removal of natural covers and intensifying agriculture is causing global land degradation. The SDGs suggest that global land degradation should be stopped worldwide by 2050 in all countries and use of phosphorous should be reduced as it is essential resource for agriculture to maintain sustainable growth. Apart from it the fertilizers consumption should be limited to the consumption levels. The Aichi Biodiversity Targets also talks about

identifying causes and reducing direct impacts of biodiversity loss to improve the status of biodiversity so that benefits can be accessed to all from biodiversity and ecosystem services. In developing countries the population is increasing very fastly than developed countries, so land resources of developing countries are at more risk (United Nations). In India we can observe that production capacity is increasing with decreasing agricultural land. The higher intake of fertilizers and water in agricultural land is causing many land degradation problems in India.

The fertile Northern Indian plain accounts around 43% of total geographical area of India. If compared to other nations it is very high. This land provides food, fibre, firewood etc to more than 50% population of India. These different physiographic divisions are preservers and protectors of different ecosystems. A vast range of ecosystems like Forest, Agriculture, Marine, Grassland, Wetlands, Urban, Corals, Mangroves, Deserts etc, can be observed in the territorial boundary of India. These ecosystems provide goods and services to more than 1.21 billion people in India. The biggest ecosystem all of these is agricultural ecosystem. This ecosystem provides food and fibre, one of the major basic needs for a human being. All these concerns require a great attention to protect natural as well as agricultural ecosystems.

6.2 AGRICULTURAL ECOSYSTEM: -

Agriculture is a dominant form of land management globally, and agriculture covers nearly 40% of the terrestrial surface of the Earth (*FAO, 2009*). Agriculture is the key source of the global economy especially in developing countries. A large number of people are supported by it. It is the livelihood and subsistence of rural communities in developing world. The world population is increasing at a very fast rate. If we look the rural urban composition, the urban population is increasing. Thus it is putting more pressure on the shrinking rural population to feed urban population. UN reports the urban settlements has increased from 1.5 billion in 1990 to 3.6 billion in 2011(*GMR, 2013*). It is estimated that more than 50% population, around 3.6 billion people live in urban areas. So with the decreasing agricultural land and maintaining the ecological balance we have to produce as much as to feed the whole world. Agriculture is one of the major drivers of environmental change (*Davari, 2010*). As the rural urban composition is changing the consumption pattern is also changing. So it is a very challenging job for human beings to produce diverse diets ensuring food safety and security. The following graphs explain the increasing pressure on agricultural land due to increase in built –up area in Ghaziabad and Faridabad districts.

FIGURE 6.1: % AGRICULTURAL AND BUILT-UP AREA IN GHAZIABAD DISTRICT

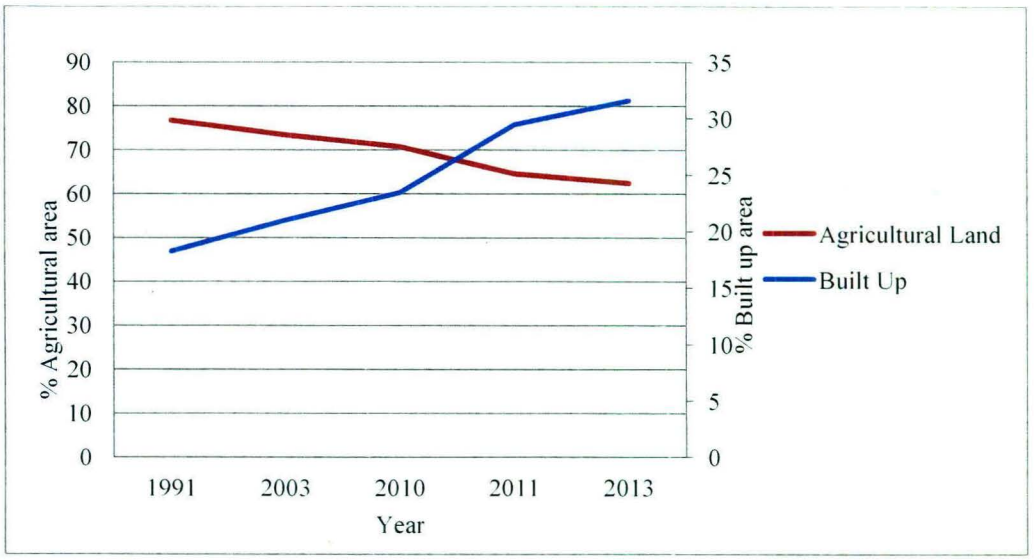
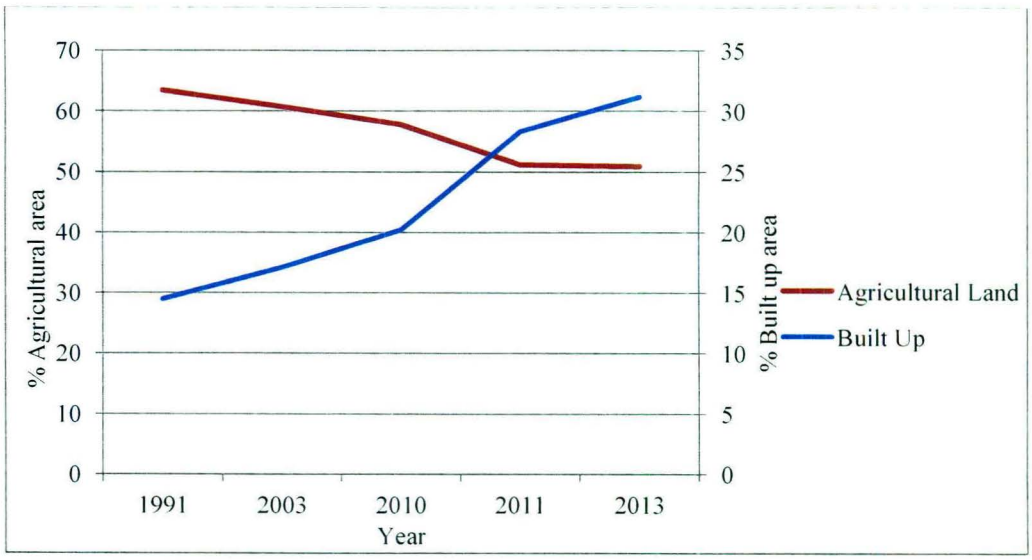


FIGURE 6.2: % AGRICULTURAL AND BUILT-UP AREA IN FARIDABAD DISTRICT

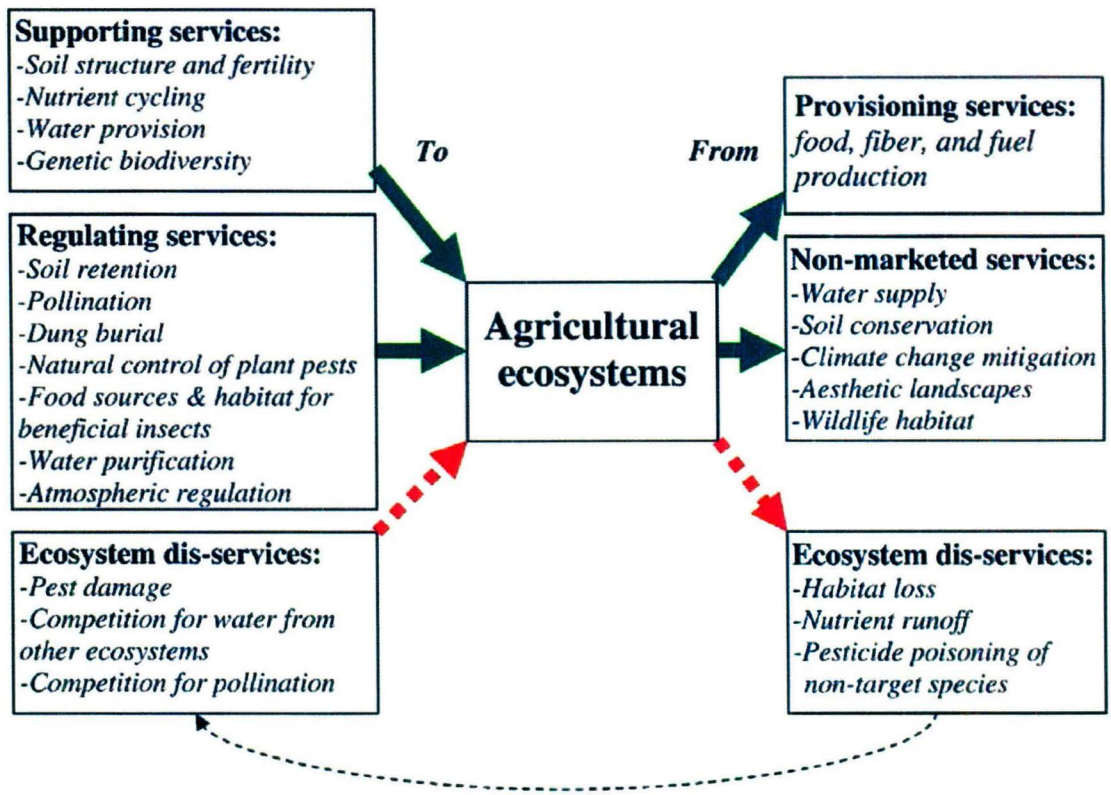


(Data Source: Study by European Space Agency and Landsat Images)

The increasing population not only demands for more food production but also for shelter. This demand leads to the conversion of fertile agricultural land into built-up area. The land conversion form natural ecosystems to agriculture reduce the flow of certain ecosystem services. It can increase the flow of other ecosystem services yet. In the same way if the agricultural land is intensified for more production or converted into urban or sub-urban use it can further degrade the provision of goods and services we get. Simplification of agro-ecosystems caused by the intensification of agricultural practices may affect important

ecosystem services via the loss of biodiversity (*Tscharntke et al., 2005*). Human has designed the agricultural ecosystems to provide provisioning services like food, fibre, bio-energy, pharmaceuticals etc. While providing these services the agro-ecosystem depends upon other ecosystems. Agro-ecosystems interact with other ecosystems and influenced by human activities both intentionally and unintentionally. Thus agro-ecosystems are both provider and consumers of ecosystem services. The following figure explains ecosystem services and dis-services to and from agriculture.

FIGURE 6.3: ECOSYSTEM SERVICES AND DIS-SERVICES TO AND FROM AGRICULTURE



6.3 ECOSYSTEM SERVICES FLOWING TO AGRICULTURE: -

The ecosystems on the Earth are dependent on each other for their proper functioning. In agricultural ecosystem the production of goods is highly dependent on the services provided by neighbouring natural ecosystems. Human has designed the agricultural ecosystems to provide provisioning services like food, fibre, bio-energy, pharmaceuticals etc. While providing these services the agro-ecosystem depends upon other ecosystems. Agro-

ecosystems interact with other ecosystems and influenced by human activities both intentionally and unintentionally. Following is a detailed description of the ecosystem services on which agro-ecosystem depends.

6.3.1 SOIL STRUCTURE AND FERTILITY: -

The nutrient rich and well-aerated soil with abundant organic matter and good water retention capacity is necessary for nutrient acquisition by crops. The macro and micro-organisms like earthworms, termites and other invertebrates decompose soil organic matter and make the soil aerated. Cover crops are used to retain soil and nutrients between crop cycles while hedgerows and vegetation along waterways reduce erosion and runoff from fields (*Zhang et al., 2007*).

6.3.2 CROP POLLINATION: -

It is an important ecosystem service that is provided by insects and natural habitats in agricultural landscape. The analysis of data from 200 countries indicate that production of over 75% of the world's most important crops that feed humanity and 35% of the food produced is dependent upon animal pollination (*Klein et al., 2007*). There are negative impacts on agricultural production if the habitat ecosystems of these beneficial insects are degraded. It is estimated that the total loss of pollinators will decrease agricultural production from 3-8 % (FAO). This will also affect the nutrient richness of products.

6.3.3 NATURAL PEST CONTROL: -

The arthropod predators, insectivorous birds and birds eat the non-crop inhabitants and thus act as natural enemies to agricultural pests and provide biological pest control in agricultural ecosystems (*Tscharntke et al., 2005).* This natural pest control process lessen the need for pesticides.

6.3.4 WATER QUANTITY AND QUALITY: -

Pure and sufficient amount of water is needed to agro-ecosystems. It is estimated that agriculture accounts around 70% of the total water use (FAO 2003). The water availability in agro-ecosystemss primarily depends upon infiltration and flow, soil moisture retention capacity and other ecosystem services. Forest cover stabilizes water flow between dry and wet regions (*Guo et al., 2000*).

6.3.5 GENETIC DIVERSITY: -

There is need to maintain the genetic diversity in crops so that they there may be less impacts of devastating natural events (Zhang et al., 2007). Genetic diversity is not only important to avoiding catastrophic losses, but also improving or maintaining agricultural productivity (*Zhang et al., 2007*).

6.3.6 LANDSCAPE INFLUENCES: -

The landscape structure significantly affects the delivery of other ecosystem services to agro-ecosystems. Agro-ecosystems are spread from simple landscapes to difficult terrains. Water availability is affected due to flow patterns of landscape and diversion of water for other uses (*Power et al., 2010*).These above mentioned ecosystem services play a major role in supporting agro-ecosystems for higher productivity. Collectively these services affect in much better way. It depends on the biome and territorial regime that which ecosystem service plays a major role.

6.4 ECOSYSTEM SERVICES FROM AGRICULTURE: -

Human has designed the agricultural ecosystems to provide provisioning services like food, fibre, bio-energy, pharmaceuticals etc. this ecosystem service is almost always mapped when we talk about land use changes. The agricultural ecosystems are primarily managed to optimise the provisioning ecosystem services of food, fire and fuel (*Zhang et al, 2007*). Crop cover is also sinks of greenhouse gases like forests. The agriculture works as a cover for soil which lessens the runoff and protects the nutrient rich upper layer of soil. Agriculture increases the capacity of carbon uptake and storage in soils (*Lal et al, 2008*). This high amount of sequestered carbon automatically enhances additional ecosystem services. This sequestered carbon into soil improves soil quality as well as water quality by infiltration. Agriculture land can also be used to grow crops for bio-energy production (*Power et al, 2010*). The use of bio fuel will lessen the use of fossil fuels. This process will decrease the greenhouse gases emissions. This will reduce the CO_2, NO_2 and NO_x emissions in the atmosphere. Bio-energy uses also release carbon into the atmosphere but it is again recaptured by vegetation during plant growth. There are other strategies to lessen the greenhouse gases emissions. The waste products produced by crops, grass harvest and even solid waste from urban areas can be used to produce bio-fuels. These practices if followed will decrease the negative impacts of crop residuals and urban solid wastes which ultimately result in lower greenhouse gases emissions.

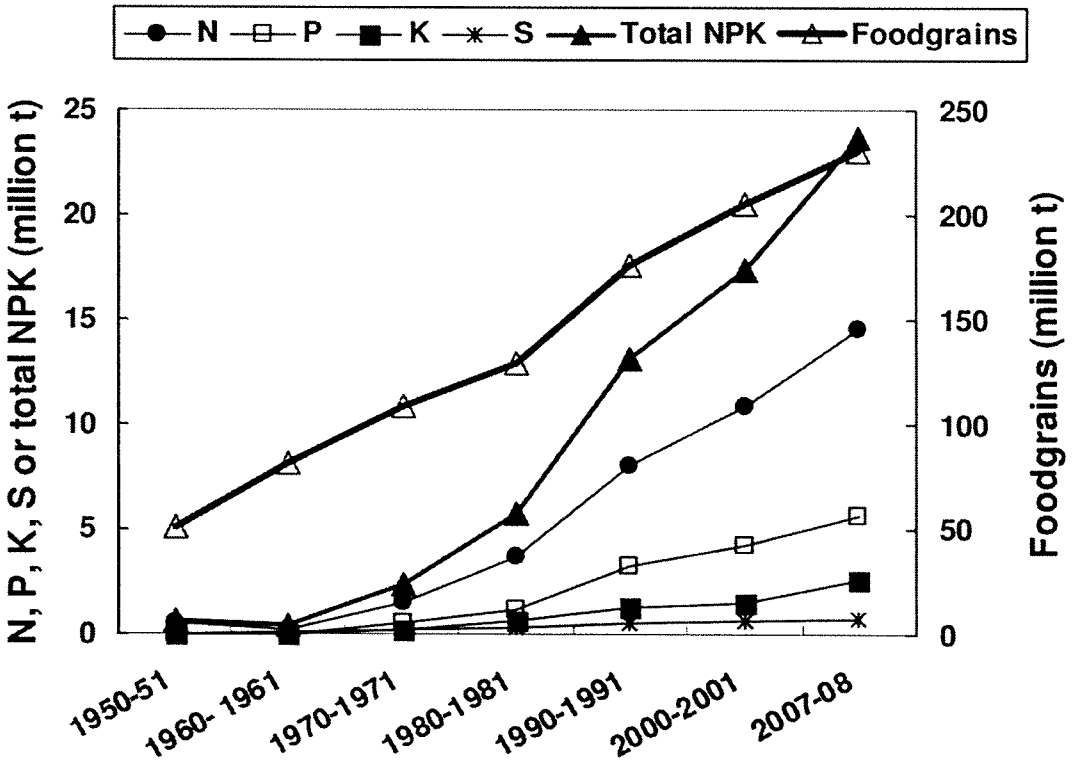
6.5 ECOSYSTEM DIS-SERVICES FROM AGRICULTURE: -

The changes in agro-ecosystems affects other ecosystems services including food, fibre, fuel, carbon sequestration, soil quality, water quality and quantity, biodiversity, pollination services etc. the prime objective of agriculture is to get food, fibre, fuel and other such goods. The agriculture ecosystem can increase or decrease supply of these services. To meet the increasing demands there are two ways to increase productivity. We should have increase area under agriculture or intensification of agriculture. To get more production it will require more input of fertilizers, manure, water and other supporting services. Agriculture decreases nutrient in an ecosystem by affecting biogeochemical cycles. The two nutrients that most limit biological production in natural and agricultural ecosystems are nitrogen and phosphorus (Power et al, 2010).

6.5.1 AGROCHEMICAL CONTAMINATION AND PESTICIDE POISONING: -

To maintain nutrient availability these two fertilizers are heavily applied. These processes have increased the ratio of new nitrogen and phosphorus in the atmosphere, leading harmful effects on other natural ecosystems.

FIGURE 6.4: TRENDS IN FERTILIZER N, P, K AND S CONSUMPTION AND FOOD GRAIN PRODUCTION IN INDIA **(1950/51 to 2007/08)**



Data Source:- Milkha S. Aulakh and Dinesh K. Benbi; Enhancing Fertilizer Use Efficiency, 2008

TABLE 6.1: FERTILIZERS CONSUMPTION IN GHAZIABAD DISTRICT

Nutrient Consumption (Kg./ha.) in Ghaziabad				
	N	**P_2O_5**	**K_2O**	**Total**
2001-02	154.52	42.26	9.59	206.37
2003-04	145.99	42.25	15.6	203.84
2004-05	148.02	40.86	18.11	206.99
2006-07	181	51	17	249
N-Nitrogen, P_2O_5- Phosphate and K_2O- Potash *Data Source: http://www.uttarpradeshstat.com/*				

TABLE 6.2: FERTILIZERS CONSUMPTION IN FARIDABAD DISTRICT

Nutrient Consumption (Kg./ha.) in Faridabad				
	N	**P_2O_5**	**K_2O**	**Total**
2001-02	120.4	38.6	0.59	159.6
2003-04	131.82	44.38	1.82	178.02
2004-05	152.9	47.94	3.02	203.86
2006-07	169.38	64.24	6.04	239.67
N-Nitrogen, P_2O_5- Phosphate and K_2O- Potash *Data Source: http://www.haryanastat.com/*				

The tables 6.1 & 6.2 show that per hectare amount of the nutrients being applied to agriculture is increasing over the time. This practice has increased production of food grains. But this will increase the amount of nitrogen and phosphorus in the atmosphere causing harmful changes in other ecosystems. It is estimated that around 20% of nitrogen fertilizers applied in agro-ecosystems move into aquatic ecosystems (Galloway et al, 2004). This increasing intake of fertilizers over decreasing agricultural land will negatively affect to other ecosystem services like surface water, groundwater, negative impacts on human health etc. The surface water and ground water will be contaminated. The food grains will negatively impact human health.

Similarly other dis-service from agriculture is application of pesticides that negatively affect bio-diversity and cause contamination of surface and groundwater resources. The pesticides will also affect the natural pest controllers i.e. arthropod predators, insectivorous birds and birds those eat the non-crop inhabitants.

6.5.2 SURFACE AND GROUNDWATER DEPLETION: -

The intensification of agriculture and heavy input of fertilizers demand more water supplies. Resultantly this will lead to the depletion of surface and groundwater sources. The data shows that the groundwater is continuously depleting. This has been due to the changes in irrigation pattern also. The easier availability of water through canal and bore wells in Gangetic Plain has caused many soil related problems. like increase in soil salinization. water logging etc.

The data from FAO shows that the share of agriculture has decreased because the share of industrial and household need has increased over the time. The surface water sources as well as groundwater sources are depleting as the use of pumps and tube-wells has increased. The table 6.4 shows the depleting water scenario in Ghaziabad and Faridabad.

TABLE 6.3: LOCATION-WISE MONITORED DEPTH TO WATER IN HYDROGRAPH STATIONS OF GHAZIABAD DISTRICT

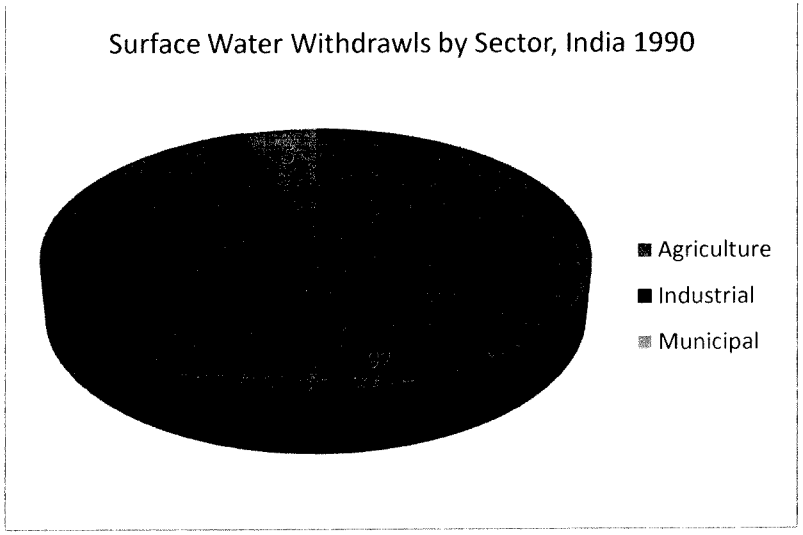
Location	**Water Level- mbgl (Meters below ground level)**			
	May-01	**Aug-01**	**Nov-01**	**Jan-02**
Garhmukteshwar	10.9	10.82	10.92	11.02
Tila Shabazpur	12.92	12.93	12.88	Dry
Simbhawali	4.74	3.84	4.28	4.45
Dhaulana	Dry	1.07	1.02	2.36
Nanpur	4	3.73	3.99	6.06
Dadr	Dry	Dry	Dry	-
Raoli	6.72	6.29	6.52	5.77
Sahibabad	8.81	7.8	8.57	9.03
Data Source:- www.uttarpradeshstat.com				

These decreases in groundwater may be attributed to the increase of tube wells in Gangetic plain. The rate of depleting is higher than the infiltration rates. The area irrigated by tube wells is increasing. The irrigated area by canals is also decreasing gradually in Ghaziabad. The following table 6.5 shows the increase of tube wells over the time.

TABLE 6.4: SURFACE WATER WITHDRAWAL BY SECTOR IN INDIA

	1990	2000	2010
Agriculture	460	558.4	688
Industrial	15	10	17
Municipal	25	42	56
Unit:- (10^9 m3 yr) (Litres)		*Data source: www.fao.org*	

FIGURE 6.5: SURFACE WATER WITHDRAWLS BY SECTOR, INDIA 1990



Data Source: - http://www.fao.org/nr/water/aquastat/data/query/

FIGURE 6.6: SURFACE WATER WITHDRAWLS BY SECTOR, INDIA

(2000 AND 2010)

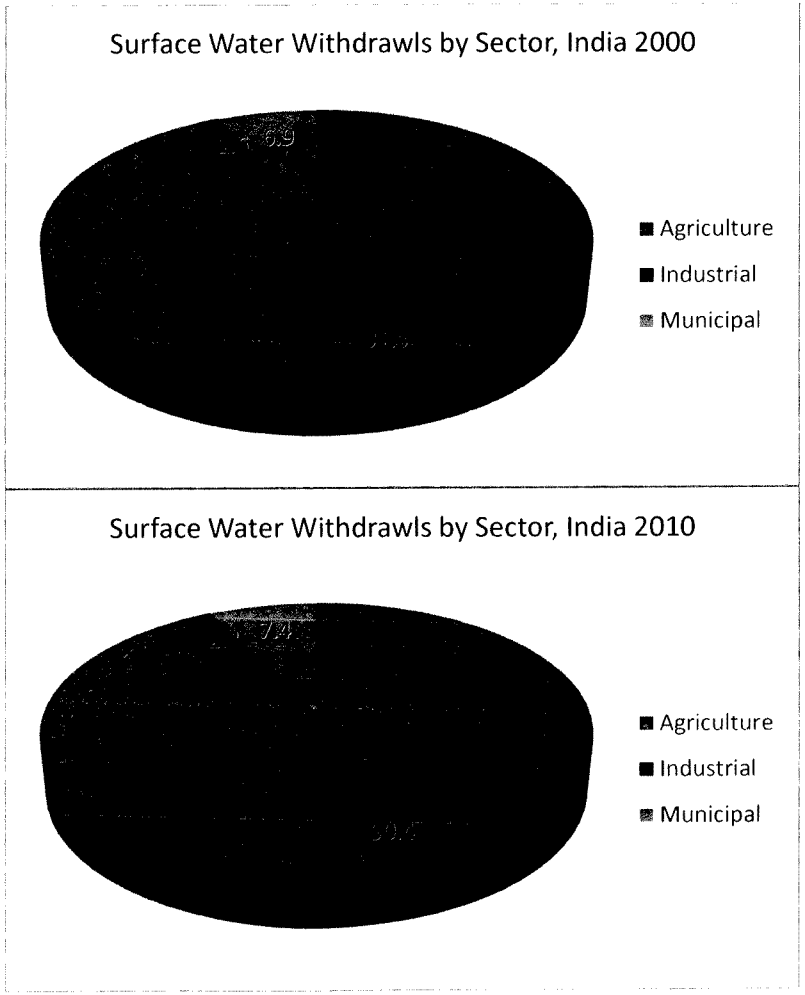


TABLE 6.5: PERCENTAGE AREA TO TOTAL IRRIGATED AREA BY DIFFERENT SOURCES IN GHAZIABAD DITRICT

	Canal	Tube Wells & Wells	Tanks & Others
2009-10**	14.17	85.83	0
2008-09*	15.84	84.16	0
2004-05	15.13	84.87	0
2003-04	12.50	82.97	4.54
1999-00	16.89	79.81	3.30

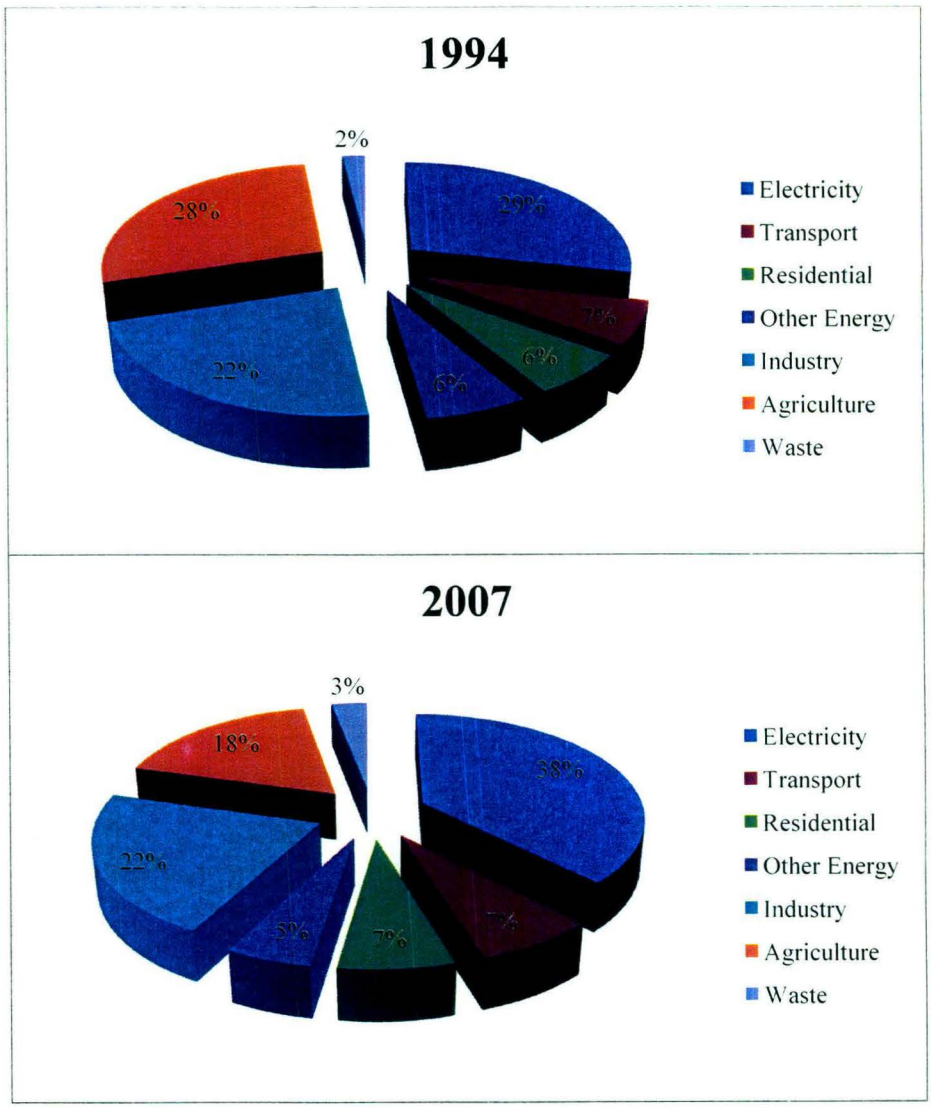
Data Source:- www.uttarpradeshstat.com
** Statistical Abstract, U.P. Economics & Statistical Division State Planning Institute U.P.*
*** Economics and Statistics Division of the State Planning Institute, Uttar Pradesh*

The increasing rate of fertilizer consumption requires sufficient water supply. This has been lead to the irrigation by tube wells and wells. The area irrigated by tube wells and wells show positive relationship with increasing depth of groundwater availability.

6.5.3 GREENHOUSE GASES EMISSION: -

The major environmental changes that occur due to agricultural practices is emissions of greenhouse gases. According to IPCC, 2007 estimations the agricultural activities accounts for 12% to 145 of global anthropogenic emissions of greenhouse gases. After fossil fuel combustion, land use change is the second largest cause of CO_2 emissions (Power et al, 2010). The figure 6.7 & 6.8 shows the emissions of greenhouse gases by sector in India in 1994 and 2007.

FIGURE 6.7: GREENHOUSE GAS EMISSIONS BY SECTOR IN INDIA, 1994 and 2007



(India: Greenhouse Gas Emissions 2007, MoEF, GOI, 2007)

N_2O emission is natural part of soil nitrogen cycle but more addition of nitrogen through fertilizers imbalances this. It is estimated that crop absorbs only 50% of nitrogen applied rest is absorbed by the other ecosystems (Galloway et al, 2004). The nitrogen than a plant cannot absorb will be released to the atmosphere. In India livestock rearing is an integrated part of agriculture. The livestock also emit CH_4 during their digestive process. So a large part of methane is contributed by livestock also in India. It is estimated that around 49% of global anthropogenic emissions of methane (CH_4) is attributed to agricultural activities (FAO 2003).

6.6 DEGRADATION OF ECOSYSTEM SERVICES AND SUSTAINABLE DEVELOPMENT: -

Biodiversity and ecosystems services are essential for human well-being and poverty eradication as they provide basic services like food, fuel and water (MEA, 2005). Ecosystems generate multiple services and by looking at ecosystem services the costs and benefits of the choices can be compared (TEEB, 2011). Human actions are disturbing the natural functioning of the Earth and putting the future generations in danger (MEA, 2005). This pressure will lead to the rapid utilization of certain resources. Thus they will not be available to the future generations. The future generations have to struggle hard to find the substitute for such resources. This will lead to the dis-functioning of the natural processes. The sustainable development will not be any longer in rhythm. For anything to be sustainable there is need to maintain quality and quantity throughout the generations. Sustainability can be defined only in the boundaries of a system's framework, that is, after specification of what is to be sustained (Rao et al., 2002). Sustainability involves a balance between the environmental, economic and social dimensions of society; Unsustainable systems are those for which growing environmental degradation eventually surpasses society's ability to substitute productive systems or to intervene to control or mitigate the damage (Lambin et al., 2011). It is sure that changes in functioning in any system will affect the other ecosystems also. Because the services we get from ecosystems come from combination of all ecosystems of that particular area.

The cities affect and are affected by natural systems beyond their physical boundaries (Alberti et al., 1996). Humanity has caused changes to the natural resources base that will reduce the capacity to support the human population in the future (Arrow et al., 1995). The unsustainable use of resources can cause biodiversity degradation and the poor section will be affected most due to these changes. They will not be able to fulfil their basic needs even because the poor section is directly dependent on the nature for their needs. If natural resources are not managed sustainably or degrade then the provision of food, water, energy and other services become difficult. The millennium development goals propagate that all people should have access to basic needs till 2015. At present around 60% population of the world live in urban areas (World Bank). There is need of proper urbanization in developing countries so that poor can also have access to basic needs like water, without paying high prices (MDGs 2013). The Sustainability of ecosystem services requires dealing with

interactions between technology, society, and environment (Lucas et al., 2014). The WBGU talks about the six planetary guard rails that mean that the development should be in limit of the planetary boundaries. The WBGU proposes integrating six guard rails as Sustainable Development Goals (SDG) targets for the most urgent global environmental problems into the catalogue of SDGs under the title 'safeguarding Earth system services (WBGU, 2014).

I. Limit climate change to 2 °C,
II. Limit ocean acidification to 0.2 pH,
III. Halt the loss of biodiversity and ecosystem services,
IV. Halt land and soil degradation,
V. Limit the risks posed by long-lived and harmful anthropogenic substances and
VI. Halt the loss of phosphorus.

The release of carbon in atmosphere due to deforestation is causing global warming as well as loss of biodiversity hotspots. To produce at large scale from agricultural land phosphorous is being used very much and significant use of fertilizers is degrading land. So SDGs propose a plan to halt the negative impacts of development. The Aichi Biodiversity Targets also talks about identifying causes and reducing direct impacts of biodiversity loss to improve the status of biodiversity so that benefits can be accessed to all from biodiversity and ecosystem services.

Agriculture is one of the key links between biodiversity and ecosystem services on the one side, and human well-being (via food security) on the other, and features prominently in the debate about the post-2015 development agenda (Lucas et al., 2014). Population growth in especially the poorer parts of the world, including growth of the global middle class will demand for more water, food, biomass to sustain those (Lucas et al., 2014). If there additional policies are not applied, the current consumption patterns prevail this will lead to the continuous degradation of ecosystems and biodiversity, and poor will be affected proportionally (CBD, 2010). In this way the sustainable use of natural capital and preservation of biodiversity and ecosystem services is vital for sustainable poverty eradication (UNEP, 2007).

The capacity of provisioning services from, mainly, agro-ecosystems is often maintained and enhanced by technical means, such as the application of fertilizers, pesticides and soil and water management (Lucas et al., 2014). The challenges for sustainable agricultural production are to avoid negative impacts on regulating services while

applying technical solutions. The Indian agriculture faces challenges like drought, water logging, flooding and salinization of fertile land etc. in the study areas Ghaziabad and Faridabad agricultural land face problems of salinization due to overuse of water (CGWB). Another major challenge is to increase production in decreasing agricultural land while minimizing environmental impacts. This will lead to the agricultural intensification to feed this increasing population. World level India has around 46% area is under agricultural use which is quite high than the other countries in the world (Kushwaha et al., 2008). If more refined agricultural practices are followed India could produce more without incorporating more land under agricultural use. The so-called green revolution is confined to few crops and has been successful in some areas only. This limited application of green revolution gave rise to new problems like overuse of water and fertilizer. This type of practices followed in agriculture is not sustainable agricultural practices. Agricultural ecosystems operate at different levels and scales while sustainability is defined in a boundary. So it is also difficult to set boundary defined goals for the huge agricultural system of India. The agricultural ecosystem provides food and fibre, one of the major basic needs for a human being. All these concerns require a great attention to protect natural as well as agricultural ecosystems in sustainable development framework.

6.7 CONCLUSION: -

In the previous chapter we analyzed that the major cause of the changes in the value of ecosystem services is loss of agricultural land. The agricultural land and barren land has been used mostly for built-up purpose. The agricultural area is decreasing but the production is not decreasing, rather it is increasing. What processes has led to the increase in production and what are their negative impacts on agricultural land are discussed in this chapter. The chapter opens illustrating agricultural ecosystem. The decrease of agricultural land and encroachment of built-up area in Ghaziabad and Faridabad districts is analyzed. Further it is analyzed that how agricultural ecosystem is provider and consumer of ecosystem services. The ecosystem services that flow to agriculture ecosystem are discussed in details. The ecosystem services flow to agricultural ecosystem are soil structure and fertility , crop pollination, natural pest control, water quantity and quality, genetic diversity, landscape influences etc. This is followed by the discussion on what goods and services we get from agricultural ecosystem. Ecosystems never work in seclusion. They always affect each other in the flow of energy and

matter from one ecosystem to another ecosystem. Similarly the agricultural ecosystem also affects other ecosystems, positively and negatively. The agricultural ecosystem has negative impacts on the environment; these are termed as dis-services from agricultural ecosystem. To get more production from the decreasing agricultural land certain measures are applied. As in the study area more input of fertilizer and water has caused land fertility problems. The salinization of land is a very big problem in Ghaziabad as well as Faridabad districts. the problems like agrochemical contamination of land and pesticide poisoning of crops, surface and groundwater depletion, greenhouse gases emission etc. are the emerging problems due to intensification and more pressure on agricultural ecosystem. Through the data it is analyzed that the fertilizer input is increasing gradually apart from it the groundwater level monitoring reports decreasing groundwater level in the study area. The sector-wise analysis shows that the share of the greenhouse gases emissions due to agricultural activities has been decreased. But in absolute terms it has increased. But we need more production as well as want to maintain fertility of agricultural land without affecting other ecosystems. This is a challenging job for developing countries where population is increasing at a very fast rate.

The discussion in this chapter ends with comments on degradation of ecosystem services and sustainable development. The Millennium Developments Goals have not achieved sufficiently. The developing countries are lacking far behind in achievement of MDGs and will not be able to achieve till 2015. A discussion has been done on the sustainable development in the degrading environment. So the measures suggested by German Advisory Council on Global Change (WBGU) of six Sustainable Development Goals (SDG) have also been discussed. These SDGs talk about halting the loss of biodiversity, fertile land degradation and degradation of ecosystem services. The chapter ends with explaining problems of agricultural ecosystem and implementation of sustainable measures to protect the agricultural ecosystem.

Chapter VII

CONCLUSION

Urbanization is the process which operates at multiple scales affecting the surrounding region also. The peri-urban areas expand over the cost of forest land, agricultural land. Especially in the peri-urban areas maintaining solid waste is emerging as a new problem. This change in periphery of the city can be observed by analyzing physical, social, demographic, economic changes in the periphery. At national level the share of urban population is increasing. In 2011 around 31.16% population of India live in urban areas and the number of million plus cities has also increased from 35 in 2001 to 53 in 2011. The major urban agglomeration of India has also showed urban growth through urban sprawl and densification of region. The national capital region of India has also been affected by the process of urbanization and development. The National Capital Region has vast area to expand. The growth rate of population and incorporation of new districts in National Capital Region signals sprawl of urbanization in NCR. The density of population in NCR in 1981 was 657 persons per km^2 which has been increased to 1349 persons per km^2. This increasing density in NCR is causing pressure on the natural resources of the region and periphery also. The number of towns in NCR in 1981 was 94 which have increased to 160 in 2011. The districts which are growing fastest are Faridabad, Ghaziabad and Gurgaon. The first hypothesis is proved that how urbanization in NCR is increasing over the time period.

The second and third hypothesis is also proved that the urbanization process of NCT Delhi is affecting and influencing urbanization in other districts and towns of National Capital Region. The national capital of India, Delhi and its surrounding region also experienced significant increase in urbanization. In 1981 NCR, only 45.95% population was urbanized which increased to 56.4% and 62.5% respectively in 2001 and 2011. The location, environment, economic structure and connectivity of NCT Delhi influenced the urbanization process in National Capital Region. According to census 2011 in whole NCR Uttar-Pradesh sub-region shows highest urbanization (48.3%) followed by Haryana sub-region (43.1%) and Rajasthan sub-region (17.8%). The district wise analysis of urbanization in NCR shows that Faridabad is the most urbanized district from 1981 to 2011. In 2011 Faridabad is the most urbanized (79.44%) district followed by Gurgaon (68.42%) and Ghaziabad (67.46%). The industrial and commercial activities in these above mentioned districts have caused significant increase in urban population. The pattern of migration towards NCR is explained to show that which states or districts send more people in NCR. It's observed that 20 districts sending 31.76 per cent migration to Delhi, out of them 11 districts within 100-200 km distance from Delhi periphery. Most of the people migrate from Uttar Pradesh followed by

Bihar in NCR. Further an attempt has been made to explain the concentration of urban population in NCR through location quotient (LQ). The location quotient analysis explains that highest concentration of urban population in Districts of NCR is in Faridabad followed by Gurgaon and Ghaziabad in 2011. The influence of urbanization of NCT Delhi on the towns is also measured through location quotient. The results came out that Faridabad and Ghaziabad are one of the most influenced towns of NCR. A zone development analysis of towns is also calculated. It explains that in within 50 km periphery of NCT Delhi the NCR towns are most influenced. The district wise analysis shows that Faridabad, Gurgaon and Ghaziabad are the most urbanized districts in NCR. The town wise analysis shows that same Faridabad, Gurgaon and Ghaziabad are the most influenced towns of NCR. All these explanations make a strong argument that Faridabad, Ghaziabad and Gurgaon are the most influenced districts of NCR by urbanization process in National Capital Region.

The fourth hypothesis is also proved that talks about that how this process of urbanization and industrialization has affected the land use land cover in the selected Eastern NCR region. The change in land use and land cover in whole NCR has occurred due to the increasing population pressure, urbanization, industrialization etc. The urbanization process within the districts also affects the surrounding regions. So the land use land cover changes of these two districts have been compared with the Eastern part of National Capital Region. After studying several classifications schemes like USGS classification scheme, Anderson classification scheme, NRSC classification scheme, an objective orient classification has been adopted. The land use land cover has been classified into eight categories. Further land use land cover category wise analysis has been done. The first LULC category identified is 'Built-up', the area occupied by settlements. The built-up area has increased in both districts. In Ghaziabad the built-up area in 1991 was 18.2% which increased to 31.6% in the year 2013. Similarly in Faridabad district the built-up area in 1991 was 14.45% of total area which increased to 31.13% in 2013. The data explains that the fertile agricultural land as well as bare land is continuously being covered by built-up areas. In all the surrounding regions of Ghaziabad and Faridabad districts except Dadri, the built-up is increasing but at lower speed than Ghaziabad and Faridabad. The second category is 'Agricultural Land' which has been identified to measure changes in agricultural land over the time. The analysis of data shows that whole Eastern part of NCR faced significant loss of agricultural land from 1991 to 2013. In Ghaziabad district the land and agricultural activities was 76.64% in 1991 which remained just 62.4% in the year 2013. Similarly in Faridabad district also in 1991 the land under

agricultural activities was 63.37% which remained 50.85% in 2013. Both districts Ghaziabad and Faridabad lost respectively 10583ha and 10414ha agricultural land from 1991 to 2013. Actually it is the fertile agricultural land or bare land which has been sold to the big contractors to built multi-story buildings. The high prices paid by the contractors to the owner of land. Thus the owner of land is lured by the high prices and sells his land for any commercial type use apart from agricultural activities. The 3rd LULC category deals with the analysis of forest cover. The analyses of forest cover by national capital region planning board measures that due to the afforestation scheme the forest cover has increased in the whole NCR region. Our analysis also shows increase in forest cover. In Ghaziabad district 1009.5 ha land was under forest cover in which increased to 1264.3 ha in 2013. In Faridabad district also the forest cover in 1991 was 10.29ha which increased to 28.59 ha in 2013. The 4rd category of LULC is 'Urban Greenery' which includes urban parks, urban gardens, urban forests, tree cover along the roads and railway lines, zoological parks, forest reserves, commercial and industrial green belts, avenues and boulevards etc. It is very necessary from climatologically as well as ecological point of view. In Ghaziabad the area under urban greenery has becomes 1.5 times from 1991 to 2013. Similarly in Faridabad has happened. In Ghaziabad district in 1991 around 628.9ha area was occupied by urban greenery which increased to 899.64ha in 2013. In Faridabad district also in 1991 around 727.7ha area was occupied by urban Greenery which increased to 1196.55ha in 2013. Thus urban greenery has increased with the increase in the built-up area.

The next LULC category 'other natural and semi-natural areas including wetlands' includes the rocky, hilly tracts, gullied land, scrub land, saline land, water logged areas or wetlands, semi-arid pastures and rangelands. The opposite scenario has been observed in Ghaziabad and Faridabad districts. In Ghaziabad district the area under other natural and semi-natural areas has increased marginally. While in Faridabad district a net loss of 3159ha has been measured. These areas are the biodiversity hotspots of National Capital Region. In the LULC category 'Bare Land including Fallow Land' an irregular pattern has been observed. The area covered by LULC category 'Water Bodies' is consistent over the time except a slight fall in 2011. The last category of LULC classification deals with the 'River Bed'. Till 2010 both districts Ghaziabad and Faridabad experienced no change in river bed area. Overall the river bed area in Ghaziabad district in 1991 was 0.80% of total area which decreased to o.52% in 2013. Similarly in Faridabad district also in 1991 around 4.83% area of total area was occupied by river bed which remained to 3.64% of total area in 2013. Overall analysis explains that built-up has increased significantly on the cost of losing agricultural and bare

land. The forest cover is increasing gradually but the semi-natural areas and wetlands have decreased causing a threat to natural ecosystems. In rest of the LULC categories no significant changes have been observed over the time period.

The fourth objective in this study was to measure the effect of changes in Land use land cover over ecosystem services and how changes in land use land cover has affected supply of benefits and services from ecosystems in Ghaziabad and Faridabad districts. This objective has also been completed by evaluating and quantifying benefits of ecosystem services by valuing ecosystem services. The chapter V advances defining ecosystem services as defined by Millennium Ecosystem Assessment, 2005 and other researchers. More or less everyone has defined ecosystem services as the goods and services we obtain from ecosystems. Broadly four types of ecosystem services have been identified by MEA, 2005 respectively, Provisioning services, Regulating services, Cultural services and Supporting services. In literature review it has been discussed that if we want to maintain supply of goods and services from ecosystems, we have to maintain and enhance natural ecosystems. Until we understand the value of ecosystem services, no significant attention is paid. A monetary value assessment has been done in this study. The method of valuing ecosystem services has been adopted from Costanza et al. 1997. Thus for each land use land cover category the representative equivalent biome and the corresponding ecosystem services values has been identified. To obtain ecosystem services value for each category the Basic value transfer aggregation method is used. The value of ecosystem services is estimated by multiplying the land area of each biome by the value coefficient of the equivalent biome which has been used as the proxy for that land use land cover category. In Ghaziabad we found that land-use changes in the 74217 ha area resulted in an average net decrease of $86.82 lakh/year in ecosystem services between 1991 and 2013. Assuming a linear decrease in ecosystem services, this represents a cumulative decrease of $955 lakh US$ in ecosystem services over the 22 year period of the study while the net loss was 194.12 lakh US$ in value of ecosystem services in Ghaziabad district. Thus actual value of decline is very low from the linear value of decline. The average decline in ecosystem services of Ghaziabad district was around 1.21% per year. Similarly in Faridabad district assuming a linear decrease in ecosystem services, a cumulative decrease of 3408 lakh US$ was observed over the 22 year period of the study while net cumulative ecosystem services loss was just 599.14 lakh US$. The conversion of ecologically fertile and valuable agricultural area and fallow land into built-up is apparent in the study area. The net effect of the huge loss of agricultural ecosystem on ecosystem services can be observed in the table 5.3 and 5.4. If built-up is assigned any value

then instead of decreasing pattern of values of ecosystem services in the study area it will show increasing scenario. The valuation is not for marketing purpose but this is done so that common man can understand the importance of ecosystems and aesthetically and morally protect ecosystems.

Through the analysis of changes in land use land cover and resulting degradation of ecosystem services in study area increase our concern about protecting natural environment. The agricultural ecosystem is the most affected ecosystem in the study area, so a special attention is given in the last chapter of this study. The agricultural land and barren land has been used mostly for built-up purpose. The agricultural area is decreasing but the production is not decreasing, rather it is increasing. What processes has led to the increase in production and what are their negative impacts on agricultural land are discussed in this chapter. The chapter opens illustrating agricultural ecosystem. The decrease of agricultural land and encroachment of built-up area in Ghaziabad and Faridabad districts is analyzed. Further it is analyzed that how agricultural ecosystem is provider and consumer of ecosystem services. The ecosystem services that flow to agriculture ecosystem are discussed in details. The ecosystem services flow to agricultural ecosystem are soil structure and fertility , crop pollination, natural pest control, water quantity and quality, genetic diversity, landscape influences etc. This is followed by the discussion on what goods and services we get from agricultural ecosystem. Ecosystems never work in seclusion. They always affect each other in the flow of energy and matter from one ecosystem to another ecosystem. Similarly the agricultural ecosystem also affects other ecosystems, positively and negatively. The agricultural ecosystem has negative impacts on the environment; these are termed as dis-services from agricultural ecosystem. To get more production from the decreasing agricultural land certain measures are applied. As in the study area more input of fertilizer and water has caused land fertility problems. The salinization of land is a very big problem in Ghaziabad as well as Faridabad districts. The problems like agrochemical contamination of land and pesticide poisoning of crops, surface and groundwater depletion, greenhouse gases emission etc. are the emerging problems due to intensification and more pressure on agricultural ecosystem. Through the data it is analyzed that the fertilizer input is increasing gradually apart from it the groundwater level monitoring reports decreasing groundwater level in the study area. The sector-wise analysis shows that the share of the greenhouse gases emissions due to agricultural activities has been decreased. But in absolute terms it has increased. But we need more production as well as want to maintain fertility of agricultural

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