IMPACT OF ECOSYSTEM SERVICES ON LIVELIHOODS IN THE NATIONAL CAPITAL REGION

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

DOCTOR OF PHILOSOPHY

NISHA

CENTRE FOR THE STUDY OF REGIONAL DEVELOPMENT
SCHOOL OF SOCIAL SCIENCES
JAWAHARLAL NEHRU UNIVERSITY
NEW DELHI 110067
INDIA

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जवाहरलाल नेहरू विश्वविद्यालय
JAWAHARLAL NEHRU UNIVERSITY
Centre for the Study of Regional Development
School of Social Sciences
New Delhi-110067

DECLARATION

This is to certify that the thesis entitled **'Impact of Ecosystem Services on Livelihoods in the National Capital Region'** is based on my original research work under the supervision of Prof. Milap Punia. I hereby submit this thesis in partial fulfillment of the requirements for the award of the degree of **Doctor of Philosophy** of this University. This study has not been submitted in part or full for any other diploma or degree of any other University to the best of my knowledge.

Nisha
Nisha

CERTIFICATE

It is hereby recommended that this thesis may be placed before the examiners for evaluation.

24.7.17
Prof. Milap Punia
(Supervisor)
Centre for the Study of Reg. Dev.
School of Social Sciences
Jawaharlal Nehru University
New Delhi-110067

Prof. B.S. Butola
(Chairperson)
Chairperson
Centre for the Study of Reg. Dev.
School of Social Sciences
Jawaharlal Nehru University
New Delhi - 110067

Dedicated To

My Loving Family

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"All praise for the Almighty, the ultimate being"

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LIST OF ABBREVIATIONS

LULC	Land Use Land Cover
ES	Ecosystem Services
NCR	National Capital Region
NCT	Nation Capital Territory
NPP	Nagar PalikaParishad
GOI	Government of India
PCA	Principle Component Analysis
InVEST	Integrated Valuation of Environmental Services and Tradeoffs
UN	United Nations
GDP	Gross Domestic Product
PPP	Private-Public Partnership
UNEP	United Nations Environment Programme
IFPRI	The International Food Policy Research Institute
NCRPB	National Capital Regional Planning Board
CNCR	Central National Capital Region
MA	Millennium Assessment
GTB	Gautam Budh Nagar
CBD	Central Business District
MRTS	Mass Rapid Transit System
BUA	Built Up Area
MEA	Millennium Ecosystem Assessment
MLP	Maximum Likelihood Parameter
DMA	Delhi Metropolitian Area
TEEB	The Economics of Ecosystems and Biodiversity
WBCSD	The World Business Council for Sustainable Development
FAO	Food and Agriculture Organisation
NEA	National Ecosystem Assessment
CICES	Common International Classification of Ecosystem Services
IWMI	International Water Management Institute
ESPA	Ecosystem Services for Poverty Alleviation
MODIS	Moderate Resolution Imaging Spectroradiometer
EVI	Enhanced Vegetation Index
FFT	Fast Fourier Transformation
DES	Directorate of Economics & Statistics
RMSE	Root Mean Square Error
GIS	Geographic Information Systems
SECC	Socio-Economic Caste Census
ATMA	Agricultural Technology Management Scheme
DASP	Diversified Support Project

NTPC	National Thermal Power Corporation
KCC	Kisan Credit Card
NCO	National Classification of Occupation
ISDR	The International Strategy for Disaster Reduction
UNDP	United National Development Programme
TEEB	The Economics of Ecosystem and Biodiversity
FGD	Focused Group Discussion
HYV	High Yield Variety
CPR	Common Property Resources
DFID	Department for International Development
ANOVA	The Analysis of Variance
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NRLM	National Rural Livelihood Mission
NULM	National Urban Livelihood Mission
SPMRM	Shyama Prasad MukherjiRurban Mission
BPL	Below Poverty Line
SDG	Sustainable Development Goals

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Chapter-1

INRODUCTION

1.1 Context of the study

Earth's ecosystems are the one on which human welfare and growth towards sustainable development are vitally dependent. Globally, ecosystems are affected by human activities and it effects not only the supply of services that ecosystem provides but also degrades it. It will have direct consequences on food, fresh water, fiber, timber etc. and indirect on frequency and magnitude of floods and drought, prevalence of diseases, and local, regional as well as global climate. Human beings also gets benefited by ecosystem in other forms of its services such as recreational, spiritual, educational, and other nonmaterial welfares. Therefore, alterations in accessibility of all these ecosystem services can intensely affected the aspect of human well-being ranging from the rate of economic growth, development, health and livelihood security to the occurrence and perseverance of poverty (Millennium Ecosystem Assessment, 2005).

Land, food and water are the three basic needs of human beings, for this they are totally dependent upon ecosystem but today unprecedented pace of urbanisation and population growth generates significant stress on it. Further it does not only effect the supply and use of ecosystem services, but also the amount, nature and circulation of potential beneficiaries of those services. For example, transformation of rural areas to urban areas is probably to decrease the provisions of many services, reduction in many ecosystem services and supplies due to increasing growth of population for e.g. provisioning services such as crop production (Alcamo et al., 2005), and by reducing the quantity available per capita without reduction in the whole quantity of service available. Moreover, urbanisation caused changes in the supply of beneficiaries: human settlements are generally located in small dense area (urban patches or settlements) that are often located distant from where services are produced. The change in the distribution of human population is relative to the places of ecosystem service provisions could further increase the cost of service supplies and decrease the per capita provision for example transport of food from rural to urban places, water transfers and dams. At end, these complicated interfaces between ecosystem service provision and urbanisation are possibly to change trade-offs among services in regions (Bennett, 2009).

Urbanisation on one hand brings economic benefits and progress the quality of life but on other unplanned and haphazard urban growth can also become to adverse environmental and social effects (Newman and Kenworthy, 1999). Problems that are related with rapid urban growth such as water pollution, air pollution, urban heat island effect, congestion, excess commuting, have been well studied (Newman and Kenworthy, 1999; Wang et al., 2003). Ecological system deterioration, is the vital problem among all these. Fast transformation from natural land use to anthropogenic dominated land uses are affecting ecological systems intensely, through rapid urbanisation. In precise, land use land cover changes alter the physical components of the earth surface, hence affecting energy and material exchanges among atmosphere and land. in addition, these changes in Land Use Land Cover (LULC) can also affect the soil and water which influence the nutrient transport among them, vegetation and biochemical cycles. Moreover, these LULC changes further impacting the biodiversity, altering the structure and composition of ecosystems (Zang et al., 2011; Nagendra et al., 2014). The peri-urban area plays a significant role in maintaining the well-being of a city. It provides the pathways by which rural livelihood connected to the urban lifestyles. The flow of services and goods from urban to rural and rural to urban is happening from this peri-urban region. Due to this people put huge stress and cause degradation in the existing peri-urban environment therefore it become less efficient in providing proper food, water and sanitation facilities and become a very vulnerable zone in terms of sustainable development of peri-urban area. Thus, it is required to develop the peri-urban area in such a way that it can bear multiple pressures on its environment and maintaining proper access of ecosystem services to its population.

In summary, the modification from fertile natural land to urban impervious land diminishing the functions, including services and goods, of natural ecosystems. Therefore, it is important to understand the process of urban growth and see how it effects on natural ecosystems is the essential research area for scholars, policy makers and planners. However, investigation of such interactions have been lacking to date.

1.2 Conceptualization

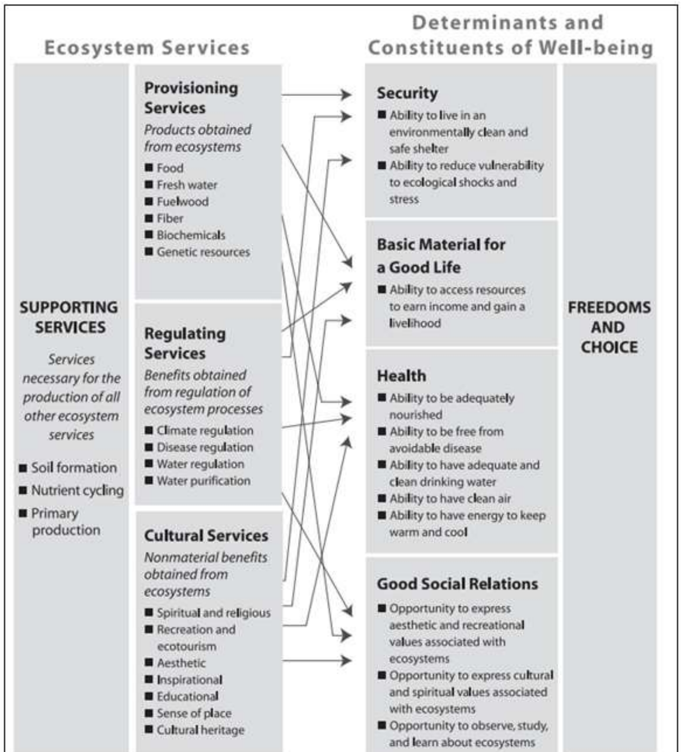
1.2.1 Conceptualizing Ecosystem Services (ES) and its linkages with Human Well-being

The Ecological Society of America defines ecology as 'the study of the relationships between living organisms, including humans, and their physical environment' (Ecological Society of America, 1997). An ecosystem is a particular level of organization in a natural world containing a diverse set of living and non-living components which are self-sustained; regulated by positive and negative feedback loops; and characterized by flows of energy and movement of matters on cyclic pathways (Istock et al., 1974, p.25-28). Ecosystem provide services to living organisms including humans. Ecosystem services are the conditions and process which are driven by solar energy, generated by a complex of natural biogeochemical cycles such as carbon, nitrogen, sulfur etc. and life cycles such as bacteria, trees etc., (Daily,1997, p. 3-4). According to Millennium Assessment 2005, services provided by ecosystems are generally categorize into four categories- provisioning services, regulating services, supporting services, and cultural services. Provisioning services includes supply of goods such as food, water, fuelwood, fiber, genetic resources, and biochemical. Regulating services are benefits obtained from regulation of ecosystem processes such as climate regulation, flood control, disease regulation, and water purification and regulation. Cultural services include the non-material benefits that human beings acquired from the ecosystems for example spiritual and religious benefits, recreation and ecotourism, aesthetic, inspirational, and educational cultural benefits. And last supporting services are necessary for production of all other ecosystem services such as soil formation, nutrient cycling, and primary production that maintain conditions for life on earth. These all services are effecting human-beings in different perspectives. Understanding their relationships between human beings are complex but it is important to maintain human well-being so it is essential to review the synergies between them.

Relationship of natural ecosystem and the supply of goods and services to the well-beings of human beings is diverse and complex. Human interventions are responsible for the unexpected and surprising consequences. It may be positive as well as negative. But in most of cases it resulted in the negative ones. Equitable and sustainable well-being depends heavily on links with ecosystem services and on who gains and who loses over time from their use.

The linkages of different services to human well-beings plays a significant role in providing sustainable environment and livelihood. As provisioning ecosystem services provides goods such as food, water, timber, fiber and other benefits but at the same time, scarcities of these goods and services would lead to the adverse impacts on human well-being, via both indirect and direct pathways. Adverse effects on livelihoods are of certain significance. Livelihood sustainability in context to both social and environmental contexts has three aspects:

- a livelihood is sustainable "when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future" (DFID, 1999);
- a livelihood is sustainable in a social aspect when it improves or does not reduce the livelihoods of others; and
- a livelihood is sustainable when it does not diminish or interrupt ecosystems to the preconception of the livelihoods and well-being of others now or in the future.



Source: Millennium Ecosystem Assessment, 2005

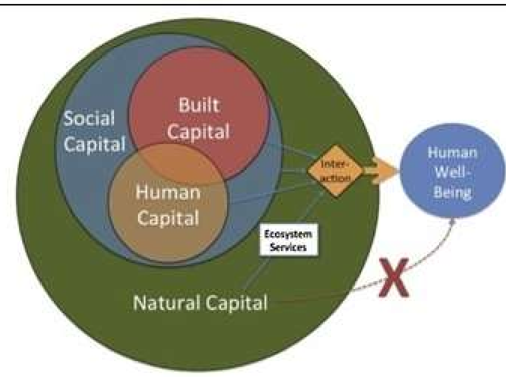
Figure 1.1 Ecosystem Services and its linkages to human well-being

Within provisioning ecosystem, biodiversity is vital to other ecosystem services. Such as, it relates to the resilience and sustainability that is essential for the livelihoods and coping plans of individuals to many peoples, specially the poor communities. They are mostly dependent upon ecosystem services for reducing their vulnerability, from engaging in complex to diverse mix of primary activities over the seasons. It will stabilize their livelihood and provide multiple source of ES (Chambers, 1997a; Ellis, 1998; Scoones, 1998; Neffjes, 2000).

On the other hand, regulating services also effects human well-being in complex ways. It provides the fresh water, filtration of air, flood control, local& regional climate stabilization etc. without these essential services or functions, populations of both humans and animals would not survive and life become inconceivable. Hence, change in any regulating services possibly have consequences on human and animal's health and other parameters of well-being

Similarly, through cultural services the linkages with human well-being are provided through non-material benefits such as scenic landscapes, rivers and lakes, sacred groves, trees, totemic species, geological formations of landscapes etc. the components and functions of ecosystems impacting the cultural, educational, aesthetic, spiritual and recreational aspects of human experiences. Any change through the process of interventions and disruption, degradation, extinction, and contamination in ecosystem functions will effect to cultural services that further impacts on human experience and cultural life. Moreover, supporting services are vital for sustaining all other three ecosystem services. Therefore, in making linkages between supporting services and human well-being it shows indirect linkages.

It is also important to understand that ecosystems cannot provide any benefits to people without the presence of human beings (human capital), their communities (social capital), and their built environment (built capital). Ecosystem services do not flow directly from natural capital to human well-being. It is only through interaction with the other three forms of capital that natural capital can provide benefits. This interaction is shown in Figure 1.2.



Source: Costanza et al., 2014

Figure 1.2 Relationships among built capital, social capital, human capital and natural capital with human well-being

Hence, the importance and functions of each ecosystem services with human well-being are vital for the sustaining life for all but the dependency on these services would effect to minor communities in a large. The linkages of access to these services to poor are prominent and depicting in providing sustainable livelihood option to them in long term. But due to changes in the landscape with the many processes and phenomena, ES's are depleting rapidly. Costanza et al. (2014) evaluated global loss of ecosystem services by $US 4.3-20.2 trillion/yr due to land use change which mainly reflecting towards rapidly increasing urban phenomenon worldwide. Hence, it is important to look ES's into sustainability aspect with the sustainable livelihood.

1.3 Statement of Problem

Urbanisation, land use and land cover, ecosystem services are one of the emerging issue all over the world. With the expansion of urban areas and population increase, demand for food, water and land, the flows of ecosystem services from rural to urban areas has increased. Thereby, the depletion in the ecosystem service and livelihoods are the challenging issues for the government and policy makers in providing sustainable rural-urban livelihood options without degradation of ecosystem services.

Urbanisation in India is growing very fast specially in the metro cities. India's 27 million plus cities, with Mumbai, Delhi and Kolkata having population over 10 million (Census of India, 2011). National Capital Region has recorded an extra ordinary growth in its urban population especially during the last fifty years. Between 2001 and 2011, the population of NCR has increased by almost nine million, out of which the urban population contributed eight million. Majority of the urban population of NCR is concentrated in the city of Delhi, and has been spreading out in the neighbouring areas of Gurugram, Faidabad, NOIDA and Ghaziabad. Faridabad and Gautam Budh Nagar districts of NCR are experiencing maximum change in terms of land use land cover, urban population growth and degradation of ecosystem services. Due to this urban expansion significantly affects the land use types and intensities. One of the resultant effect on the soil fertility due to intensification of land for both agriculture and non-agriculture purpose. Non-agricultural uses of land in the NCR caused the deterioration of several ecosystem services. The agricultural area expands over the cost of forest land, agricultural land, fallow land etc. Thus, change in land use and land cover are the emerging as central attention with development linked sustainability challenges.

1.4 Challenges and scope of the study

The present research work is mainly focused on the National Capital Region whereas its major findings would be centered to the south-eastern part of NCR. Therefore, it is an opportunity and as well as challenge to study interaction between urban-rural areas in NCR as a system, in order to understand south-east region in NCR is selected. First, selected area (Kheri Kalan) comes under the peripheral part of million plus city i.e.

Faridabad and second, selected area (Bishada) is a peripheral part of the Class-I town i.e. Dadri near to NOIDA. These both selected areas of the region are a part of the Megalopolis.

Another important challenge for this work is that it is mostly illustrates the issues of peri-urban region in context to ecosystem services and livelihoods without consideration of urban region as a part of study. Because there are lot of studies have been done on cities like Bangalore, Delhi, Mumbai, Chennai etc., but there are few who took initiative to understand peri-urban area as part of the larger megapolis. Therefore, it would be one initiative to study region specific issues and challenges in peri-urban areas specially in the south-east region of NCR.

Understanding linkages between ecosystem services and human well-being are not well studied in the National Capital Region. Therefore, study is important in order to analyze, urbanisation impact on ecosystem services and further how it will be impacting to the livelihoods of the rural poor communities, which is lacking to date specially in the National Capital Region. It will not only provide the whole scenario of study region but also at micro level ground realities of the region will also be discussed.

1.5 Study Area

Study area selection for this research is based on general to specific approach. First, whole National Capital Region of India has been studied as general, then Faridabad and Gautam Budh Nagar district of NCR has been studied as particular, and finally specific case studies has been studied from Faridabad (Kheri Kalan village) and Gautam Budh Nagar (Bishada village) district. The introduction of study area is discussed below:

1.5.1 National Capital Region

The National Capital Region (NCR) includes Nation Capital Territory (NCT)-Delhi, 13 districts of Haryana (Faridabad, Gurugram, Rohtak, Sonepat, Panipat, Jhajjar, Rewari, Mewat, Palwal, Mahendragarh, Bhiwani, Karnal, Jind), 7 districts of Uttar Pradesh (Meerut, Ghaziabad, Muzaffarnagar, Gautam Budh Nagar, Bulandshahr, Baghpat, Hapur) and 2 districts of Rajasthan (Alwar and Bharatpur). Among total area of NCR, the NCT region accounts of 4.4% area, Haryana accounts of 39.3% area, Rajasthan accounts of 24.5% area and Uttar Pradesh accounts of 31.8% area. The NCR region lies between 27° 03' and 29° 29' North latitude and 76° 07' and 78° 29' East longitude. The average annual rainfall in the NCR region generally varies from 500 mm to 850 mm about 75% of which is received in monsoon months (July-September). The NCR is drained by three important rivers i.e. Ganga, Yamuna and Hindon. The river Ganga is bordering the region as its eastern boundary and the river Yamuna is traversing north-south of the region forming the boundary between Uttar Pradesh and Haryana. Hindon is the major tributary of the river Yamuna which flows in southerly direction in the NCR region. The alluvial plain mainly formed by the rivers Ganga and Yamuna occupies a major portion of NCR. In the western part of NCR (around Jhajjar and Rohtak), sand dunes are found. From north-east to south and south-west, the region is plain with a gentle slope. The rocky hills consisting of Quartzite are found in south-west of Delhi and region lying to south of Delhi’s surroundings (Delhi, Gurugram, Rewari and Alwar).

The NCR region is found to have extreme climatic conditions. In most time of the year, the climate of NCR is primarily influenced by its inland position and the prevalence of continental air. The three different types of seasons are found in NCR i.e. summer (March to June), monsoon (July to September) and winter (November to February). The summer season is governed by high temperature which may go up to 45°C, hot climate and high speed winds. The monsoon season is dominated by rains and high humidity levels in air. The winter season is dominated by cold, dry air and low speed winds and have very low temperatures which go up to 2° C or even less during extreme cold conditions.

The NCR is a hub of economic activities and evolving as one of the largest metropolitan regions of the world. The urbanisation level has risen from 56 percent in 2001 to about 62.5 percent in 2011. This is nearly double the national urbanisation level of 31.2 percent.

1.5.2 South-East NCR

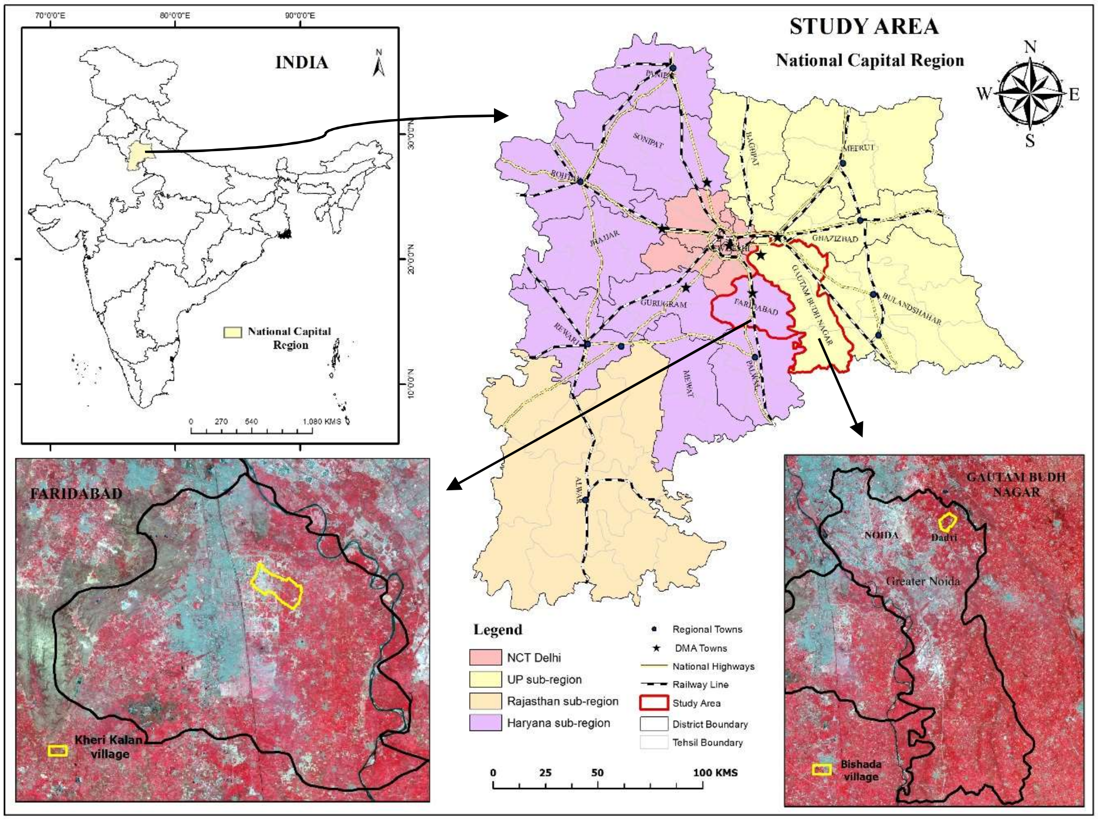
As particular, study area is south-east National Capital Region i.e. Faridabad and Gautam Budh Nagar. Both are fast developing areas of National Capital Region. Faridabad district is part of Haryana and sub-region of NCR. Gautam Budh Nagar is part of Uttar Pradesh sub-region of NCR. The urbanization and industrialization has changed the land use land cover pattern in and around NCT Delhi region.

1.5.2.1 Faridabad

Faridabad, the largest city and first metropolitan city in the Delhi Metropolitan Area. Faridabad is the south-eastern district of Haryana state in India and sub-region of NCR. It is located at 28.42° N and 77.30° E. it enjoys the prime location both geographically and politically. 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. The Delhi-Agra National Highway No.2 passes through the center of the district. The presence of Aravalli hills on the western side and Agra Canal on the eastern side has been responsible for the linear development of the city. There are only two tehsils Faridabad and Ballabhgarh in Faridabad district according to Census 2011. The total area of Faridabad District is around 743 sq.km.

1.5.2.2 Gautam Budh Nagar

Gautam Budh Nagar is the south eastern part of U.P sub-region of NCR. It is located in the close proximity to the metropolitan city of Delhi and lies along the eastern and south-eastern boundaries of the NCT-Delhi. The Yamuna river separates the district of Haryana state and Delhi to the west. The total area of the district is 1442 sq.km. It consists of three tehsils namely Dadri, Gautam Budh Nagar and Jewar. The emerging urban growth center are NOIDA and Greater Noida in the district which attracts huge masses from different parts of the region. The town Noida is situated in the Yamuna basin in the area between Yamuna and Hindon.



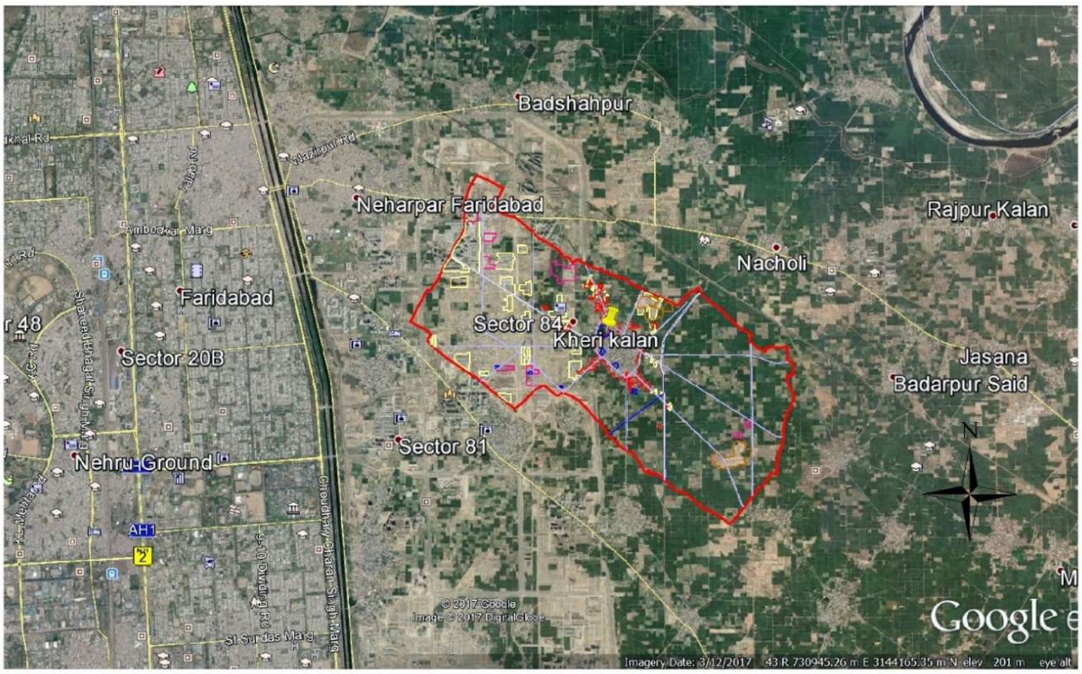
Map 1.1 Location of Study Area

1.5.3 Specific case studies from Faridabad and Gautam Budh Nagar districts of NCR

1.5.3.1 Kheri Kalan village, Faridabad

Kheri Kalan is situated in the periphery region of Faridabad urban area and experiencing huge land use land cover dynamics from past ten years. It is located at a distance of 8 km from the main city and in the east direction beyond Agra canal. The total geographical area is 973 hectares. In the recent years, ground water depletion and loss of agricultural land is the major environmental problem of this area. *Ghosh, 2011* studied the proximity regions of Faridabad in which she added the dynamics of land use change, expansion of urban area towards village and ecological problems in Kheri Kalan village. She added that '*hoardings on the main Kheri road that leads to the village in Sector 89 announces the first affordable mall in the NCR and luxurious homes that can still be owned only if you hurry'.* That shows the remnants of sprawling agricultural landscape. She further added with real estate developers and private educational institutions acquiring fertile agricultural land resulted in the shrinkage of opportunities of work. With falling incomes, nutrition levels too have plummeted. Tuberculosis and pneumonia are common in the families of agricultural workers (Ghosh, Jayati 2011). According to census 2011, it has a total population of around 6,664 persons and 1103 Nearly 75 percent of the village population is Jats and rest are mostly Dalits.

KHERI KALAN VILLAGE

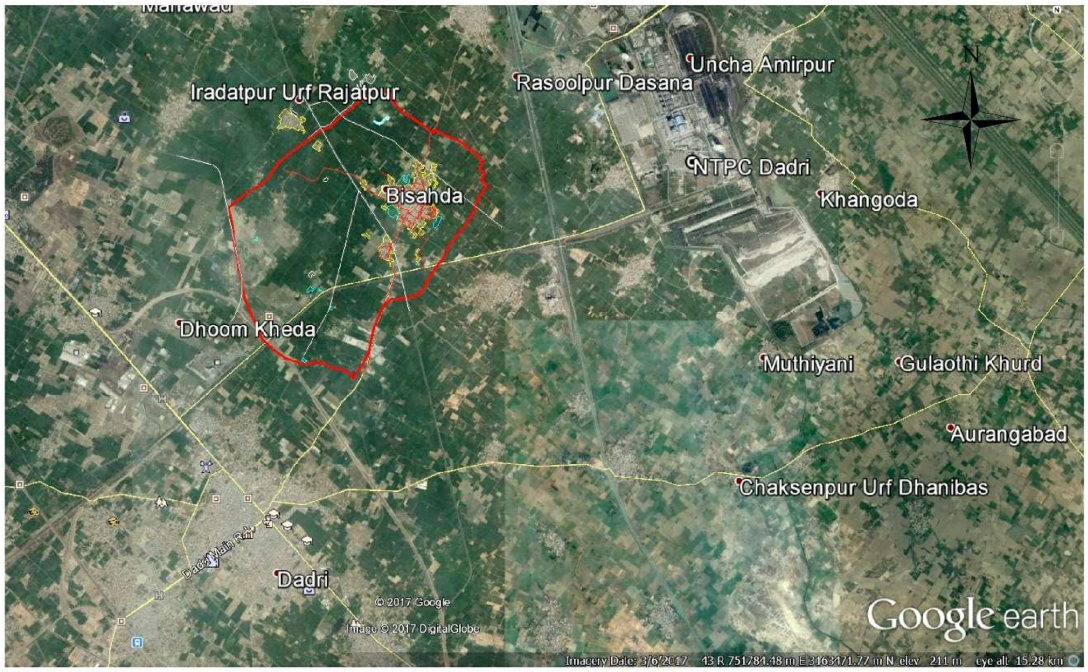


Map 1.2 Google earth image for Kheri Kalan village, Faridabad

1.5.3.2 Bishada village, Gautam Budh Nagar

Geographically, Bishada village is situated between the Dadri NPP (Nagar Palika Parishad) and Patadi census town. It is a peripheral location of both areas. Therefore, it has experienced the remarkable change in the land use and land cover change. The total geographical area is 714.43 hectares. Waterlogging, depletion of ground water and *usar* (barren or wasteland) land is the major problem in the village. 70 percent of the village population is Rajputs and rest belongs to minor communities. The total population of the village is around 6669 with 1167 households (Census, 2011). Average sex ratio is 844 which is lower than Uttar Pradesh state average of 912.literacy rate is 77.2 percent. 80% percent of the village population are dependent on primary activity for their livelihood. Due to region specific problems and issues from both villages, therefore, it is significant to study the loss of ecosystem services and to see its impacts on their livelihoods.

BISHADA VILLAGE



Map 1.3 Google earth image for Bishada village, Gautam Budh Nagar

1.6 Research Questions

2. What is the relationship of urbanisation and land use and land cover change?
3. What is the impact of land use and land cover change on ecosystem services?
4. How do ecosystem services relate to the livelihoods of communities in peri-urban and rural areas? What pressures are acting on ecosystem services and how do they impact on livelihoods for the peri urban marginalized communities?
5. Whether loss of ecosystem services in peri urban and rural areas led to proliferation of poor or marginalized people. If so, whether this has happened due to intensified urban growth which has resulted in scarcity and overexploitation of provisioning ecosystem services.

6. What are the implications of urban development policy initiatives for ecosystem services and poverty, and what are the alternative approaches which can enhance ecosystem services depletion and poverty alleviation in peri-urban region & support wider sustainable development goals?

1.6 Objectives

The main focus of the study is to know the loss of ecosystem services in urban and peri-urban region and to see its impact on livelihoods especially in the rural areas.

1. To understanding the process of urban growth in the National Capital Region and exploring its impacts on ecosystem services.
2. To assess the loss of provisioning ecosystem services (food and water) in the National Capital Region.
3. To study the impacts of loss in ecosystem services on livelihoods.
4. To examine the urban policy gaps and suggest required guidelines for sustainable environment, especially keeping peri-urban areas in contexts.

1.7 Data Sources

The present research work is necessarily an empirical one and is based mainly on field survey data at the primary level. However, the analytical background of the study (primarily the third, fourth and fifth chapters) is based on secondary data sources. Therefore, study is involved a combination of both primary and secondary data. ***Primary data*** includes detailed field survey of Kheri Kalan village of Faridabad and Bishada Village of Gautam Budh Nagar on the impact of ecosystem services on livelihood aspect. Detailed field survey was conducted by using structured questioner in the region for collecting complex information containing a high proportion of opinions, attitudes and personal experience of the respondents. ***Secondary data*** involve remote sensing data (1991 onwards to 2011) to Census data (1991, 2001, and 2011), topographical sheets, Cadastral village maps, governmental reports etc. The brief detail of the datasets used in the present research are summarized in table 1.1

Table 1.1 Overview of the source, purpose and description of data sets

S.No.	Source	Year/Time period	Purpose
1.	Census of India, Primary Census Abstract	1991, 2001 &2011	To analyse socio-economic characteristics of NCR
2.	Directorate of Economics & Statistics, Ministry of Agriculture	2001 & 2011	To analyse cropping pattern and nine-fold classification of land use change.
3.	Landsat imageries	1991, 2001, 2011	To analyse land use and land cover mapping of study area.
4.	Horticulture data from Department of Agriculture Cooperation & Farmers Welfare	2013-14 & 2014-15	To analyze horticulture scenario across districts of NCR
5.	Statistical abstracts for districts of NCR	2001-02, 2003-04, 2004-05	To analyzed fertilizer consumption data across districts of NCR
6.	Cadastral village maps, Revenue Department of Faridabad and Gautam Budh Nagar districts	2016	To get the base maps for the selected villages.
7.	Topo sheets, Survey of India, GOI	1970,2001,2005,2007	To provide ancillary data for study area.
8.	Google Earth images	2006 & 2016	To digitize study area latest village map.
9	SECC data, Ministry of Rural Development, GOI	2011	To analyse household level socio-economic characteristics and vulnerabilities of Kheri Kalan and Bishada village

1.8 Methods

The present study has been done at three levels. The macro-level analysis of the general urbanisation and land use and land cover pattern of the whole National Capital Region, a meso level analysis of the influence of NCR urbanisation on land use and land cover change, ecosystem services, and livelihood at the village level of the study area (the district of Faridabad and Gautam Budh Nagar), and finally, forming the core of the analysis, a micro-level analysis at the household level of the effect of urbanisation on ecosystem services and livelihoods of the people.

1.9.1 Study area selection and sample design

The selection of study areas was based on the working population engaged in the primary activities such as they are main cultivators, agricultural labourers whose primary source of livelihood is generated from ecosystem services and also the demarcation is done within the 5 km periphery from the urban areas to see the urban effects on its fringe areas with respect to loss in the ecosystem services and urban expansion leading to the deterioration in the ecosystem services. Thus, selected study area is Kheri Kalan village in Faridabad Tehsil of Faridabad and Bishada Village in Dadri Tehsil of Gautam Budh Nagar district of National Capital Region.

Sample design: Based on the total population and number of household in a village, 10 % of samples have been collected from the study regions with cluster random sampling method. A household survey has been done in selected villages with a sample design depicted in below figure 1.3:

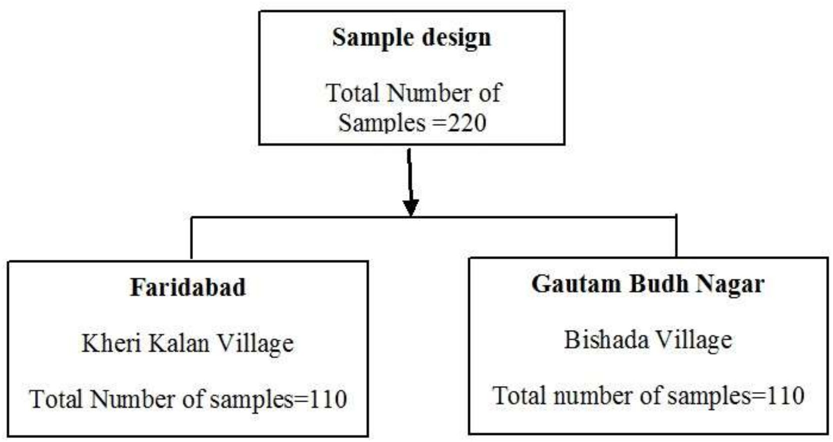


Figure 1.3 Sample design

Table 1.2 Selection of sample size

Name of village	As per Census 2011		Sample Size	
	No. HH	Population	No. of HH	Population
Kheri Kalan (Faridabad)	1103	6664	110	683 (10.2%)
Bishada (GT B Nagar)	1167	6669	110	694 (10.4%)

(Source: Census 2011 & Primary survey, 2016-17)

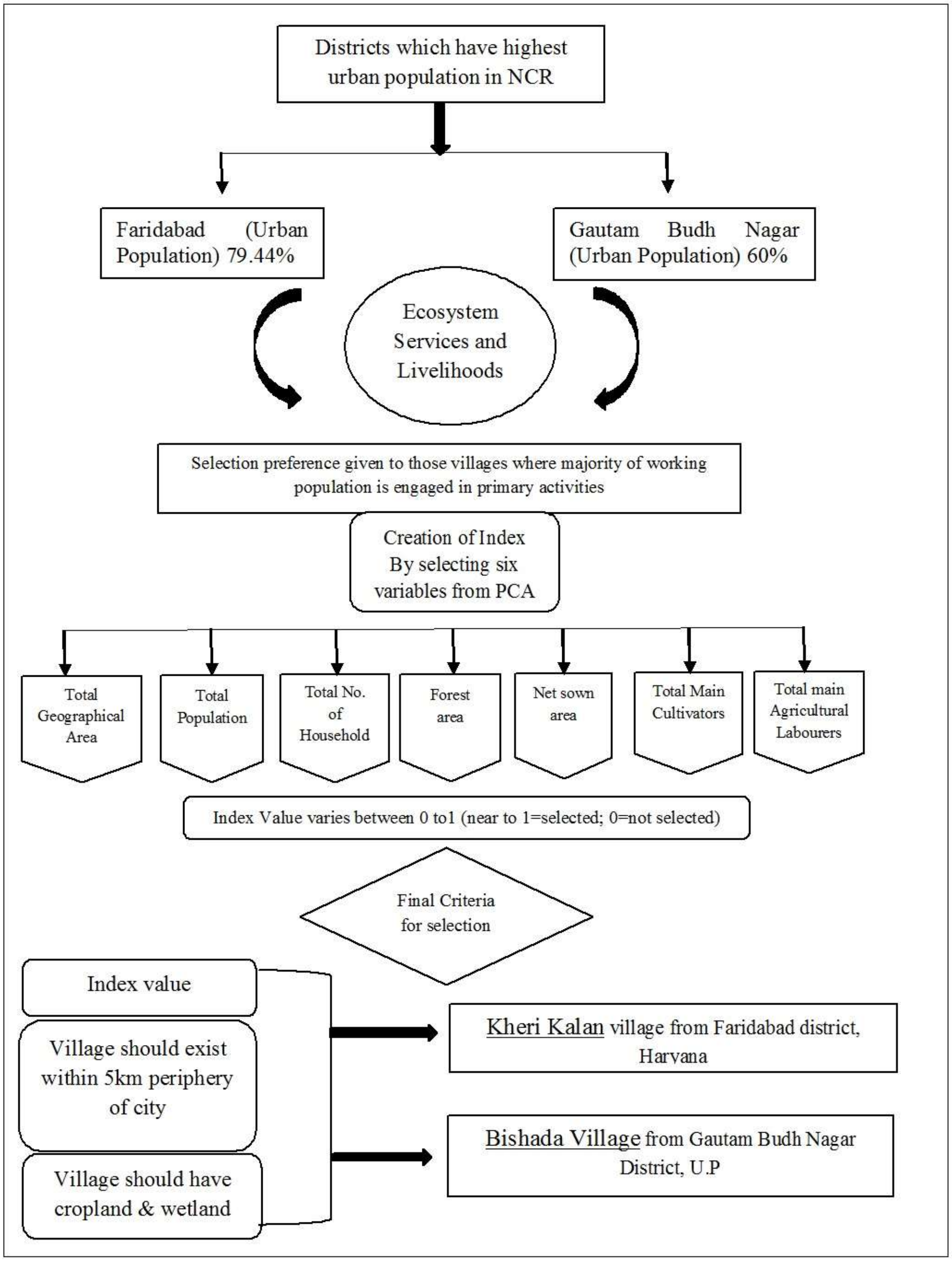
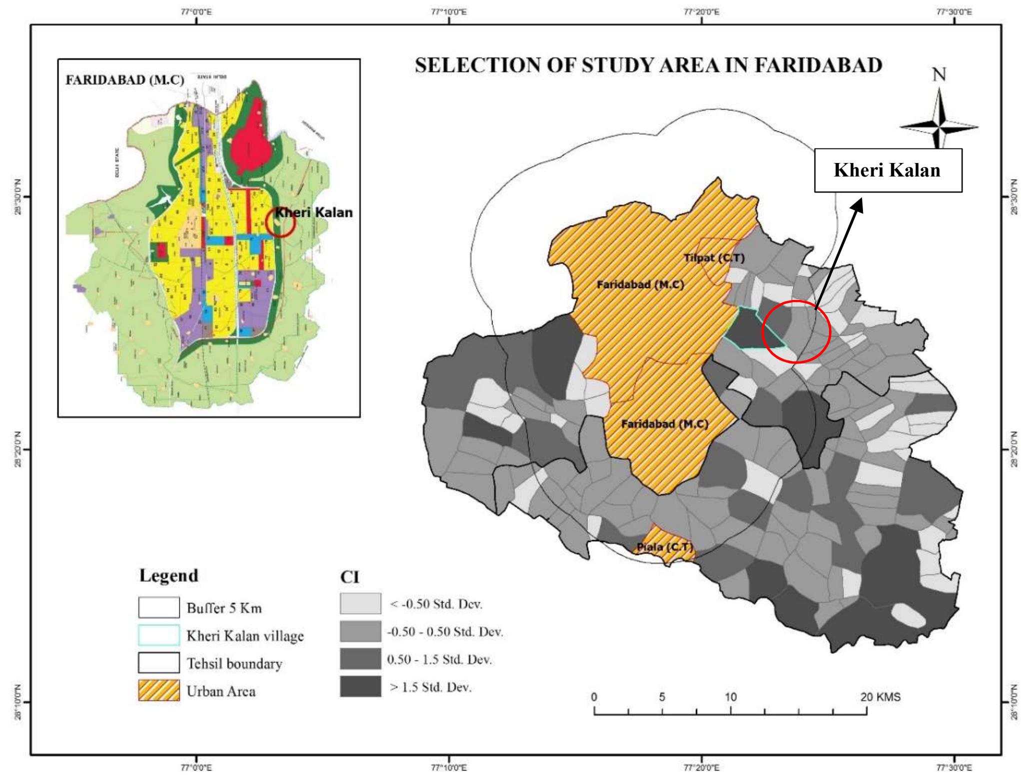
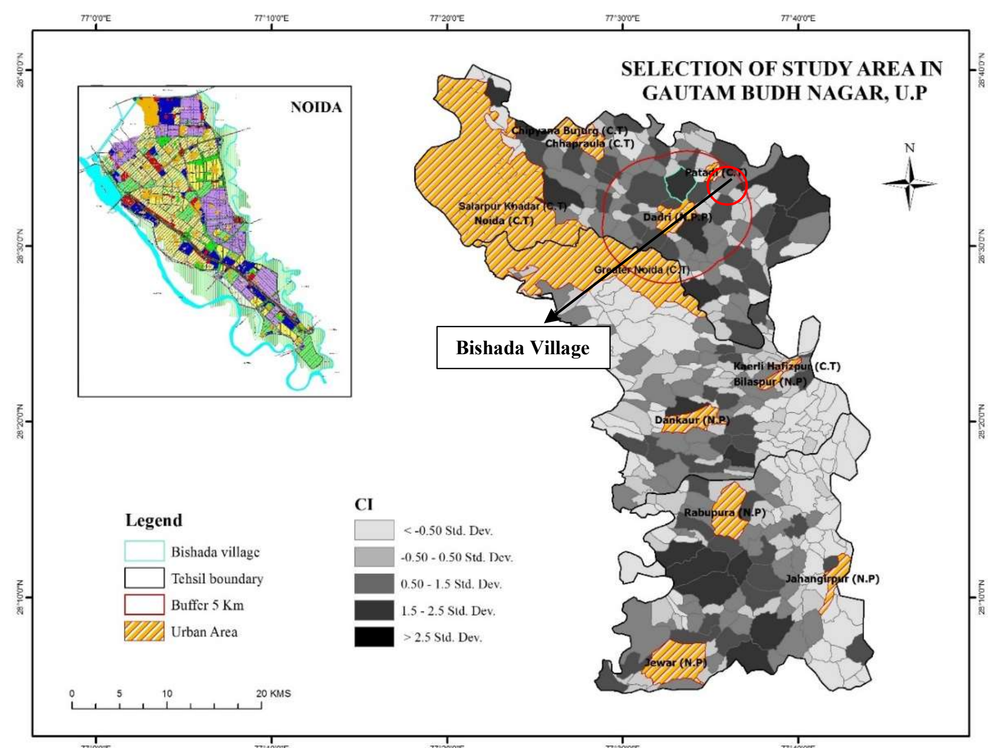


Figure 1.4 Flow diagram for selection of study area



Map 1.4 Location of Kheri Kalan village in Faridabad



Map 1.5 Location of Bishada village in Dadri, Gautam Budh Nagar

1.9.2 Objective-wise methodology in brief

In order to achieve the above mentioned objectives, various methods, techniques, algorithms and tools are used, which are discussed below in brief and further, detailed methodology will be discussed in each chapter.

In order to achieve first objective, the urban population decadal growth rate is calculated to present the increase in population in different census years. Level of urbanisation in National Capital Region is analyzed by calculating percentage of urbanisation. It refers to absolute or relative number of people living in urban area at specific point of time. Concentration of urban population in National Capital Region analyzed through Location Quotient. Further, rings have been identified on the basis of NCR policy zones. Then Landsat images has been classified to detect land use land cover changes in ring wise in NCR for determining influence of urbanization on ecosystem services. Supervised Classification is used to detect the temporal changes of land use land cover. Further Costanza et. al, 2014 methodology have been adopted in order to valuation of ecosystem services.

In order to achieve second objective, valuation of ecosystem services (for assessing loss of provisional ecosystem services- crop production and water) is done by using Spatio-temporal modeling (InVEST). Crop Production model and Water Yield model have been used to assess the provisioning ecosystem services in NCR. Integrated Valuation of Environmental Services and Tradeoffs (InVEST) is a suite of software models used to map and value the goods and services from nature that sustain and fulfill human life. InVEST enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.

In order to achieve third objective, a detailed field survey has been done in selected sites of study area to study the impacts of loss of ecosystem services on livelihoods. DFID framework has been adopted in order to assess the sustainable livelihood framework for the selected study area.

And lastly, in order to achieve fifth objective, governmental reports, policies have been studied and analyzed. It also tries to find out the policy gap to address the issue of loss in ES and its impact on livelihood.

1.9 Rationale behind study Area

Delhi is the National Capital and biggest city in North India with 16.7 million populations (Census 2011). According to UN report 2011 Delhi ranked 2nd after Tokyo in terms of largest urban agglomeration. 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 Gautam Budh Nagar districts. These adjoining districts Gurgaon, Faridabad, Ghaziabad 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 Faridabad and Gautam Budh Nagar are one of the most developing districts in NCR Delhi. The urban expansion in these regions will be followed by land use and 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 areas and livelihoods of the people. It poses challenges of environmental pollution as well as food security in the region and put high pressure on urban poor for sustaining their lives. Therefore, there is need of sustainable development planning to minimize loss of ecosystem services and environmental degradation.

1.10 Limitations of the study

Due to the vast area of NCR, data gaps from secondary sources for multiple time period were the major limitations of the study. Satellite imageries were also not at high resolution scale so to some extent results may be varying from the other research outputs. The higher resolution data could have produced better results. Further, from the primary field survey, it is more relied on respondents answers and pre-assumption about the truthfulness of respondent, and respondents not shared right information about them due to insecurity about stranger were some limitations from field.

1.11 Organization of Chapters

This study has been divided into eight chapters, which are in the following order:

Chapter 1: This chapter includes introduction of the study, significance of the study, description of study area, research questions, objectives, data source, methodology, and rationale behind study area, limitations of the study and organisation of thesis.

Chapter 2: This chapter includes review of literature in detailed way for the understanding of the research problem.

Chapter 3: this chapter is divided into two sections. First section is deals with the assessment of urban growth in National Capital Region. Section two includes land use and land cover change, and its impacts on ecosystem services.

Chapter 4: deals with the assessment of provisioning ecosystem services with the help of crop production modelling and water yield modelling.

Chapter 5: this chapter divided into two sections. Section one, deals with the study of land use land cover change and urbanisation in Faridabad and Gautam Budh Nagar districts. Section two, deals with the socio-economic characteristics of the selected case studies from Faridabad and Gautam Budh Nagar and further analysed identification of rural poor's and examined socio-economic vulnerabilities.

Chapter 6: This chapter deals with the primary survey results to see the impact of ecosystem services on livelihoods based on selected case studies.

Chapter 7: This chapter comes out with policy inferences, from macro and micro level studies.

Chapter 8: This chapter deals with brief summary and conclusion of the study.

Chapter-2

REVIEW OF LITERATURE

To get insight into the understanding of ecosystem and its services to the society or human wellbeing, its loss and impacts on livelihoods and for studying risk and response to urban development planning, a literature review has been undertaken. For doing this review, it has been divided into certain subheads:

- Urban Growth and Ecosystem Services
    - Defining Ecosystem Services
    - Drivers of change in Ecosystem services
- Assessment and Loss of Ecosystem Services
- Impacts of Ecosystem Services on livelihoods
- Methods and Models related to LULC and ES
- Literature on study area
    - Urban expansion
    - Peri-urban issues

2.1 Urban Growth and Ecosystem Services

Urbanisation has been a universal phenomenon. It is the general enhance in population and the quantity of industrialization of a settlement. It admits enhance in the quantity and coverage of cities. It represents the mobility of community from rural areas to urban areas. Urbanization takes place due to enhance in the coverage and compactness of urban areas. As per the Census, 2011, urbanization has amplified faster than predicted in India. For the first time afterwards independence, the absolute enhance in the population in urban areas was greater than that in case of the population in rural areas with 31.16 % of its population strength or 377 million people currently residing in cities, an raise from 27.81 % in 2001 (Census of India, 2011). In India, there was a rapid raise in quantity of million plus cities. At present there are total 53 million plus cities comprising 43 % of total urban population. This has vast significance to provide transportation and other public facilities in urban areas (Ahluwalia, 2011; Kundu, 201; Bhagat, 2011). The fast rate of commercial and residential growth is substituting cultivation and other immature land across them. The issues of urban sprawl, defeat of open plant life and a general reduce in quality of environment can be usually qualified to growing population which makes more people to concentrate on less land yet as the land dedicated to urbanization expansion (UN-HABITAT, 2006; Martinez et al., 2008; Nijman, 2008; United Nations, 2009). In India, because of unmanageable urbanization, environmental deprivation has been happening very quickly and resulting many issues like worsening water quality, land insecurity, problem of water disposal, excessive air pollution and noise. In India, peri-urban areas are growing. People are commuting towards cities; consequently, urban expansion around the core cities gives birth to suburbs or peri-urban area. These are mainly the pathways through which livelihoods in urban areas got linked to ecosystem services in rural areas for fulfilling their necessities of food, fuel and fodder whereas livelihood in rural areas linked to urban lifestyles (Narain 2009).

In India, urban growth is habitually nucleate, along with recently urbanized land typically seen in a rigid band across the old sections of the city. Currently, India contains three out of ten of the world's fastest growing cities like Faridabad, Surat and Ghaziabad, and three out of ten of the world's largest cities as well like Delhi, Mumbai and Kolkata (United Nations 2011). Since last 20 years, the area under urban cover in India comes in the top 100 cities in the world has enlarged by approximately 2.5 fold, with extent of bigger than 5000 km^2 (Sudhira , et al. 2013; Nagendra et al. 2014). Built-up area in Delhi found a by and large increase of 17% of the total area in India i.e. from 540.5 km to 791.6 km throughout the study period from 1997 to 2008 that mostly came from waste land and arable land (Mohan, et al 2011). Population pressure along with migration from diverse parts of the nation has put marvelous stress on the natural assets like water, land, and air of Delhi and adjoining areas, wholly known as the NCR in search of employment (Kumar 2009).

2.1.1 Defining Ecosystem Services

An ecosystem is a vibrant complex of animals, plant and microorganism biotic communities and the most important non-living environment, which interact as a purposeful unit. Humans are an essential element of ecosystems. A precise ecosystem has well-built connections among its mechanism and fragile connections around its borders. A functional ecosystem frontier is the space where a amount of discontinuities overlap, for instance in the allocation of organisms, depth of a water body, drainage basins or soil types. At a bigger scale, regionally, even globally disseminated ecosystems can be measured on the basis of a harmony of fundamental structural units. Thus, ecosystem services are referred to the reimbursement, which people achieve from ecosystems (Millennium Ecosystem Assessment, 2005). Those include provisioning services such as water and food; modifiable services such as disease and flood control; civilizing services such as recreational, cultural and spiritual benefits; and sustaining services, like nutrient cycling, maintaining the circumstances for life on the Earth. Ecosystem services are the circumstances and procedures throughout which species and the natural ecosystems, made up by them, sustain and accomplish human life. They preserve biodiversity and the output of ecosystem goods, like forage timber, many pharmaceuticals, seafood, natural fiber, biomass fuels, industrial products and their predecessor (Daily 1997). Ecosystem goods (like food) and services (like waste assimilation) symbolize the reimbursement human populations directly or indirectly obtain from ecosystem functions (Costanza et al. 1997).

Like the term ecosystem itself, the concept of ecosystem services is comparatively current it was used for the first time in late 1960s (King 1966; Helliwell 1969). Research on ecosystem services has developed radically since the last two decades (Costanza et al. 1997; Daily 1997; Bolund et al 1999; Daily et al. 2000; de Groot et al. 2002; Boyd and Banzhaf 2007; Fisher et al 2009; Petter et al 2012; Smith 2013; Qiu and Turner 2014; Costanza et al 2014).

Studies on defining ecosystem services analyze the urban ecosystem by identify seven urban ecosystems such as urban forests, street trees, cultivated land, lawns/parks, streams, wetlands and lakes/sea. Then identified six direct and local services such as micro climate regulation, air filtration, rainwater drainage, sewage treatment, noise reduction and cultural and recreational principles in Stockholm. Study concluded that ecosystem services which are locally generated, have a considerable influence on the excellence of urban life (Bolund and Hunhammar 1999). Fisher et al (2009) talked about the idea of ecosystems services in 'Defining and classifying ecosystem services for decision making' and give emphasis on model for connecting the performance of ecosystems to welfare of human being. Accepting this connectivity is significant for an extensive range of decision- making process. They disagree that any effort at grouping ecosystem services should have been on the basis of both the characteristics of the ecosystems of attention and a decision making context for what the idea of ecosystem services is being circulated. They also discussed numerous examples about how classification strategies will be a role of both characteristics of ecosystem and ecosystem service and the decision- making circumstance. Boyd and Banzhaf (2007) in 'what are ecosystem services? The need for standardized environmental accounting units', recommends constantly definite units of description to determine the donations of nature to welfare of human being. They disagree that these units have to appoint not been definite by ecological secretarial advocates and that the term 'ecosystem services' is very temporary to be of realistic utilize in welfare secretariats. They projected a description, entrenched in economic ideology, of concluding ecosystem examination units. An objective of those units is equivalence with the meaning of conservative goods and services initiated in GDP and other national balance sheet. They also disagree that these similar units of description supply structural design for ecological presentation dimension by governments, environmental markets and conservancies.

All studies that have been discussed here talking about the defining ecosystem services that we are getting from our nature and classifying it on the basis of services they provide such services are provisioning like food and water availability, regulating services climate extremes like flood, heat wave and heavy rainfall & treatment of handling of waste, cultural services recreation, tourism etc., supporting services pollination, biodiversity, energy etc. Also give emphasis on representation for connecting the performance of ecosystems to welfare of human being.

2.1.2 Drivers of change in Ecosystem services

Understanding the elements that induce modifications in ecosystems and ecosystem services is necessary to the purpose of interferences that improve constructive and reduce pessimistic effects. A driver is any human-made or natural element which directly causes an alteration in an ecosystem or indirectly. A straight driver explicitly impacts ecosystem procedures and therefore can be recognized and calculated to conflicting degrees of precision. A circumlocutory driver controls more in diffuse manner, frequently by changing one direct driver or more, and its impact is recognized by accepting its influence on that direct drivers. The circumlocutory drivers of alteration are primarily economic, demographic, scientific, technological sociopolitical, religious and cultural. In turn the communication of numerous of those drivers impacts by and large the level of resource utilization and inequalities in utilization in intra-national and inter-national level (MA 2005). Obviously these drivers are altering: the global economy and population are increasing, there are major encourages in biotechnology and information technology, and the world is getting more interlinked. Modifications in those drivers are visualized to raise the necessity for food, clean water, energy and fiber which will subsequently impact the direct drivers (Kumar 2009). That direct drivers are largely physical, biological and chemical, like climate change, land cover change, water and air pollution, use of fertilizer, irrigation, introduction of alien enveloping species and harvesting.

Present research has growingly paid attention on changes in land use between rural and urban regions. A rural-urban region is an organism of purposes, ensuing in practice of actions that generate assured land uses in reaction to these activities. The equilibrium between urbanization and open space, results in interconnecting urban land uses and agro-ecosystems (Loibl and Koster 2008). Single cause behind the land use change in urban rural regions often proves distinct and highly versatile is due to the plurality of use of land along urban fringes. It is connected with a plurality of common demands and supplies, services and functions, thus showing that it is to a high number of driver-pressure relationships. Demography and world economic trends are considered to be the useful drivers of land use change, and particularly affect urbanization and counter-urbanization.

Recently, studies on social-ecosystem system interaction identifies that interactions exist between people, biodiversity and ecosystems. Altering human lifestyles drive, both directly and indirectly, alters in biodiversity, alters in ecosystems, and finally alters in the services ecosystem provide (MA 2005). Though to capture social and ecological dynamics, human dependence on the capacity of ecosystems to generate essential services, and massive importance of ecological feedback for societal development (Galaz et al. 2007) it is pre-assumed that ecological and social systems is complex, based on partnership and not domination over each other. Svarstad et al 2007 underlies the fixed relation with drivers, pressures and situation in respect to biodiversity. Drivers as the reason of environmental change are often understood as external negative energy to ecosystems and species, lossing complexity of mutual-dependent ecological-social methods linked with dynamic interactions and outcomes.

Drivers are fundamental element of dynamics often with cascading impacts throughout diverse scales, which results in the changes to social systems and ecosystems. Pressures are ways of such processes interacting between ecosystems and social systems. In same way, state is understood by the concept of dynamic stability, known as socio-ecological resilience (Folke 2006) or adaptive capacity of an ecosystem to remain within different equilibriums or its ability to reorganize into a possible mechanism of adapting. Feedbacks are the adaptations to socio-ecological variability likewise adaptive governance.

2.2 Assessment and Loss of Ecosystem Services

Transformation in land use and land cover change is probably be a major driver for changes and alterations in the distribution of ecosystem services before 2050 (MA, 2005). The main cause of change in the land use is likely to be the urban phenomenon in India. This rapid increase in urban population will result in the spatial shifts in the supply of ecosystem services and also to the beneficiaries to those services. Several studies documented and forecasted the worldwide urban expansion and evaluated its impacts on ecosystems services and biodiversity (Mace et al., 2012; Guneralp et al., 2013; Nagendra et al., 2014).

Urbanisation effected biodiversity by both directly or indirectly such as directly through the physical expansion over land, and indirectly through human interventions and change in the land use. Expansion of urban settlements has an effect of decreasing land size, fragmentation, shape, isolation of natural patches to the natural landscape (Ricketts, 2001; Alberti; 2005).

With the expansion of urban areas and population increment, demand for food, land and water has increased nowadays. Human needs for the natural resources has increased therefore ecosystem in urban regions are strongly affected by the human interventions. The advancement of urbanisation in the world, particularly after 1950s accorded with global environmental change, habitat loss, increasing consumption of resources especially natural, and ecosystem services change (McNeill, 2000). Presently 60 percent of the ecosystem services are being degraded or used unsustainably (MA, 2005). It is therefore necessary to develop strategies to cope with and adapt to long term environmental changes that will be caused by degradation of ecosystem services.

In the recent study of Srinivasan et al. (2013) showed the impact of urbanisation on water vulnerability by using coupled human-environment system approach for Chennai city of India. They examined the correlation between the water vulnerability and urbanisation which indicated that urban transformation of the water systems are not managed properly. Further results indicated that urban vulnerability to shortages of water responsible on a combination of many factors such as formal water infrastructure, spatial pattern and the rate of change of land use, adaptation by households and characteristics of the presented aquifers and surface water system. Finally, study suggested that in order to decrease vulnerability to shortages of water, there is need for the new forms of urban governance and planning institutions.

Another study of Qiu and Turner (2013) examined supply of ten ecosystem services across a urbanizing agricultural watershed for 2006 in the upper Midwest of the United States. Location of these services were not the coincident with the high supply of multiple services in this region. They analyzed the spatial interactions between the urbanized agricultural watershed and ecosystem services and found tradeoffs among water quality and crop production. Results of this study indicated that different areas have supplied different kind of ecosystem services and their absence of spatial concordance suggested the significance of management over enormous watershed areas to sustain several ecosystem services.

Unnikrishanan and Nagendra (2014) studied ecosystem services in Bangalore's lakes on the influence of governance through Private-Public Partnership (PPPs) in three lakes of this region by assessment of impacts on cultural and provisioning ecosystem services. Study revealed that public governed lakes supported a large diversity of traditional livelihoods, cultural services and non-profitable uses as comparison to private governed lakes. Results of this study also indicates that there is a need to implementation of PPP approaches in an equity manner and reconsideration of government policies in global south cities.

All these studies on loss of ecosystem services reveal that unplanned urban growth and land use dynamics are a key factor in losing the urban ecosystem services. The loss of biodiversity is linked with irreversibility, because the restoration of ecosystems is only possible to a limited extent and with huge effort. Thus, there is a need for urban planning strategies that would consider safeguarding of ecosystem services.

2.3 Impacts of degradation of Ecosystem Services on environment and livelihoods

Rapidly growing urban population are responsible for the several difficult challenges for the ecosystem and its services as well whole natural environment. For example, increasing contamination in water and pollutants in the air leading to further degrade the whole ecosystems (Narain, 2009; Janakarajan, 2009). Accelerated encroachment and modification of ecosystem from agricultural land, forests, scrub and grass land, rivers, water bodies or wetlands into the urban areas often takes place, leading to further degradation of ecosystem services. Apart from this remaining green spaces in many parts of the cities have been converted from their own form and species compositions to the human modified designed landscapes and pesticides intensive parks. These regions are the dominated areas of exotic species (Nagendra et al., 2011). Srinivasan et al. (2013) studied the similar effects of urbanisation on ecosystem. They have examined the relationship among the water vulnerability and urbanisation for the very fast growing city of Chennai by using coupled environmental and human systems modelling approach. Further, other impacts studied in the literature that urbanisation also have impacted on food and food security that further effects to the livelihoods of the people. The direct loss of natural ecosystem to urban impervious land is of big concern to the extent that high yielding croplands are lost whereas indirect loss considered to the impact of urbanisation on the dietary or health of the people.

At environment concern, negative impacts of transforming social dynamics that relates to industrialization and urbanisation has been a rise of pollution of air, soil degradation, water quality depletion, which further had a most impacts on the ecosystems. For example, air pollution leading to the significant change in the ozone layer that shields the earth from ultra-violet radiation from the sun. at the time of recognition of the depletion of the ozone layer, scientist's community posed an issue before the government for making an effective governance response. By that time in 1987 Montreal Protocol generated by the governance response on Substances that Deplete the Ozone layer (UNEP, 2006). The increase in the amount of greenhouse gas emissions over past 100 years or so is relatively or strongly linked with the anthropogenic interventions, industrialization and economic development which further leading to the higher amount of energy use and more carbon intensive economies. Due to increment in the atmospheric greenhouse gas concentrations, climate change has many negative effects on biodiversity at global level. For example, ecosystems likely to be impacted mostly through direct affecting factors and that severely includes coral reefs and polar north and south regions of the globe. Another issue raised through the climate change effect is number of species facing extinction in all ecosystem worldwide due to change in the temperature anomalies in worldwide (Peters et al., 1992; Schneider et al., 2002). Moreover, return impacts of climate change affected the human well-being, perhaps by likely to increase food prices. The International Food Policy Research Institute (IFPRI, 2009) projects that climate change will further responsible for the additional price increase of 32 to 37 per cent for rice, 92 to 111 percent for wheat, and 52 to 55 percent for maize by 2050.

At livelihood concern, MA health Synthesis Report (2005), indicates that in poor or underdeveloped countries, the health of people especially in the rural areas often is directly dependent on local environment and ecosystems that provides them basic nutrition for their survival. Therefore, local food production in these areas are critical in reducing hunger issues and promoting rural development in areas where the people especially the poor who do not have the capacity to purchase food from the market or elsewhere. Areas which are highly effected by the urban expansion or industrialization resulted in the loss of ecosystem services which effected many of the people in the worse and highly vulnerable & ill-equipped condition to cope with further loss of ES. The social-economic impacts of loss of ecosystem services are on the declining food production yields, lack of adequate safe water supplies etc. to the poorer communities hence increased the chances of malnutrition and impaired child development.

2.4 Methods and Models related to LULC and ES

Ecosystem are considered to be an essential part to our human-life and well-being. It generates various goods and services which collectively called as ecosystem services. From the last two decades, understanding about how ecosystem services are providing goods and services and how it translates into the economic value, an attempt and progress has been made by various institutions (Daily, 1997; NRC, 2005; MEA; 2005; Nelson et al., 2009). But still it has proven that it is difficult to understand the benefits value into the economic value. Therefore, it is required to estimates the ecosystem services in value terms. Without these assessments, and few incentives for landowners to afford them, these services incline to be unnoticed by those making land management and uses decisions. Presently, there are two paradigms for producing ES assessment that are intended to influence to policy decisions. In the first paradigm, broad scale assessments for multiple services and functions to infer some estimates of values, based on small to large habitat types such as entire region or the whole planet (Costanza et al., 1997; Turner et al., 2007; Troy and Wilson, 2006; Nelson et al., 2009). 'Benefits transfer' approach in the first paradigm incorrectly assumes the each and every hectare of a given habitat kind is of equal value irrespective of its spatial configuration, quality, size, rarity, nearer to population centers, or the usual social practices and values. Moreover, this approach does not permit for service provision analyses and changes in values under new circumstances. For example, when a wetland is transformed to cropland, how will this impact the provision of pure and clean water, climate regulation, flooding and soil richness in context to fertility? Despite the information on the effects of land use management practices on production of ecosystem services, it is quite difficult to create or design policies or payment agendas that will give the anticipated ecosystem services.

Whereas in compare to second paradigm for establishing policy for importance of ecosystem services assessments, 'ecological production function' which exists within the small areas kind of models with single service established by the researchers which shows how provision of that single service rely on local dependent ecological variables (Kaiser and Roumasset, 2002; Ricketts et al., 2004). From this production function approaches some of also used non-market and market based valuation methods to compute the economic value of the ecosystem service and also analyses how that value alters under different ecological conditions. However, second paradigm methods in valuing ecosystem services are considered superior to the habitat assessment benefits transfer approach. First paradigm approach lack both the number of services and scale (spatial, geographic and temporal) to be essential for major policy raised questions. By comparing what is needed here are the approaches that can combine the precision of small scale with the extensiveness of broad scale studies assessments (Jackson et al., 2005; Chan et al., 2006; Boody et el, 2005; Nelson et al., 2008).

Methods for modelling ecosystem services valuation are increasingly followed the second paradigm approaches such as spatially explicit modeling tool for the ecological production functions used by many researchers (Nelson et al., 2009). It is also called Integrated Valuation of Ecosystem services and Tradeoffs (InVEST). Other models that have been used frequently like IMPACT (evaluates global food production supply, trade, demand, and international food prices for states, regions and countries Rosegrant et al., 2002); AIM based on land cover and computes its changes over services with other indicators of global change, with an importance on Asia (Kainuma et al., 2002); WaterGAP which estimates global water use, stress, availability and return flows on river catchment scale (Alcamo et al., 2003). IMAGE 2.2 evaluates the global land cover and climate on a grid scale (IMAGE team 2001 and Alcamo et al., 1998). Terrestrial biodiversity model estimates the terrestrial biodiversity in aggregate form as a function of loss of climate change, habitat, species, and noninvolvement of alien species (Sala et al., 2005). Latest with the global ecosystem service coefficients values of ecosystem given by again Costanza et al., 2014 determines the changes in the global values of these services at biome conditions which is quite helpful for understanding the valuation and management of ecosystem services.

De Groot et al. (2002) examined the valuation of ecosystem services by making comparative ecological economic analysis and adopted standardized method for the inclusive valuation of ecosystem services, goods and functions. They described main 23 ecosystem functions that provide large quantity of goods and services and further they linked it with the main ecological, economic and socio-cultural methods.

Petter et al. (2012) developed the methodology for mapping ecosystem functions in South-east Queensland by using land sue data as surrogates or proxy with main preference of using biophysical data layers. They identified proxy land use and biophysical data for 19 ecosystem functions and produced the map for each of them, this method to map ecosystem functions worked with the overlapping of both existing data layers that further depicted the ecosystem functions. It has the potential to contribute to maximum ecosystem services provision.

Zhao et al. (2006) analyzed ecological consequences of rapid urban expansion over the city of Shanghai, China. Their study focused on impact on water and air quality, climatology and biodiversity of the city due to urbanization. They found dramatically increase in the urban area of the city and also found high concentrations of SO_2, NO_x total suspended particles etc. in the city as compared to those of rural areas. Due to urbanization, their study indicated the occurrence of urban heat island over the city and a decrease in native plant species were also observed.

Antle, J.M. and Valdivia, R. O. (2006) developed a spatially explicit production model to analyze supply of ecosystem services from agriculture. The study showed that in what way their model can be used to develop a minimum-data approach and they applied this approach to stimulate the supply of carbon. Their findings revealed that the minimum data approach obtained from supply curve is more explicit model based on site specific data which further depicts the sufficient accuracy.

Bennett et al. (2009) reviewed the literature on ecosystem services and suggested a typology of relationships among ecosystem services depending on the role of the drivers and the interactions among these services. The purpose of their approach was to provide a better understanding of the relationships among different ecosystem services that will improve capability to sustainably manage landscapes to provide multiple ecosystem services. They suggested some important reasons to be concerned with the relationship among ecosystem services i.e. trade-offs can cause decline in ecosystem services and ignoring dynamics may cause sudden shift and changes in ecosystem services.

Nelson, E.J. and Daily, G.C. (2010) described some of the methods and tools to calculate ecosystem services in terrestrial systems. They also described different methods to predict change in landscape. Analysis of prediction can be done through use of multi ecosystem services models to evaluate significant changes and find out the trade-offs in ecosystem service provision present and future.

Canqiang et al. (2012) estimated water runoff in the Xitiaoxi river basing using InVEST model. They also tested the accuracy of the model by estimating the natural runoff of the river based on linear regression relation of rainfall-runoff. Their findings revealed that south and southwestern regions of the watershed had higher water yield volumes per hectare.

Crossman et al. (2013) developed a blueprint for modelling and mapping of ecosystem services. The aim of their blueprint was to provide a template for beginners studying mapping and modelling of ecosystem services and to provide a database that can give key information for methods and information that were used in previous studies for mapping and modelling ecosystem approach. The advantage of their blueprint was that it reduced the uncertainty and minimize the gap among theory and practice for computing ecosystem services.

Ghosh et al. (2014) proposed seasonal mapping of land use dynamics through random forest classification method by using Landsat and ancillary data which consists of minimum training samples with operational mapping algorithm and limited image processing. Second classification is based on expert knowledge involving the decision level fusion and the seasonal maps resulted in an annual composite image with high number of land use land cover classes. This study revealed the accuracy of classified land use and land cover maps with detection of the seasonal variations of land use practices in the complex urbanizing area.

Duarte et al. (2016) developed an ecosystem services model for priority areas selection process over the Iron Quadrangle, Brazil. The study focused on quantifying and evaluating the overlap between ecosystem services using InVEST software and GIS. Their results showed that conservation planners can better locate the trade-offs in the landscape. They also provided improved habitat quality model using a topography parameter. They also used a model that included the tree mortality to estimate the carbon stock.

Maczka et al. (2016) explored the concept of ecosystem services by analyzing national environmental policy documents in Poland. They also explored ecosystem services approach by taking interviews of the experts. They found two major barriers in implementing these policies, first being lack of understanding among the policy makers and latter being sectoral divisions that obstructed the spreading of this concept. Their study found that before the occurrence of the ecosystem services concept, the concept of services provided by nature had already been perceived in national level environmental policy in Poland.

2.5 Literature on study area

2.5.1 Urban expansion and Land Use and Land Cover Change (LULCC) in NCR

According to the to the Master plan report of NCR 2021, green cover in Delhi has been reduced between 1991 and 2012 whereas when it comes to the matter of urban growth and development, the whole NCR, including Delhi shows almost 97 percent urban which is way ahead of the national average. Presently, 62 percent urban population is residing in the cities of NCR. However, this will not make any balance between the local environment and ecological components. Currently the forest cover in NCR is mere 6.2 percent which much below the national average of 21 percent. It is decreased between 1991 to 2012 from 4.73 per cent to 4.24 per cent whereas the built-up area in Delhi has gone increased between 1999 and 2012 from 48 per cent to 57 per cent which further indicating threat of decline in the next ten years. National Capital Regional Planning Board (NCRPB) further mentioned in the regional plan report about making a important point that reduction in the environmental standards in capital is certainly affect other basic civic services such as water supply and sewage. However, it also highlighted that due to decline and degradation of environment then it possibly effects on living standard of the residents.

The study of Mohan (2005) showed that within NCR, city of Faridabad shows expansion in the urban areas and reduction in the green cover alters the pattern of land use change and livelihoods. Due to rapid urbanisation, it not only degrades the natural landscape and shrinkage of forest area but also land values have gone high in and around the city.

Narian (2009) explained from the various studies that the fringe of NCR region is reducing due to land acquisition for residential and industrial purpose. Gurugram showed changes in the LULC scenario of the region with expansion of city at the cost of fertile land and created cultural, social and economic changes and inequities in the region and raised resentment between most of peri-urban locals against urban authorities.

Mohan et al. (2011) evaluated the LULC changes and urban growth in the city of Delhi, India during period of 1997 to 2008. Their results showed expansion of city towards its peripheral region due to conversion or rural regions to urban extension. The city of Delhi found an increase in built-up area to 16.86% of the total city area during this period. Their findings also revealed 0.5% increment of forest cover and 52.9% decline in waterbodies during period 1997 to 2008 over Delhi. They analyzed LULC change pattern with the urban expansion factors like vehicles, population, gross state domestic product etc. of that study region.

Bijender, S. and Joginder, S. (2014) compared changes in land-use/land-cover pattern of Delhi using 2 different sensors (Landsat TM and LISS III IRS P-6) during the period 1992 to 2004. Their results showed rapid change in LULC pattern of Delhi showing growth of 46.6% in residential area and loss of agricultural land from 45% in year 1992 to 37% in year 2004 over Delhi. They also generated land transformation map of the study region for different time periods showing LULC change.

Jain et al. (2016) monitored changes in land-use/land-cover in Delhi using Landsat and Indian Remote Sensing (IRS) satellite scenes during a time period of 1977 to 2014. They found increase of 30.61% in built-up area, decline in 22.75% of cultivated area, decrease of 5.31% in dense forest, decline of 2.76% in wasteland and increase in 2.41% for road and rail network over the study region during this period. Their findings revealed a significant negative correlation between built-up area with cultivated area and wasteland.

2.5.2 Peri-urban issues

In recent literature the phenomenon of overall modification of the urban fringe villages have been referred to as 'peri-urbanisation' (Dupont, V 2005). It encompasses the processes related to the development and progressive expansion of the urban fringe and also the formations that evolve in this process. As distance from the core increases, indicators of development decline while those of social and economic backwardness increases (Kundu et al, 2002). Kundu et al. (2002) referred this phenomenon as 'degenerated peripheralisation'. The nature of the peri-urban space and its extent are structured by the extent of communication links. The highly modernized pockets seem to be concentrated around the towns while less modern zones are characterized by the relative absence of urbanisation (Kundu et al., 2002)

Bentick (2000) focused on the urban expansion of Delhi and its impact upon land use and livelihood of the villagers in the peripheral villages. The study has found that urbanisation caused massive land-use changes in the peripheral villages on one hand and on the other has caused the village households to improve and diversify their livelihood situation. It has also been found that the agricultural decline is only partial as many of the fields remaining were use for intensive agriculture and horticulture.

Das (2017) studied urban expansion in the periphery of 7 largest metropolitan cities mainly focusing on city of Delhi. The study found increasing trend of urban growth in the areas closer to the urban centers during the post-reform period due to change of agricultural lands to built-up areas. The findings of the study reported a significant negative correlation among the built-up area and distance from the city center of Delhi.

Chapter 3

URBANISATION AND ITS IMPACTS ON ECOSYSTEM SERVICES IN THE NATIONAL CAPITAL REGION

3.1 Introduction

Urbanisation is often considered as a process connected with change in the demographic and economic dynamics of society; however, at the same time it is a phenomenon that transforms ecological environment at local as well as global scales (Huang et al., 2010, Sharma et al., 2016). Rapid urbanisation in the global scale leads to fast transition of uses of natural land to human-dominated land uses that has resulted in extensive environmental changes including decreased soil fertility, urban heat island effect, air pollution, land degradation (Eigienbrod et al., 2011), biodiversity losses (Nagendra et al., 2014), desertification, deforestation, water contamination (Srinivasan et al., 2013; Rosin et al., 2013), fragmentation of land holdings (Satterthwaite et al., 2010) and loss of ecosystem services (Nagendra et al., 2014). Among these, degradation of ecological system is essential one as it is associated with the human well-being. According to the Millennium Assessment report 2005, urbanisation significantly impacting the function ability of the earth's ecosystem in both local and global level and the services provided by to humans and other special as well on the earth.

World is urbanising very fast. Trends of world's urbanisation, reveals an unprecedented urban growth in the recent past. The age of industrialization can be marked as important dividing line in the trends of urbanisation. In the year 1800, it was recorded that only 3 percent of the total population in the world used to live in urban areas. The proportion of world population residing in urban areas went up to 6.4 percent in 1850, 13.6 percent in 1900, and finally 40 percent in 1980. By the year of 2000, the percent of the world population, residing in urban areas reached 47 (Dayal, 2004), and by 2030, the share of urban population to total population is expected to reach up to 60 percent (Human Development Report, 2006). However, the trend and tempo of urbanisation differ widely between less and more developed parts of the world, and they pose serious challenges for planners and policy makers. Currently some of the developed countries are found to be in the terminal stage of urbanisation; as a result of which they have already started undergoing slowing down the rate of urbanisation (Brockeroff, 1998).

But the level of urbanisation in less developed countries on the other hand is projected to increase substantially during the coming future, and the proportion of people living in urban areas is likely to surpass that in the rural areas by 2020. The levels of urbanisation thus will increase up to 56 percent in the developing countries by 2030 (United Nation Report, 1999). In the wake of rapid urban growth, it is estimated that by 2020, near about 80 % of world's urban population will have residence in the less developed countries.

With the expansion of urban areas and population increment, demand for food land and water has increased day by day. Human needs for the natural resources has increased therefore, ecosystems are strongly impacted by anthropogenic activities in the urban centres. The advancement of urbanisation in the world, coincided with the change in global environment, habitat loss, increasing consumption of natural resources and ecosystem change as well particularly after 1950s, (McNeill, 2000). Currently 60% of the services provided by the ecosystem, evaluated, used unsustainably or got degraded (MA, 2005). It is very necessary to develop strategies to deal with and accommodate long term environmental changes that will be caused by degradation of ecosystem services.

With this context, the present chapter is an attempt to evaluate the trends, patterns and processes of urban growth in National Capital Region. Further, in connection to linking urbanisation to ecosystem services, an attempt has been made to examine the influences of urbanisation on ecosystem services in National Capital Region. This chapter divided into two sections: 1) Analysis of Urbanisation in India and NCR, and 2) Analysis of impacts on ecosystem services in NCR.

SECTION-1

3.2 Urban Growth

Urban growth is well known to consist of three major components i.e. natural population growth, reclassification and migration (Guin & Das, 2014). Reclassification occurs mainly by two factors. On one hand, rural areas bordering a town or a city are generally contained into the urban administration. While on the other hand, rural settlements sometimes got reclassified as urban along with provision of urban status (Pradhan, 2013), because they also experience a structural transformation, if they acquire and got densified along with increase in non-agriculture employment and development in urban services and infrastructure.

Urban growth is hence, continually increasing, especially in developing countries. There are now at least 150 'million cities' and of these fifty or more are in Asia, excluding Asiatic U.S.S.R and another twenty or more are in Africa and Latin America (Gubry, 2012). In China, India and Japan population growth, though unevenly distributed, is more similar to the western pattern, embracing not only the largest cities but also the largest moderate towns. However, in many developing countries the strains imposed by city growth are exacerbated by the almost exclusive development of primate cities (Scheider et al., 2015).

Urban growth poses several problems either caused by population expansion or by physical expansion of the cities. Urban Sprawl, also visualized as areal expansion, especially the rapidly growing cities is considered to be the most concerning among the above mentioned issues possessed by town growth. In this way, towns are spreading at the disbursal of surrounding agricultural land which is common in the global scale (Zang et al., 2011). Historically, among the suburbs is noticed to have the first growth along the major roads in a linear pattern which leads to town and finally shape the ribbon settlement. Such cities thus, are the first to get developed due to their accessibility, but later the increasing demand for residence in suburb areas too end up resulting into built up areas in-between the ribbon settlements and connectivity through new roads construction which is called as infill. On the other hand, villages and small towns within commuting distance of mega cities got developed too at the same time for residential use. In this way towns keep on growing continually and in special cases, the suburbs of numerous neighbouring towns may put together by their proximity to form a continuous urban development also called as conurbation (Scheider and Woodcock, 2008).

3.3 Urban Agglomerations

Urban agglomeration on the other hand, is a continued city or town area surrounding the built-up area of a central district (usually consists of a municipality) which includes any suburbs as well which got linked to the main centre by continuous urban stretch. Urban agglomeration is a highly developed spatial form of integrated cities. It occurs when the relationships among cities shift from mainly competition to both competition and cooperation (Fang et al., 2017). The conception of urban agglomeration starts early in 1898 by Ebenezer Howard, the British urban scholar, postulated the concept of 'town cluster 'in his book Garden of Cities of Tomorrow (Ebenezer, 1902). Later on this concept widely studied by number of scholars and researchers. Patrick Geddes was among the first scholar to studied a comprehensive regionalisation approach to exploring the internal dynamics of cities and the process of urbanisation. He argued that urban sprawl was a result of over-separation between cities and their suburban areas and over concentration was a result of the concentrated locations having resource advantages and transportation facilities. He had published his book Cities in Evolution on cities in the United Kingdom (Geddes, 1915).

After Geddes, in 1918 urban scholar E. Saarine proposed the theory of organic decentralisation which states cities as 'organic states' and the development of cities should follow the order from chaotic concentration to ordered decentralisation. In 1920, scholars in the former Soviet Union also suggested various concepts which describe the clustering of cities that was similar to urban agglomeration. These concepts included the urban economic zone, the economic city, and the planned area (Lappo et al., 2011). In 1931, Fawcett (1932) argued that a conurbation, as proposed by Geddes (1915), is a place of continuous urban areas that are not separated by rural lands. The British Census Bureau coined the expression "Aggregates of Local Authority Area," which defined urban agglomeration/conurbation. This concept was very similar to the "Metropolitan Regions," as in the US census, "urban area," as in New Zealand, and "population agglomérée," as in France. All of these terms referred to a concentration of urbanized areas that had a higher concentration of population, urban functions and urban landscape (Fang et al., 2017). In 1933, the German geographer W. Christaller proposed the Central Place Theory, which for the first time systematically defined the spatial organization and structure of a conurbation/urban agglomeration (Lin & Chen, 2003). This theory not only established the foundation for urban studies but also evolved to be the fundamental theory for regional development and analysis. In 1939, M. Jefferson and G.K. Zipf studied the scale and spatial distribution of urban agglomerations. Zipf was also the first to introduce the gravity model to spatially analyze interactions among different urban agglomerations (Lin & Chen, 2003).

With context to India, there are 27.8 percent of total urban population reside in 5100 towns or even more and 380 urban agglomerations. Migration to cities is a crucial factor for fast increase in urban population and 31.2 percent of urban areas have grown between 1991 and 2011. 27 million plus cities in India, like Mumbai, Delhi and Kolkata have population over 10 million. (Census of India 2011). Currently, India contains major three among the ten fastest growing cities in the world i.e. Faridabad, Ghaziabad and Surat and three among the ten largest cities of the world i.e. Delhi, Kolkata and Mumbai (United Nations, 2011).

3.4 Process of Urbanisation

Urbanisation is often considered as an exponent of transformation of a conventional rural based economy to modem industrial one as well. It is thus, a progressive assiduity of population in urban centers of a region (Datta, 2006). Historically, urbanisation is closely associated to the process of industrialization. Urbanisation depends largely on industrialization and infrastructure development in cities, towns and their neighbourhoods (Roy, 1986). In this context, Tripathi (2005) remarks urbanisation as one of the most significant attributes to the socio-economic development of a particular area. It is usually believed that the highly urbanized areas rank high in terms of socio-economic development also. Johnson (2001) has rightly remarked that urbanisation is an inevitable consequence of country's socio-economic and technological development. It is, therefore, argued that urbanisation provides new social and economic establishment and opens up new horizons of development in a society.

In India, the process of urbanisation has a long history which begins with the evolution of Indus valley civilization, near about around 2500 BC (Dunbar, 1951). The core of the urban landscape was located in the Sindu-Ganga plain which spread to other parts of country with the passage of time. India's urbanisation has passed through periods of different dynasty, kingdom and revolutions. The pattern of today's urbanisation is mosaic of various kingdom, dynasty and rule viz. Hindu, Mughal and British (King, 1976). Despite its long urban history of over nearly five millennia, India remains one of the least urbanized countries in the world. The share of urban population is only marginally higher than a quarter of the total population. In historical past no evidence indicating urban explosion, as it happened in many other parts of the world is available. Nevertheless, India's absolute urban population is gigantic and thus the country is the second largest urban populated country of world in terms of absolute size.

3.5 Level of urbanisation across states of India

During the last 100 years, size of urban population in the country has increased more than 10 times. In 2001, the urban population has arisen from near about 30 million in 1901 to 300 million and by 2011 in reached 377 million in India (Census of India, 2011). The count of urban centres has grown too by 2001 from less than 2000 to near about 4,500 though list and number are still inconsistent over time (Kundu, 2006). An increasing trend towards "metropolitanization" (cities with 4 million populations or more) among the Indian cities has been observed though in the recent past. During 1991- to 2001, the count of metropolitan cities got raised from 4 to 8 and the count of metros (cities with population 1 million or more) has risen from 23 to 53 during 1991-2011 (Census 1991 and 2011).

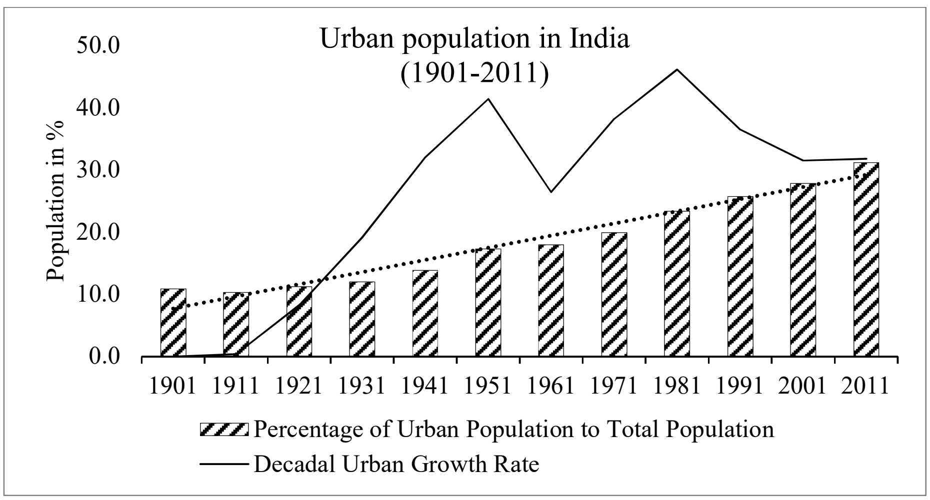


Figure 3.1 Urbanisation in India (1901-2011)

Table 3.1 Trend of Urbanisation in India (1901-2011)

Trend of Urbanisation in India (As per 1901 to 2011 Census)					
Census Year	**Total Population**	**Urban Population**	**Percentage of Urban Population to Total Population**	**Decadal Urban Growth Rate**	**Annual Exponential Growth Rate**
1901	238396327	25854967	10.85	NA	NA
1911	252093390	25948431	10.29	0.36	0.04
1921	251321213	28091299	11.18	8.26	0.80
1931	278977238	33462539	11.99	19.12	1.77
1941	318660580	44162191	13.86	31.98	2.81
1951	361088090	62443709	17.29	41.40	3.52
1961	439234771	78936603	17.97	26.41	2.37
1971	548159652	109113977	19.91	38.23	3.29
1981	683329097	159462547	23.34	46.14	3.87
1991	846302688	217611012	25.71	36.47	3.16
2001	1028610328	286119689	27.82	31.48	-
2011	1210569573	377106125	31.15	31.80	-

(Source: Census of India, 2011)

A notable point is that the growth of urban population around the metropolitan cities in last few decades has been extraordinary. In additionally, the differential share of urban population to total population throughout the states or within states is also uneven. The major proportion is presently focused in six most developed states, namely Gujarat, Maharashtra, Tamil Nadu, Punjab, Karnataka and West Bengal, which accounts near about half of the country's urban population. This can be largely assigned to colonial inheritance. In 2011, the above mentioned states report percentages of population residing in urban areas greater than the national average of 31.15.

Among the various States and Union territories of the nation, the Union territory of Chandigarh and the National Capital Territory of Delhi are considered to be mostly urbanized with 97.25 % and 97.5 % of urban population respectively, accompanied by Daman and Diu with 75.2 % and Puducherry with 68.3 %.

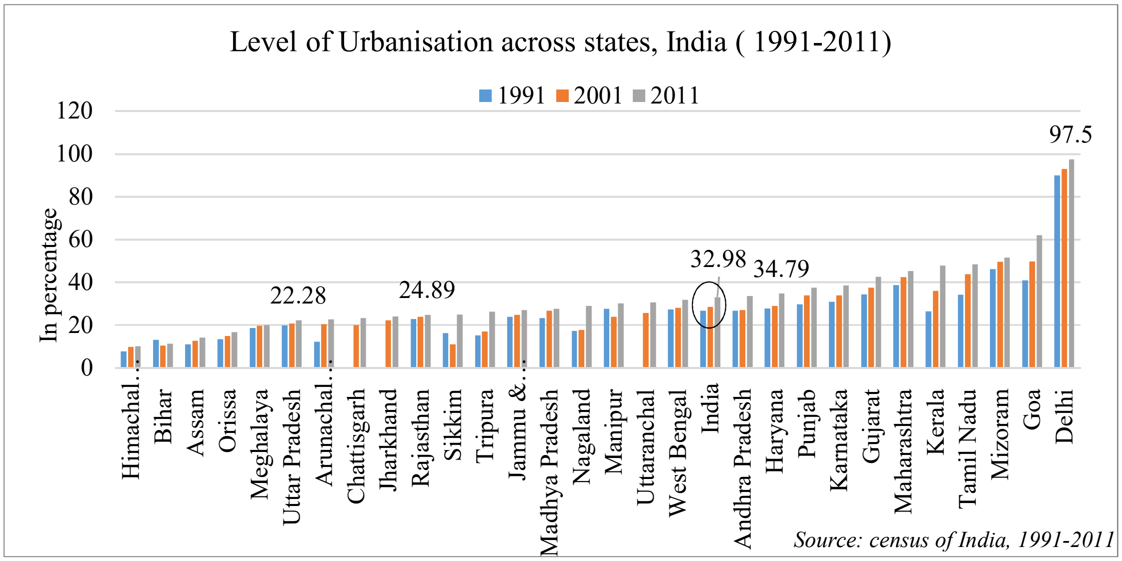


Figure 3.2 Level of Urbanisation across states of India (1991-2011)

Among other States, Goa is found as the most urbanised with 62.2 % urban population, caused by a significant rise from 49.8 % in 2001. Another substantial instance of rapid rate of urbanisation is that of state Kerala, whose urban population got increased from 25.9 % to 47.7 % over the last decade. Mizoram, on the other hand is most urbanised among the north-east states with 51.5 % urban population. However, Mizoram contribute just 0.1 % in respect absolute share to total national urban population. Likewise, in 2011, Sikkim also got developed to 25 % urbanized which had an urbanisation rate just 11.0 % a decade ago. Among other major states, Tamil Nadu remains the most urbanized state having 48.4 % of urban population followed by Kerala with 47.7 % and upstaging Maharashtra with 45.2 %. The share of urban population remained the lowest in Himachal Pradesh as well with 10.0 % followed by Bihar (11.3 %), Assam (14.1 %) and Orissa (16.7 %). In terms of absolute count of persons residing in urban areas, Maharashtra leads as usual having 50.8 million persons which constitutes 13.5 % of the total national urban population. Uttar Pradesh on the other hand accounts for near about 44.4 million, accompanied by Tamil Nadu with 34.9 million.

Numerous studies have demonstrated that the states with per capita income in the higher side are generally intended to have higher levels of urbanisation as well and vice versa (Kundu and Singh, 2005). Some of the metropolitan regions of the country which have reported rapid growth of population are - Kolkata Metropolitan Region, which is one of the largest of the world; Mumbai Metropolitan; Chennai Metropolis, which is also expected to get converted into one of the Mega Cities in the global level with more than 10 million populations in the next 10 years; and finally National Capital Region with 460 lakhs population in 2011.

3.6 Urban growth, process and pattern in National Capital Region

3.6.1 Background of National Capital Region

Delhi, the national capital of India, has recorded a phenomenal growth in population in the twentieth century, especially after independence (Figure 3.3). the vast economic opportunities available in Delhi have attracted large number of migrants not only from its immediate neighbourhood but also from the far-off places in the country. This large-scale influx of people has put heavy strain on infrastructural facilities of the city which include among other things, housing, employment, transport, electricity, water, sewerage, education, medical facility, etc. the concept of National Capital Region was conceived to reduce pressure of increasing population on these infrastructural facilities. Any strategy of containing the growth of Delhi within limits will have to be taken within the regional frame in which Delhi exists. The region in the immediate hinterland of Delhi, within which the development had to be planned in order to release pressure from Delhi, is known as 'National Capital Region'.

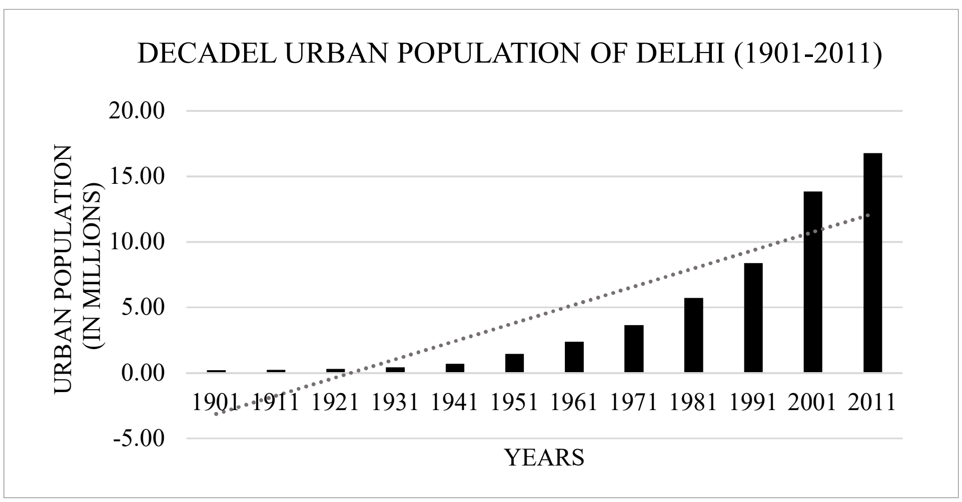


Figure 3.3 Decadal Urban population of Delhi (1901-2011)

The Master Plan of Delhi was prepared in 1959 and was finally approved by the Government of India in 1962. The Master Plan contained amongst others a recommendation of setting a statutory NCR Planning Board. Initially, this board was constituted as an advisory body which was reconstructed in 1973. Its task was to coordinate the urban and rural development in the National Capital Region under a comprehensive regional plan and to secure the collaboration of the concerned state governments in implementing the plan. However, it was only in 1985 that a statutory organisation, named as National Capital Region Planning Board could be instituted through the enactment of NCRPB Act with a view plan, implement and supervise regional development planning in the NCR.

3.6.2 The Physical Extent of NCR

The National Capital Region extends over the Union Territory of Delhi and adjoining parts of Haryana, Uttar Pradesh and Rajasthan. The administrative units constituting the NCR are as under:

i) Union Territory of Delhi
ii) Haryana sub-region consisting of 13 districts of Faridabad, Gurgoan, Mewat, Sonepat, Rohtak, Jhajjar, Rewari, Panipat, Palwal, Mahendragarh*, Bhiwani*, Karnal** and Jind[1]**.
iii) The Uttar Pradesh sub-region comprising five districts of Ghaziabad, Meerut, Bulandshahr, Gautam Budh Nagar and Bhagpat.
iv) The Rajasthan sub-region comprising two districts i.e. Bhratpur* and Alwar. Alwar is the largest district in NCR.

The total area of the NCR as is over forty-six thousand sq km which is more than the total area of Haryana. The NCR has a population of about 47.97 million according to 2011 census which is more than population of Odisha.

NCR accounts for about 1.64% of the country's land area. It is characterized by the presence of ecologically sensitive areas (Aravalli's, forests, wildlife and bird sanctuaries, river Ganga, Yamuna and Hindon etc.), fertile cultivated land, and is a dynamic rural-urban region.

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[1] Note: Districts with * symbol were included in NCR in July 2013 i.e. Mahendragarh, Bhiwani and Bharatpur; Districts with ** symbol were included in NCR in January 2014 i.e. Karnal and Jind.

3.6.3 Urbanisation in Nation Capital Region

The National Capital Region (henceforth NCR) has recorded an extra ordinary growth rate in its urban population especially during the last fifty years. Between 2001 and 2011, the population of NCR has increased by almost nine million, out of which the urban population contributed eight million. Maximum portion of the urban population of NCR is centralized in the city of Delhi, population growth has been spreading out in the neighbouring areas of Faridabad, Gurugram, Ghaziabad and NOIDA (also called as 'New Okhla Industrial Development Authority'). These cities together with Delhi are now referred as Central NCR (CNCR). According to 2011 census, CNCR accounted for about 21.9 million populations, which is almost 6 percent of India's total urban population. And according to Regional Plan 2021, urban population of NCR is expected to swell by another 17 million to reach 45 million and will turn into the largest urban hub of India.

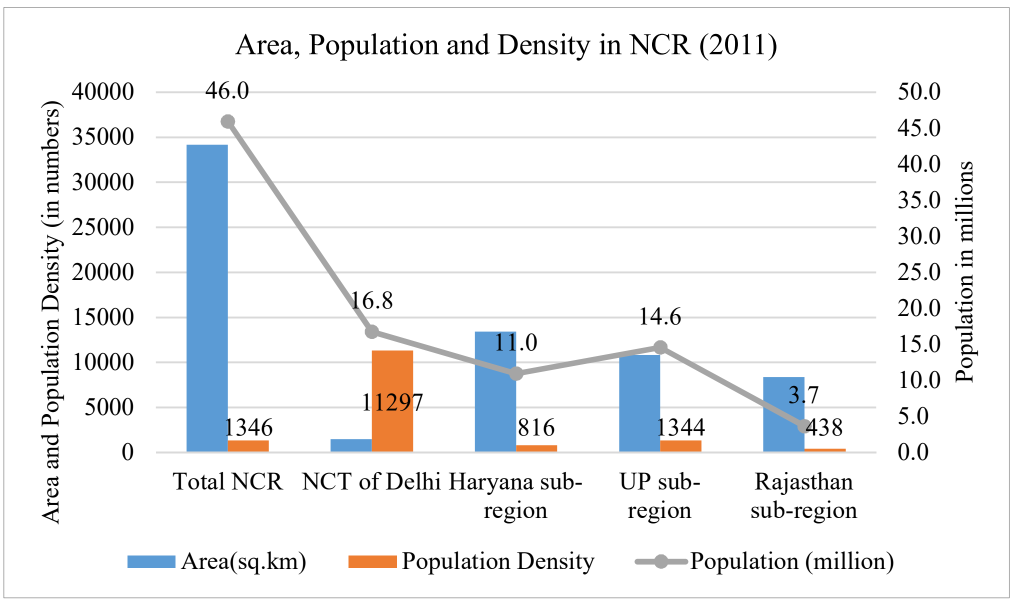


Figure 3.4 Area, Population and Density in National Capital Region (2011)

3.6.3.1 Level of Urbanisation in NCR

Level of urbanisation is a ratio of urban population and total population of that region. It depicts the rate of urbanisation with the period of time. The determinant factors which are responsible for the level of urbanisation are population size, population density, economic configuration of towns, transport capability, surrounding condition, setting of towns, built-up density, and trade and commerce relation with the peripheral or nearby towns. The level of urbanisation also depicts the level of economic development of that region.

The urbanisation level in NCR has risen from over 56 percent in 2001 to about 62.5 percent in 2011. This is nearly double the national urbanisation level of 31.2 percent. The ramification of the region is caused by its spatial extension and vastness over the three states and NCT Delhi is thus, a challenge for incorporated development. The NCT Delhi has the highest urbanisation level in NCR at 97.5 percent.

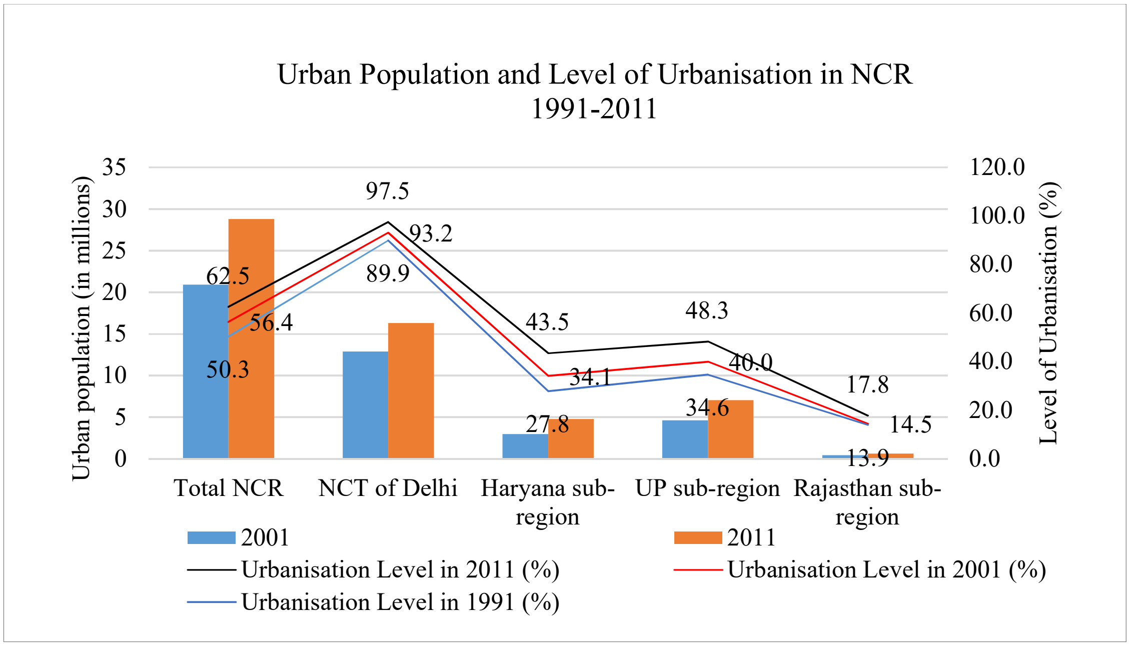


Figure 3.5 Urban population and level of urbanisation in NCR (1991-2011)

The sub-regional study clarifies the sharp variation in the level of urbanisation in NCR region. In 1991, NCT Delhi recorded 89.9% urbanisation, the highest urbanisation in NCR followed by UP sub-region (34.6 %), Haryana sub-region (27.8%) and Rajasthan sub-region (13.9%).

In 2001, level of urbanisation in NCR was 56.4% which is increased to 62.5 % by 2011. Haryana sub region showed 34.1% level of urbanisation which is increased to 43.5% in 2011. Similarly, in UP sub region level of urbanisation was increased from 40% to 48.3% in 2001 and 2011. Rajasthan sub region of NCR recorded 14.5% urbanisation which has increased to 17.8% in 2011. NCT Delhi showed highest level of urbanisation through all three years. In 2001, urbanisation in NCT Delhi was 93.2% which has increased to 97.5% in 2011.

3.6.3.2 Spatial Patterns of Urbanisation in NCR: District level analysis 1991-2011

On the basis of level of urbanisation, districts of NCR can be divided into five categories, with its respective portion of urban to the total population as given below:

i) Very high level of Urbanisation (More than 80%)
ii) High level of Urbanisation (60-80%)
iii) Moderate level of Urbanisation (40-60%)
iv) Low level of Urbanisation (20-40%)
v) Very low level of Urbanisation (Less than 20%)

Spatial patterns of urbanisation for NCR has been attempted temporally since 1991 to 2011 for the previous census with the help of above mention five levels of urbanisation.

Table 3.2 Level of Urbanisation in districts of NCR, 1991-2011

S.No	Districts	Total Population			Urban Population			% of Urbanisation		
		1991	2001	2011	1991	2001	2011	1991	2001	2011
1	NCT DELHI	9420640	13850507	16753235	8471625	12905780	16333916	89.93	93.18	97.50
2	Alwar	2296580	2992592	3671999	320287	434939	654288	13.95	14.53	17.82
3	Baghpat	-	1163991	1302156	-	229432	274135		19.71	21.05
4	Bulandshar	2849859	2913122	3498507	592795	674458	867791	20.80	23.15	24.80
5	Gautam Budh Nagar	-	1202030	1674714	-	449415	997410	-	37.39	59.56
6	Ghaziabad	2703933	3290586	4661452	1248260	1816415	3144574	46.16	55.20	67.46
7	Meerut	3447912	2997361	3447405	1276557	1451983	1762573	37.02	48.44	51.13
8	Faridabad	1477240	2194586	1798954	717513	1221344	1429093	48.57	55.65	79.44
9	Gurgaon	1146090	1660289	1514085	232704	369004	1042000	20.30	22.23	68.82
10	Jhajjar	-	880072	956907	-	195097	242974	-	22.17	25.39
11	Mewat	-	-	1089406	-	-	124017	-	-	11.38
12	Palwal	-	-	956907	-	-	242974	-	-	25.39
13	Panipat	833501	967449	1202811	226345	392080	552945	27.16	40.53	45.97
14	Rewari	578301	765351	896129	95200	136174	231411	16.46	17.79	25.82
15	Rohtak	1808606	940128	1058683	385473	329604	444819	21.31	35.06	42.02
16	Sonipat	754866	1279175	1480080	178025	321375	451687	23.58	25.12	30.52

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

i) Area with very high level of Urbanisation in NCR

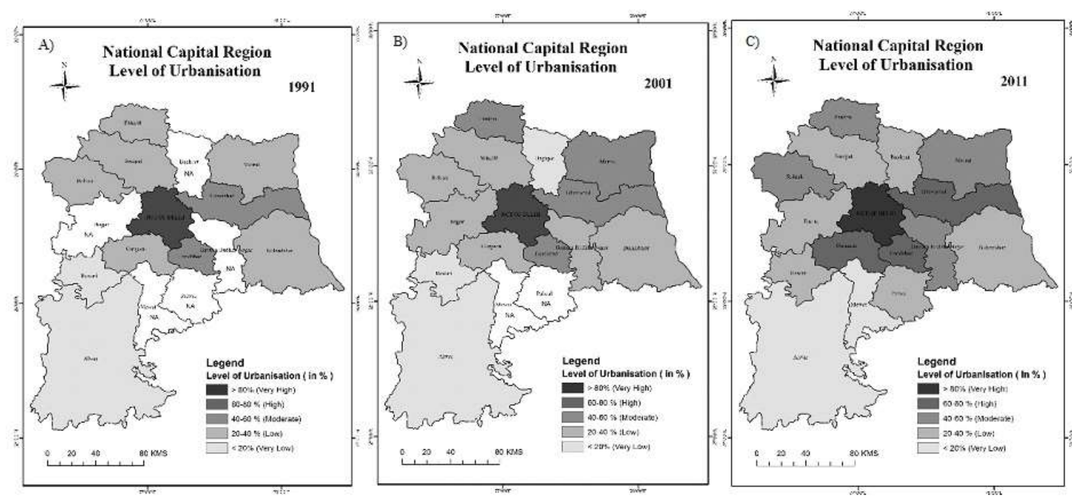
Since the last two decades, the highest level of urbanisation is found in NCT Delhi only because being a capital of India, there is availability of highest density of population, employment facility, main urban hub in northern India, thereby people from other states and districts come here for getting better employment, life and standard of living. As already discussed above that NCT Delhi recorded 97.5 % of urbanisation in 2011 which is highest with compared to other sub-regions and districts of NCR.

ii) Areas with high level of Urbanisation in NCR

As we noticed from the maps of 1991, 2001 and 2011 of urbanisation in NCR that in this category (60-80%), there are three districts of NCR namely Faridabad (79.44%), Gurugram (68.82%) and Ghaziabad (67.46%) in 2011 whereas in 1991 and 2001, there is not any district that fall in this category even not Faridabad and Ghaziabad which means high level of urbanisation found in 2011 only.

iii) Areas with moderate level of Urbanisation

This category falls into the 40% to 60% level of urbanisation. In 1991, there were two districts Faridabad and Ghaziabad with the 48.57% and 46.16% level of urbanisation. Further, in 2001, Meerut (48.44%) and Panipat (40.53%) were included in this category with Faridabad (55.65%) and Ghaziabad (55.20%). And in 2011, Gautam Budh Nagar (59.56%) and Rohtak (42.02%) is falling in this category with Meerut (51.13%) and Panipat (45.97%). It has been noticed from 1991 to 2011 that moderate level of urbanisation is increasing towards suburbs.



Map 3.1 Level of Urbanisation in National Capital Region: A) 1991; B) 2001; C) 2011

iv) Areas with low level of Urbanisation

Low level of urbanisation falls under category of 20% to 40 % of urbanisation. Most of the districts of the NCR comes under this category which is mostly not touches the boundary of NCT Delhi except Gurugram and Gautam Budh Nagar. In 1991, Meerut (37.02%), Panipat (27.16%), Sonipat (23.58%), Rohtak (21.31%), Bulandshar (20.80%) and Gurugram (20.30%) falls under this category. However, in 2001, low level of urbanisation is found in Sonipat (25.12%), Rohtak (35.06%), Gurugram (22.23%) and Jhajjar (22.17%) from Haryana sub region and, Gautam Budh Nagar (37.39%), Bulandshar (23.15%) districts from UP sub region. In 1997 three new district were added in national capital boundaries, out of which two Gautam Budh Nagar and Baghpat were from UP sub-region and one Jhajjar from Haryana sub-region. In 2011, Sonipat (30.52%), Rewari (25.82%), Jhajjar (25.39%), Palwal (25.39%), Bulandshar (24.80%) and Baghpat (21.05%) have low level of urbanisation.

v) Areas with very low level of Urbanisation

Areas consisting of very low level of urbanisation denote less than 20% level of urbanisation in NCR. Under this category only Alwar district is a district which consistently found in this category from 13.95% in 1991, 14.53% in 2001 and 17.82% in 2011 which shows the very low level of urbanisation in NCR particularly in Rajasthan sub-region whereas from other sub regions Rewari has found very low level of urbanisation in 1991 and 2001 only further it has moved to very low to low level category. Bhagpat (19.71%) from UP sub-region in 2001 and Mewat (11.38%) from Haryana sub-region found very low level of urbanisation.

Table 3.3 Comparison of ranks of Urbanisation across districts of NCR (1991-2011)

Cat. No.	Level of Urbanisation	Rank 1991	Rank 2001	Rank 2011
1	Very High	**1**.NCT Delhi	**1**.NCT Delhi	**1**.NCT Delhi
2	High	NIL	NIL	**2**.Faridabad **3**.Gurugram **4**.Ghaziabad
3	Moderate	**2**.Faridabad **3**.Ghaziabad	**2**.Faridabad **3**.Ghaziabad **4**.Meerut **5**.Panipat	**5**.GTB Nagar **6**.Meerut **7**.Panipat **8**.Rohtak
4	Low	**4**.Meerut **5**.Panipat **6**.Sonipat **7**.Rohtak **8**.Bulandshar **9**.Gurugram	**6**.GTB Nagar **7**.Rohtak **8**.Sonipat **9**.Bulandshar **10**.Gurugram 11.Jhajjar	**9**.Sonipat **10**.Rewari **11**.Jhajjar **12**.Palwal **13**.Bulandshar **14**.Baghpat
5	Very Low	**10**.Rewari **11**.Alwar	**12**.Baghpat **13**.Rewari **14**.Alwar	**15**.Alwar **16**.Mewat

(Source: author's computation)

3.6.3.3 Urban population growth rate in NCR

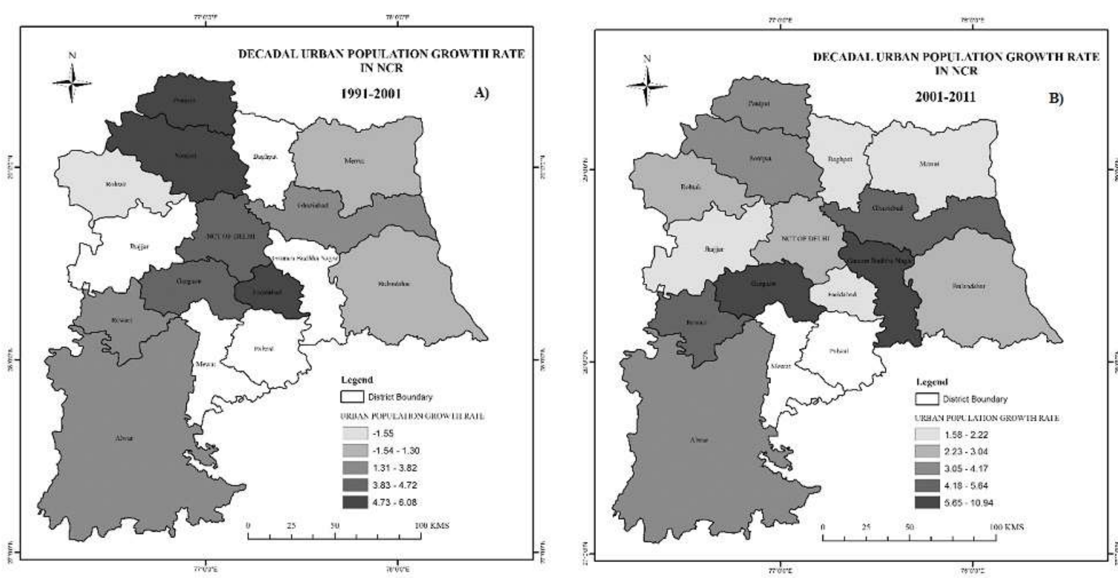
Population growth refers to the change in the counts of inhabitants of any area during a particular time period and also called as population change. Population growth in any region is an important indicator which highlights the historical and cultural background, economic development and social upliftment of any place. It implies to the changes that have taken within the population in a specific area between two periods in particular.

The table below illustrates the district wise rate of urban population growth in NCR region from which it can be easily understood that the rate of urban population growth is decreasing in NCT Delhi. In whole NCR, the Gurgaon shows highest rate of urban population growth followed by Gautam Budh Nagar and Ghaziabad. The literature analysis shows that the massive positive fluctuation in the urban population can be contributed to the in-migration in these districts because of economic liberation and State Government's policies on industrial development, which enable cities to attract large number of multinational companies that resulted in in-migration for better employment opportunities. From 1991 to 2011 only Rohtak district has shown negative growth rate in urban population which possibly attributed to the negative natural growth in a district. In Uttar Pradesh sub-region GTB Nagar shows highest growth in urban population in 2011 followed by Ghaziabd and Bulandshahr.

Table 3.4 Decadal urban population growth rate across districts of NCR (1991-2011)

Districts	Decadal Urban Population Growth Rate	
	1991-2001	**2001-2011**
NCT OF DELHI	**4.30**	**2.38**
Alwar	3.11	4.17
Baghpat	-	1.80
Bulandshar	1.30	2.55
Gautam Budh Nagar	-	8.30
Ghaziabad	3.82	5.64
Meerut	1.30	1.96
Faridabad	5.46	1.58
Gurgaon	4.72	10.94
Jhajjar	-	2.22
Mewat	-	-
Palwal	-	-
Panipat	5.65	3.50
Rewari	3.64	5.45
Rohtak	-1.55	3.04
Sonipat	6.08	3.46

(Data source: Census of India, 1991-2011)



Map 3.2 Decadal urban population growth rate across districts of NCR: A) 1991-2001; B) 2001-2011

3.6.3.4 Census Towns in NCR

The number of census towns in NCR has increased from 83 in 2001 to 183 in 2011 (Census of India, 2011). The classification of towns shows that there are 22 Class-I cities (including Delhi Metropolis), 13 Class-II towns, 41 Class-III, 43 Class-IV, 44 Class-V and % Class-VI towns in 2011. The Class-I towns accommodated about 89% of total urban population of this region. The rest of the urban population was distributed among 146 towns of Class-II to Class-VI. The number of metropolitan cities (above 10 lakhs population) within the region increased from one (Delhi) in 1991 to three (Delhi, Meerut, and Faridabad) in 2001 to four (Delhi, Faridabad, Ghaziabad and Meerut) in 2011. Urban settlements in Haryana sub-region has increased from 40 in 2001 to 65 in 2001; in Rajasthan sub-region has increased from 9 to 16 in 2001 and 2011 respectively; and in UP sub region, it has increased from 66 to 86 towns in 2001 and 2011. Excluding NCT of Delhi in NCR, there are eight Class-I urban centres in Haryana sub region, two Class-I urban centres in Rajasthan sub-region and 11 Class-I urban centres in Uttar Pradesh sub-region.

Table 3.5 Distribution of urban settlements across NCR sub-regions, 2001 & 2011

Sub Region	Year	Statutory Town				Census Town	Total Towns
		Municipal Corporation	Smaller Town	Transitional Area	Total		
Haryana	2001	1	7	20	28	12	40
	2011	2	6	22	30	35	65
Delhi	2001	1			3	59	62
	2011	1			3	110	113
Rajasthan	2001	0	1	5	6	3	9
	2011	0	1	6	7	9	16
UP	2001	2	19	35	57	9	66
	2011	2	20	34	57	29	86
NCR	2001	4	27	60	94	83	177
	2011	**5**	**27**	**62**	**97**	**183**	**280**

(Source: Census of India, 2001 & 2011)

3.6.3.5 Concentration of Urban Population in NCR

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 (Mahmood, 1998).

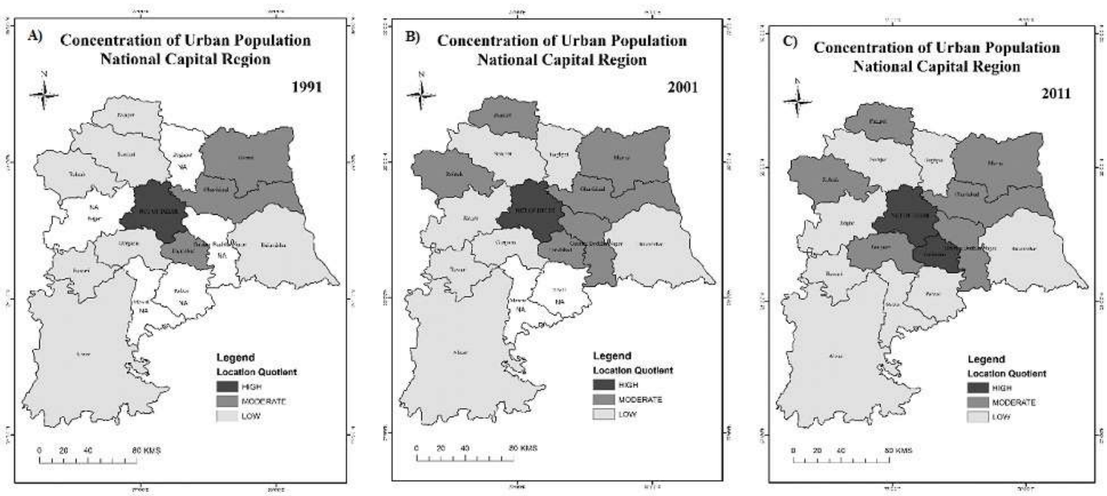
The analysis for concentration of urban population in NCR Delhi is done for 1991, 2001 and 2011 for examining the pattern of urbanisation and also see the pressure on concerned region. For examining the concentration of urban population, NCR region is divided into three categories:

1. High concentration of Urban Population (>1.2)
2. Moderate concentration of Urban Population (0.6-1.2)
3. Low concentration of Urban Population (<0.6)

Table 3.6 Concentration of urban population across districts of NCR (1991-2011)

Category	LQ 1991	LQ 2001	LQ 2011
High	1. NCT Delhi	1. NCT Delhi	1. NCT Delhi 2. Faridabad
Moderate	2. Faridabad 3. Ghaziabad 4. Meerut	2. Faridabad 3. Ghaziabad 4. Meerut 5. Panipat 6. GTB Nagar 7.Rohtak	3. Ghaziabad 4. Meerut 5.Panipat 6. GTB Nagar 7. Rohtak 8. Sonipat
Low	5.Panipat 6.Sonipat 7.Rohtak 8.Bulandshar 9.Gurgaon 10. Rewari 11. Alwar	8. Sonipat 9.Bulandshar 10.Gurgaon 11.Jhajjar 12.Baghpat 13.Rewari 14.Alwar	9. Bulandshar 10.Gurgoan 11. Jhajjar 12. Baghpat 13. Rewari 14. Alwar 15. Palwal 16. Mewat

(Source: Authors computation)



Map 3.3 Concentration of urban population across districts of NCR: A) 1991; B) 2001; C) 2011

The maps explain that in 1991 the highest concentration of urban population was in NCT Delhi measuring 1.79. It was followed by Faridabad, Ghaziabad and Meerut measuring respectively 0.97, 0.92 and 0.74 in 1991. In 1991 the least population concentration was measured in Alwar which was 0.28. It was followed by Rewari and Sonipat measuring respectively 0.33 and 0.4. The least concentration in these districts is due to the higher proportion of rural population to the total population. In 2001, highest concentration is in NCT Delhi (1.65) again because of capital region. Moderate concentration of urban population besides Faridabad, Ghaziabad, Meerut are found in Panipat (0.72), GTB Nagar (0.66) and Rohtak (0.62) which was earlier considered as low concentrated urban regions. It shows that land pressure on these districts are increasing.

Table 3.7 Concentration of urban population across districts of in NCR (1991, 2001 & 2011)

Districts	Location Quotient		
	1991	2001	2011
NCT OF DELHI	1.79	1.65	1.56
Alwar	0.28	0.26	0.28
Baghpat	-	0.35	0.34
Bulandshar	0.41	0.41	0.40
Gautam Budh Nagar	-	0.66	0.95
Ghaziabad	0.92	0.98	1.08
Meerut	0.74	0.86	0.82
Faridabad	0.97	0.99	1.27
Gurgaon	0.40	0.39	1.10
Jhajjar	-	0.39	0.41
Mewat	-	-	0.18
Palwal	-	-	0.41
Panipat	0.54	0.72	0.73
Rewari	0.33	0.32	0.41
Rohtak	0.42	0.62	0.67
Sonipat	0.47	0.45	0.49

(Source: Authors computation)

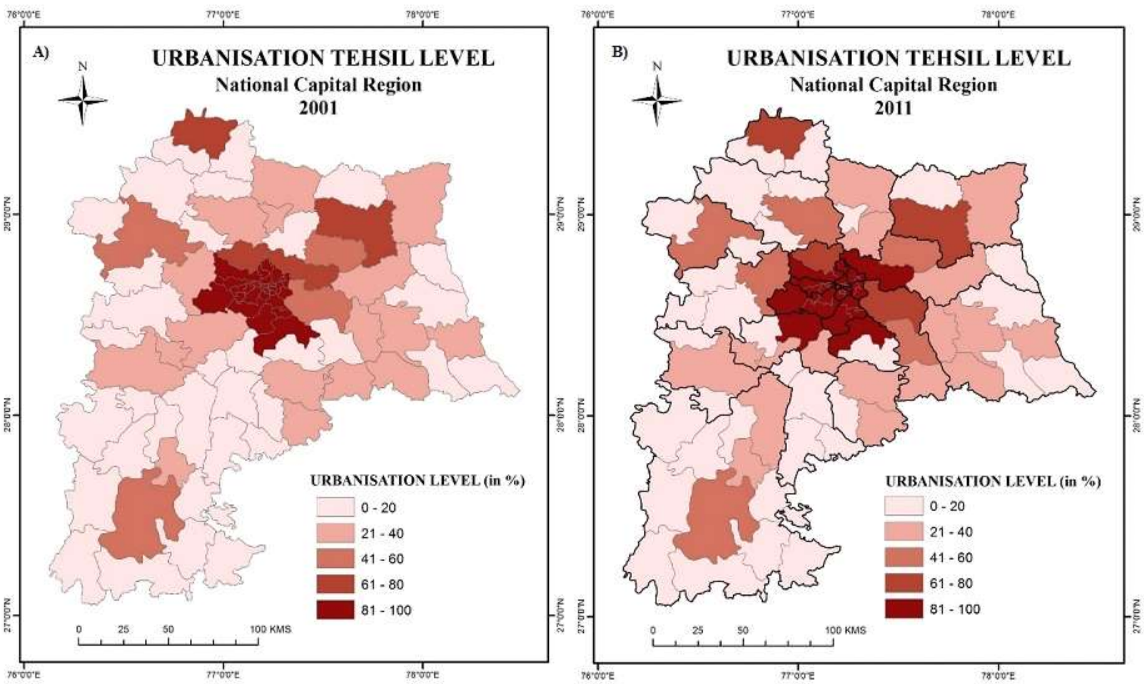
Due to development of the satellite towns in NCR in 2011, the concentration of urban population became periphery oriented than NCT Delhi. In Delhi the concentration of urban population is decreasing because the relative concentration of urban population is increasing in the satellite towns of NCT Delhi. NCT Delhi shows the concentration value 1.56 in 2011 earlier in 2001 it was 1.65. The district wise analysis of urban population concentration shows that Ghaziabad and Gautam Budhha Nagar (NOIDA) emerging as new centres of urban population concentration in national capital region in 2011. Overall, it can say that concentration of urban population is increasing in the eastern part of NCR.

3.6.3.6 Urbanisation in NCR: Tehsil level analysis (2001-2011)

i) U.P sub region in NCR

The UP Sub-region consists of 20 tehsil of the State viz. Sardhana, Mawana, Meerut, Baraut, Baghpat, Khekeda, Modinagar, Ghaziabad, Hapur, Garhmukteshwar, Dadri, GB Nagar, Jewar, Sikandrabad, Bulandshahr, Siana, Anupshahr, Debai, Shikarpur and Khurja.

The highest population share of the Tehsils in the respective districts is as follow: Meerut is 60% of Meerut District, Baraut is 56% of Baghpat District, Ghaziabad is 50% of Ghaziabad District, Dadri is 58% of GB Nagar District and Bulandshahr is 29% of Bulandshahr District (Census 2011). The level of urbanisation in the Sub-region was highest in Ghaziabad tehsil (76% in 2001 and 89% in 2011) followed by Dadri (70.54%), Meerut (69.45%) in 2011. And lowest urbanisation in Debai, Garhmukteshwar, Gautam Buddha Nagar in 2001 and Shikarpur, Siana and Sikandrabad are least urbanised in 2011.



Map 3.4 Tehsil level urbanisation in NCR: A) 2001; B) 2011

ii) Haryana sub-region in NCR

Haryana sub region consistes of 31 tehsils of the state viz Bahadurgarh, Ballabgarh, Bawal, Beri, Faridabad, Farrukhnagar, Ferozepur, Jhirka, Ganaur, Gohana,Gurgaon,Hathin ,Hodal, Israna, Jhajjar, Kharkhoda, Kosli, Maham, Manesar, Matenhail, Nuh, Palwal, Panipat, Pataudi, Punahana, Rewari, Rohtak, Samalkha, Sampla, Sohna, Sonipat and Taoru.

Tehsil level analysis reveals that Faridabad, Gurgaon are highly urbanised whereas, Panipat Patuadi, and Bahadurgarh, Rohtak, Sonipat are moderately urbanized tehsils of Haryana sub region, while Gohana, Jhajjar, Nuh, Hatin, and Panhana are the least urbanized tehsils in 2001. In 2011 highly urbanised tehsils are Gurgaon, Faridabad and

Panipat and moderately urbanised tehsils are Rohtak, Sonipat, Bahadurgarh, Pataudi, Sohna, Rewari and Palwal. The least urbanised tehsils are Kosli, Nuh, Hathin and Ballabgarh.

iii) Rajasthan sub-region in NCR

Rajasthan sub-region consists of 12 Tehsils from Alwar district only. These are Alwar, Kishangarhbas,Tijara, Rajgarh, Kathumar, Behror, Lachhmangarh, Bansur, Kotkasim, Mandawr, Rammgarh and Thanagazi. Among these Alwar Tehsil is highly urbanised in 2001 and 2011. And Bansur, Kotkasim, Mandawr, Rammgarh and Thanagazi are rural areas. The least urbanised tehsils in Rajasthan sub-region are Behror and Lachhmangarh in 2001 whereas Rammgarh and Lachhmangarh are least urbanised in 2011.

3.6.4 Understanding the spatial pattern and process of urban growth in NCR

For analysing the process and patterns of urban growth in NCR, remote sensing imageries have been used from the Landsat sensors for the years 1991, 2001 and 2011 to fulfil mapping purposes related to the spatial configuration of urban development as well as analysed spatial growth over time. Thus, the NCR-Delhi region was separated into core plus rings based on boundaries of the tehsil as suggested in the NCR policy zones from NCR Regional Plan 2021. The core was then identified on the position of the new Central Business District (also called CBD) and the old one too in Delhi, consisting of new Delhi tehsils and old Delhi tehsils. Among the Rings, no. 1 consisted of remaining districts of NCT Delhi while no. 2 and no. 3 were distinguished in the neighbouring states. The boundary of Ring 2 was discovered with the help of buffer of 50km from the core NCT-Delhi. It contains satellite towns as well as other tehsils of UP and Haryana sub-regions with the aim to encompass NCT region of Delhi, and thus, has been addressed as suburbs which comes under ‘Delhi Metropolitan Area’. Ring 3 on the other hand, comprises of the remaining talukas of the UP, Rajasthan and Haryana sub-regions with more or less agrarian character, hence, contributing to the complete NCR-Delhi region.

The spatial expansion of NCR-Delhi is conveyed as a function of growth of population plus economic transformation, as well as the alteration in mode of transportation. It has been found that, Delhi never experienced heavily industrialization in the state before rather was more dependent on trade and commerce. Prior to economic liberalization

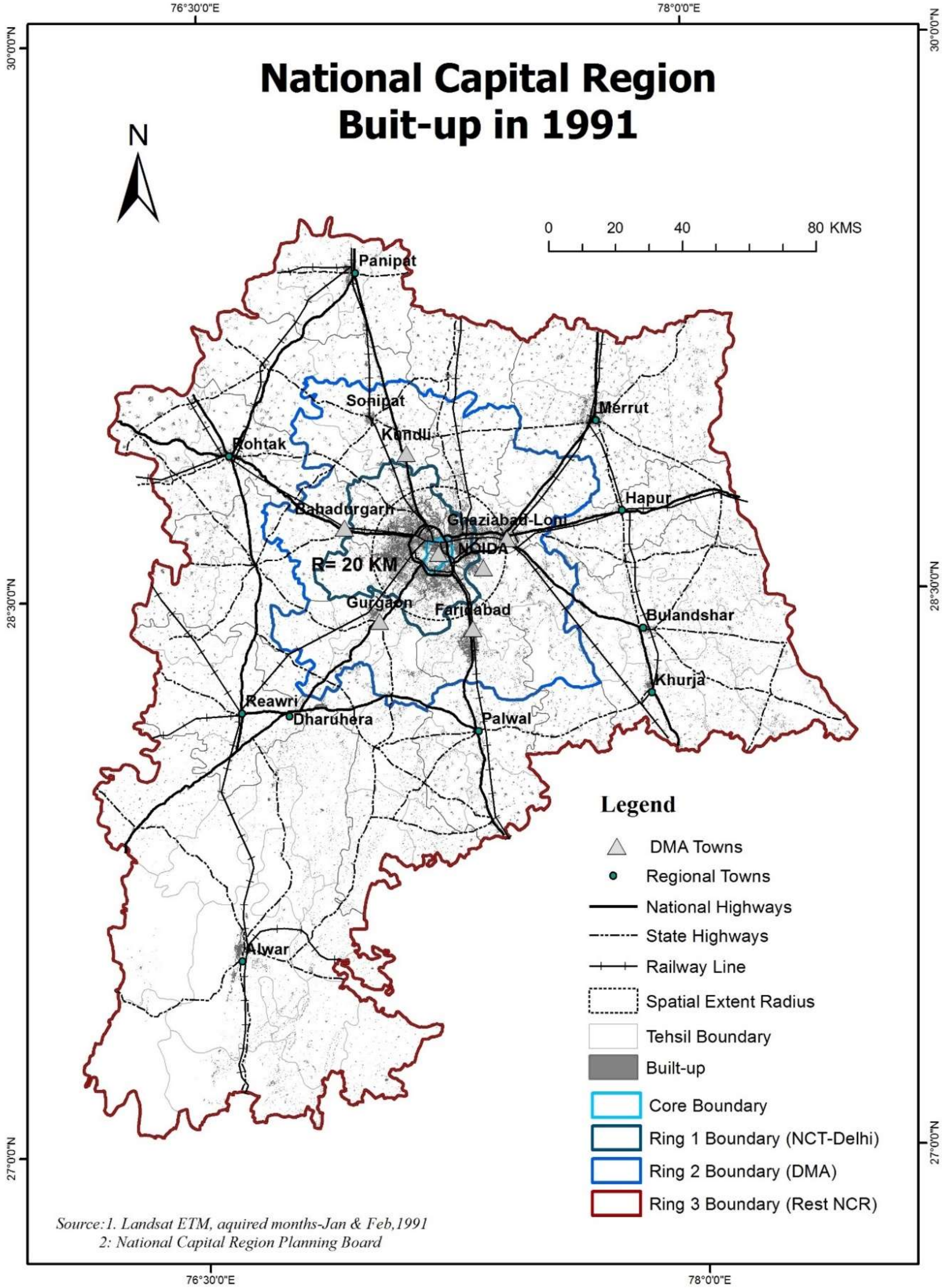
1991, public sector acted as the key to drive the state economy with comparatively slow paced growth. At that point of time the public transportation was sufficient to provide services to the population growth via buses which in turn has resulted in to the concentration of development around the core. The growth nodes of suburban regions, also called satellite towns were distinguished from the core and ring jointly by the stretch of open spaces but connected through national highways.

Since, the transportation network is an important key in the proceeding of growth, the decisions regarding transportant are made differently from one year to another with the aim to result into a invariably changing urban structure, which has shifted its emphasis along the continuum betweem the situation of highly distributed centres to the situation with major undistributed facility (Gutenberg, 1960). Similarily in NCR region transportation plays a significant role in enlarging the urban centres in the region .

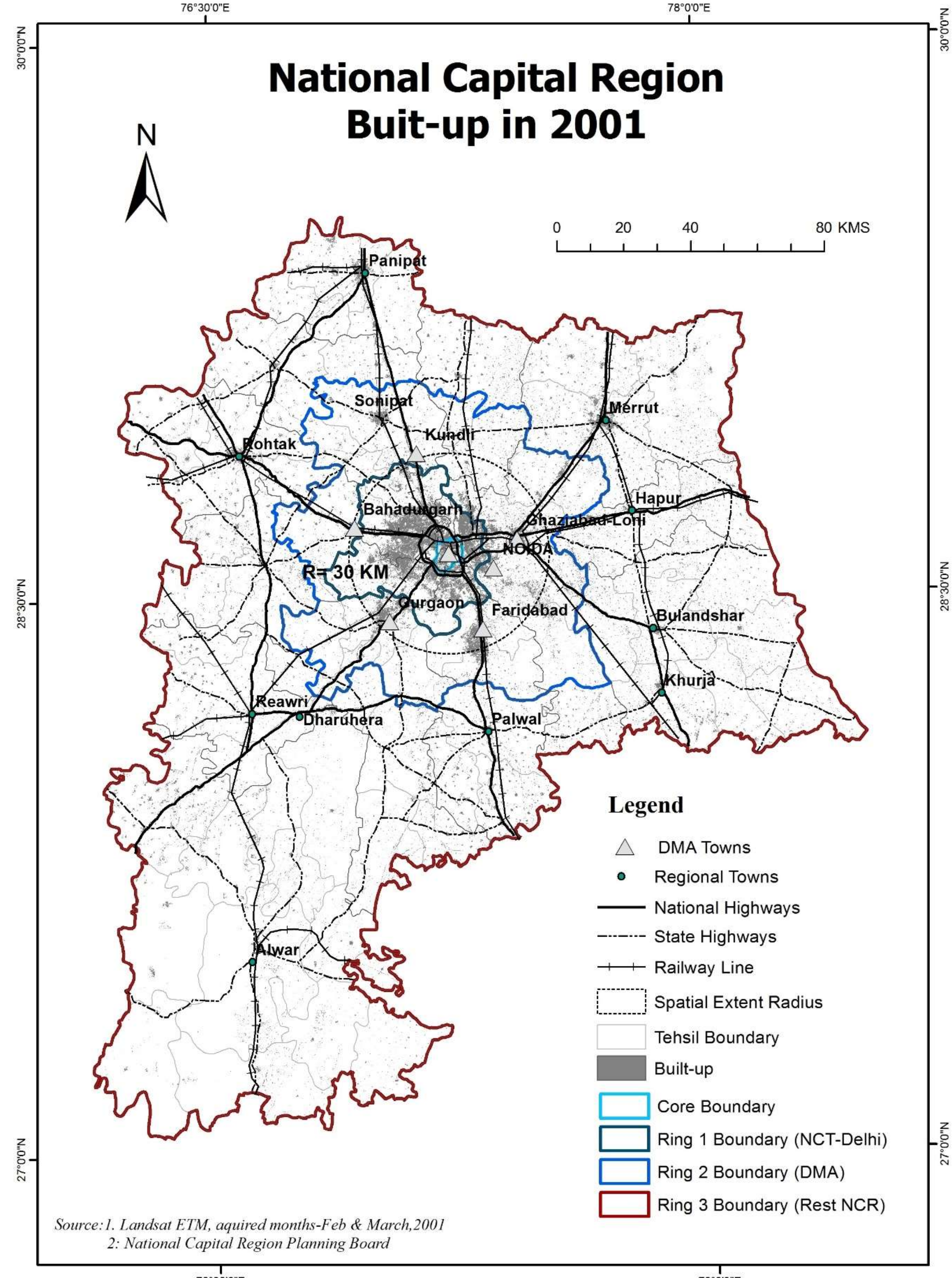
As depicted in map (3.5, 3.6 &3.7) of NCR, the spatial transformation of NCR from 1991 to 2011 can be qualified as ‘Nodes-Corridor-Megalopolis’. Until 1991, the growth was identified as nodes with the developments determined to the particular satellite towns. But later the nodes were replaced with corridors by 1991 and developments had been noticed along the transportation network like regional rail lines and the national highways which connect core Delhi with its satellites. Percentage of built up area along road is continuously increasing which shows ribbon sprawl development in the region.

From the year1991 which was characterized by the very first stage of economic liberalization, the urban growth found its momentum to the second stage by 2000 with the characteristics of increasing job opportunities to cope up with the population explosion at that time as well as intensifying the pressure of development to residential spaces and house office. Moreover, the increasing nature of population along with rise in their income has contributed to more preference and affordability towards individual ownership of car caused by insufficient bus service to cater to the contemporary demand of population plus unreliability of public transport. Thus, the increasing dependency on cars burst into the city in almost all direction and formed ribbon development of settlement along the national highways which connects Delhi with its satellite towns. This situation got further expanded towards each other combining their built-up area and resulted into a conglutination of the initially distinguished suburbs with Delhi depicting the state boundaries obsolete. Eventually, by 2000, Mass Rapid Transit

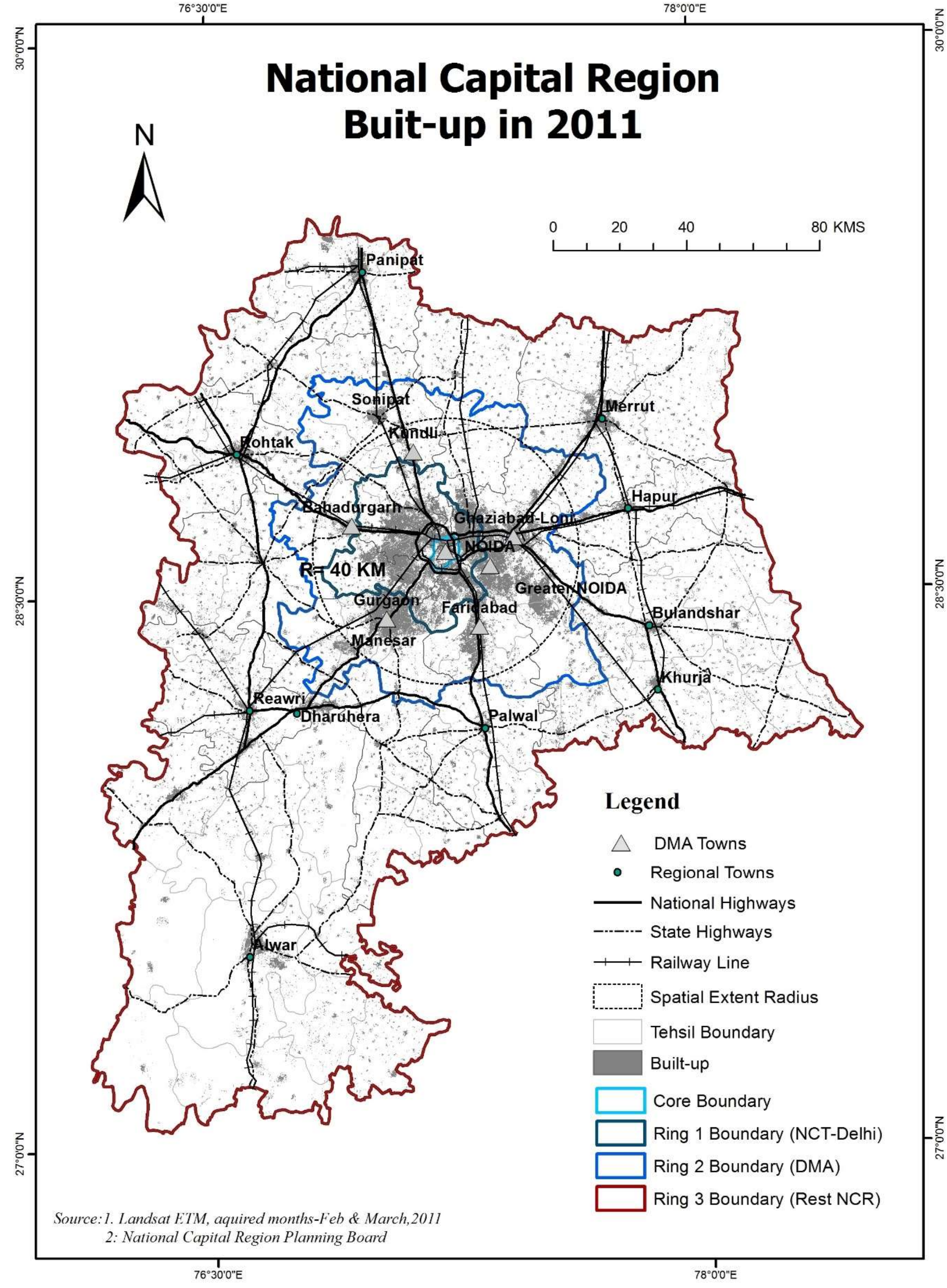
System (also called as MRTS) was introduced which has accelerated further the growth (Jain et al 2013).



Map 3.5 Ring-wise Built-Up expansion in NCR (1991)



Map 3.6 Ring-wise Built-Up expansion in NCR (2001)



Map 3.7 Ring-wise Built-Up in NCR (2011)

From 1991 to 2011, the above said urbanisation process has increased the share of built-up areato the total area of NCT Delhi. Subsequently, the growth mainly focused on the periphery of the urban core because of the availability of large section of land as a result of which the spatial extent of built-up areas around Delhi got increased from 20 to 40 km in the last two decades.

3.6.4.1 Indicators to investigate spatial expansion of National Capital Region

i) **Buit Up Area Density** It is estimated as the ratio between built up area and total area of core region or ring (Kananko et al., 2005). It basically evaluate the growth intensity.

Table 3.8 Ring-wise Built-Up area density in NCR (1991, 2001 & 2011)

BUA Density (BUA per sq.km)	1991	2001	2011
Core	0.54	0.58	0.63
Ring 1	0.27	0.34	0.47
Ring 2	0.06	0.08	0.17
Ring 3	0.03	0.03	0.06
Total	0.90	1.03	1.33

(Source: authors computation)

ii) **Percentage of Built up area growth** it is estimated as the share of BUA to total BUA of core region or ring. It measures the rate of growth in the core region or ring.

Table 3.9 Ring-wise percentage of Built-Up area growth in NCR (1991, 2001 & 2011)

Percentage of BUA Growth	1991	2001	2011
Core	53.5	57.9	62.6
Ring 1	27.5	33.8	47.3
Ring 2	6.2	8.3	17.4
Ring 3	3.0	3.4	5.7
Total	4.6	5.6	9.5

(Source: authors computation)

iii) **Population density:** it is estimated as ratio of total population to total area of core region or ring. It denotes people living in per square kilometre area indicating how much dense the area is.

Table 3.10 Ring-wise Population Density in NCR (1991, 2001 & 2011)

Population Density (Population per sq.km)	1991	2001	2011
Core		17660	15096
Ring 1	6512	8827	10966
Ring 2	852	1299	1707
Ring 3	484	598	703
Total	799	1093	1329

(Source: authors computation)

iv) Rate of population change and Built up area change from 1991-2011

It is estimated by subracting new value from old value and standerdised by the division of the result by the old value. If the land is occupied at a faster pace than the contemporary growth of population, it is then characterized as a urban sprawl and the opposite situation is called as densification (Fulton et al., 2001; Schneider and Woodcook, 2008).

Table 3.11 Ring-wise change in Built-Up area and Population change in NCR (1991-2011)

Rate of Population Change and BUA Change	Pop. Change 1991–2001	BUA Change 1991–2001	Pop. Change 2001–2011	BUA Change 2001–2011
Core		8.2	-14.5	8.1
Ring 1	35.6	23.0	24.2	39.9
Ring 2	52.5	33.8	31.4	107.8
Ring 3	23.6	13.7	17.5	67.2
Total	36.8	20.4	21.6	69.2

(Source: authors computation)

v) Built up along transport network

It is estimated as the share of total BUA to BUA in 1 kilometer buffer of transportation network and thus, represents strip or ribbon development.

Table 3.12 Built-Up along transport network in NCR (1991, 2001 & 2011)

BUA in sq.km along 1 km Transport Network	built up along transport network in sq.km			Percentage to total BUA of Transport Network		
	1991	2001	2011	1991	2001	2011
Total BUA of NCR	**1589.1**	**1913.4**	**3238.4**	**49.4**	**48.2**	**49.0**
Percentage of BUA along road	483.0	597.5	1009.3	30.4	31.2	31.2
Percentage of BUA along rail	301.8	366.7	576.5	19.0	19.2	17.8

(Source: authors computation)

3.6.4.2Analysis of Urban spatial expansion in different zones of NCR

Core is always treated as central bussiness district of NCR and had highest density of built up area. From 1991 to 2011 it has increased from 0.54 to 0.63 (Table 3.8) built up area which shows the densification in core area but the gwoth rate of built up area was declined. The three major factors being i) dispossession of slums from NCT delhi because of the happening of commonwealth Games in 2010 (Upal, 2009) ;ii) remotion of polluting and hazardous industries from Nct Delhi in a row based on supreme court order 1996 and 2000 (Chakrabarti, 2001); and iii) destruction in development of core region and ring no. 1 has facilitated the construction of MRTS way back in 1998. If we compare population density with this, it has found that population density has declined which indicating the sprawling towads its surrounding regions (Schneider and Woodcook, 2008).

The analysis of population density (Table 3.10) found a declining trend from 1991 to 2011 in the Core region but Ring 1, 2 and 3 shows increment in the population density which can be attributing to the people are migrating to the suburbs that indicating the process of suburbanisation in the region.

The examination for the pace of change in population and built-up area (Table 3.11) has discovered that for the time span from 1991 to 2001, the change in built-up area was slower than that of population, whereas for the very next decade, the situation was exactly opposite. Thus, the area grew initially, acquiring large amount of land and densified, whereas in the following decades the rate of growth was sprawled. This also confirmed the process of suburbanisation in the NCR.

In the time period from 1991 to 2011, the results of built-up along transport (Table 3.12) network found out that the built-up area along 1 kilometre buffer of rail network and roads as well got increased from 19 % to 19.2 % and 30.4 % to 31.2 % respectively which was enough substantial to be categorized as ribbon development along the above mentioned network. There are both residential and commercial developments along those transport networks sustaining the sprawl (strip or ribbon development).

Briefly, it can say that spatial development of NCR from Core to Ring analysis proves that economic transformation, population increase, and change in mobility pattern shaped the spatial convention, along with the characteristics like fluctuating density of built-up area, increasing fragmentation, densification of core region (also called CBD) and Ring 1(also known as NCT-Delhi), sprawling along the transportation network in Ring 2 (mainly the Delhi Metropolitan Area) and Ring 3 too (Rest part of NCR) and increasing rate of growth of population and built-up area as well.

SECTION-2

3.7 Impacts on Ecosystem Services

Ecosystem services are referred to the benefits or services, people deduce from ecosystems in term of the support provided by the ecosystems for sustainable human well-being (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005. These services are broadly classified into four categories namely, regulating services, provisioning services, supporting services and cultural services. All are vital for managing human life. We will discuss all four services in a detailed way in chapter 4.

Urbanisation is the main cause for alteration in land use and land cover changes that lead to the unequal distribution of vital ecosystem services at local and global scales as well. It not only impacted on the supply, use, distribution of that services to the beneficiaries but also to the degradation and shortages of those services (Eigenbrod et al., 2010). The unplanned and haphazard structure and growth of the city exerting pressure on environment and resulting into the pollution and loss in ecosystem services.

Previous studies shows that urbanisation is the important driver for pollution, climate change, alters biotic and a biotic ecosystem properties (Grimm et al., 2008). Urban development on one hand, contribute to the isolation, fragmentation and degradation of natural hibatats along with disruption of hydrological system; but on the other hand, it is responsible for simplification and homogenization of species composition and modification of nutrient cycle and energy flow (Alberti, 2005). The mechanisms through which urbanisation impact the functionability of the ecosystem include the changes in natural disturbanc and modification in land cover with having distinct ecological consequenses. Cities are dependent upon ecosystem services such as clean water, clean air, food, fiber etc. which differ from any other kind of ecosystems in various ways (Trepl, 1995; Sukopp et al., 1995; Niemala, 1999; Alberti, 2005).

3.7.1 Linking Urban Patterns to ecosystem functions and their services

The modification in land cover impact soil quality, sedimentation rates, run off, biotic diversity and primary productivit. With the help of alteration in the availability of water and nutrients, urban structure also impact ecosystem dynamics, population and communities. Urban system also influence the micro climate and air quality through the generation of excess amount of heat by the alteration of the nature of the surface. The urban heat island, thus, serves as an entrap for atmospheric pollutants (Oke, 1987). Furthermore, the growth in impervious land area consorted with urbanisation impact both hydrological and geomorphological processes causing modification in water and sediment flows (Wolman, 1967; Leopold, 1968; Gibbons et al., 1996; Paul et al., 2001 and Alberti, 2005).

Table 3.13 Summary of selected literature findings on the impacts of urbanisation on ES

Urbanisation impact on Ecosystem and their services	Findings	Sources
	AT GLOBAL	
flood mitigation services , carbon storage, agricultural production services	Densification of urban areas shows loss of permeable surfaces. Suburban sprawl shows losses in agricultural production, carbon storage in Europe.	Eigenbrod et al., 2011
loss of agricultural land	Urban expansion-more stress on agricultural land in the world	Satterthwaite et al., 2010
loss in stream ecosystem -fish production	Urbanisation alone depressed growth or reproduction of 8 of 39 species in USA.	Nelson et al., 2009
loss of wetlands, forest, and grasslands	Human-dominated land uses(urban) have expanded at the cost of natural lands. In Heilongjiang, China. ESV decreased about 29%.	Zang et al., 2011
	AT NATIONAL	
Loss in habitat for species, Climate regulation	High population urban density creates challenges to mitigare the impact of climate change. Native bird species diversity declined in Indian cities.	Nagendra et al., 2014
Ecosystem vulnerability modeling	Cropland and paltntation are under high vulnerability zone in Simaur, Himachal pradesh Area under forest cover has decreased	Stutee Gupta & Roy
	AT REGIONAL	
Loss in food production, gas regulation, pollination and biological control.	Urban sprawl leading to decline in agicultural land and total ecosystem service value has declined 0.58 million per year in NCT Delhi.	Morya & Punia , 2017

There are number of studies that have linked urbanisation to its environment, ecosystem and ecosystem services. Today the world is more concerned about the provising ecosystem services as they are direcct impacted to the human-well being although other services are significant role to play in an ecosystem to balancing the other processes that maintain ecosystem sustainable. But in recent years the impact of urbanistion is getting worse and it not only effect the loss in the supply of services but also highly impacted to the poor or marginalised communities who depended on it for their livelihood.

In this chapter, an attempt has been made to assess the impact of urbanisation on ecosystem services in National capital Region. For doing this first with the help of classified land use land cover maps different ecosystems were identified. Further, with the help of Costanza et al. 2014, methodology different services were identified. It presented the temoparal change of loss in ecosystem services due to the change in the land use and land cover pattern in the region

3.7.2 Assessment of Impacts on Ecosystem Services

3.7.2.1 Land use change

With the aim to understand how urbanisation alters land use land cover change that resulted in changes in the earth systems in the global level, information is necessitated on what modification occur, when and where they occur, their rate of occurance, and physical as well as social repelling forces that drive these fluctuations (Lambin et al., 1999). Earlier in this chapter it was discussed that the urban population growth in NCR has increased over the period of time and spwaling effect was found in their counterparts. The sprawling of urban population and changes in built up area can be connected with alteration in the ecosystem services in both urban and peri-urban spaces. It is found from the literature that urbanisation process created number of problems to ecosystem for example disrupted nutrient cycles, concentration of pollutants, loss in food services, gas regulation, water regulation etc.(McDonnell et al., 1997; Bolund and Hunhammar, 1999) but on the other hand it creats highest recreational services (Costanza et al. 2014) to urban ecosystem services. Therefore, it is important to examine the land use dynamics of both urban and peri-urban areas and their consequent impacts on ecosystem services.

3.7.2.2 Estimation of land use land cover change

To assess spatial and temporal trends of land use and land cover (1991, 2001 and 2011) for National Capital Region, satellite images have been taken from the Landsat 5 (TM) and Landsat 7 (ETM) for above mentioned years and the same is represents in the given below table:

Table 3.14 Datasets used for land use land cover

S. No	Satellite	Sensor	Path/Row	Acquiring month
1.	Landsat	TM	146/40,41	Jan-Feb 1991
2.	Landsat	ETM	146/40,41	Feb-March 2001
3.	Landsat	ETM	146/40,41	Feb-March 2011

Erdas Imagine 14.0 and Arc GIS 10.2 software has been used to clarify the land use/land cover assortment following the multi-temporal approach. The training sites acquired for the current research are based on the available ancillary information and reference data, which got collected from versatile sources. As per to the land use categorization scheme supervised approach which includes the maximum likelihood parameter (MLP) scheme, was implemented to ameliorate the precision of the land use categorization for the images of all three years (1991, 2001 and 2011). Eight land use/land cover classes thus, have been identified that includes water bodies, built-up,open vegetation, dense vegetation, scrub land, fallow land, waste or barren land, and agricultural land. In particular, built-up includes urban and rural settlements; water bodies refer to river, lakes, ponds and floodplain; open vegetation includes the lands with canopy density of 10 to 40 percent, similarily dense vegetation includes the land with land canopy density of 70 percent or more; scrub land refer to the lands which have a canopy density of less than 10 percent (State Forest Report, 2015); fallow land includes ground ploughed harrowed land but left unseeded for a season; agricultural land refers to cropland. This classification method used a first level of classification method, because of the difficulty to differenciate them using remote sensing data with medium resoalution. To ensure acceptable classification precision, ground information as well as local land use maps and toposheets were used as denotations from manual digitization.

After supervised classification, study area was extracted into core and rings (disscussed in section 1) according to the NCR Regional Plan 2021 for the assessment of land use and land cover change in each rings and further the same method was applied into the assessment of ecosystem services valuation (Costanza et al., 2014) ring wise. The prior analysis of urban growth and process was also analysed by zonation (core or ring) technique. Thereby, here also it is important to maintain the consistency of analysis for better understanding of results.

3.7.2.3 Land use land cover change analysis according to NCR policy zones (Rings)

I. LULC-NCR

National Capital Region is a primarily urban region occupied with dense urban settlements. The overall land use dynamics from 1991 to 2011 were showed in Table 3.15. From the table it can be seen that areas of agricultural land and fallow land decreased from 1991 to 2011. On the other hand, the areas of built up, water bodies, dense & open vegetation, scrub land, and barren land increased.

The most notable dynamics of land use in NCR were a declining trend in agricultural land whereas increasing trend in built up area. In 1991, agricultural land covers about 67.38% of the study area and with an approximated area in total 2300886.8 ha, but by 2001, the total area under agricultural land was estimated to get declined substantially by about 1.9% to 2257712.2 ha. Further it is decreased to 2073951 ha in 2011. The annual rate of decrease from 1991 to 2001 is 0.2% per year but from 2001 to 2011 it is further decreased by 0.8% per year. Meanwhile, built up area got increased from 160651.9 ha in 1991 to 327971 ha in 2011, with a growth rate of 2.0-7.0 per annum (Table 3.15). The considerable decrease in agricultural land and increase in built up area resulted from the rapid urban growth in NCR. The land use changes affect 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 problem like fragmentation of land, excavation of fertile land, transformation into farmhouses etc. Apart from this the high economic value of the land in the NCR regions evokes farmers to sell the fertile agricultural land (Narain, 2009).

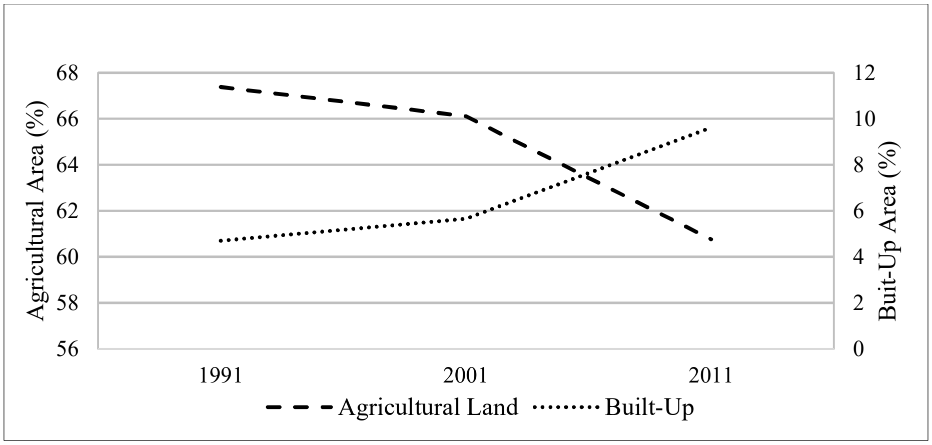


Figure 3.6 Agricultural land and Built up area in NCR from 1991 to 2011

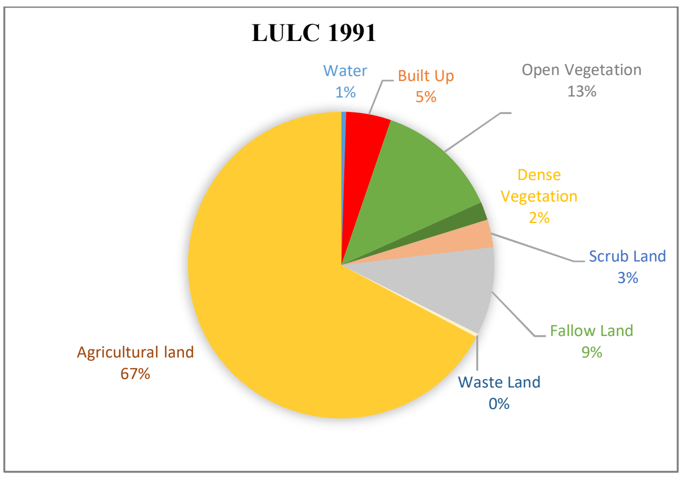


Figure 3.7 Pie chart showing distribution of Land use and Land cover classes in NCR (1991)

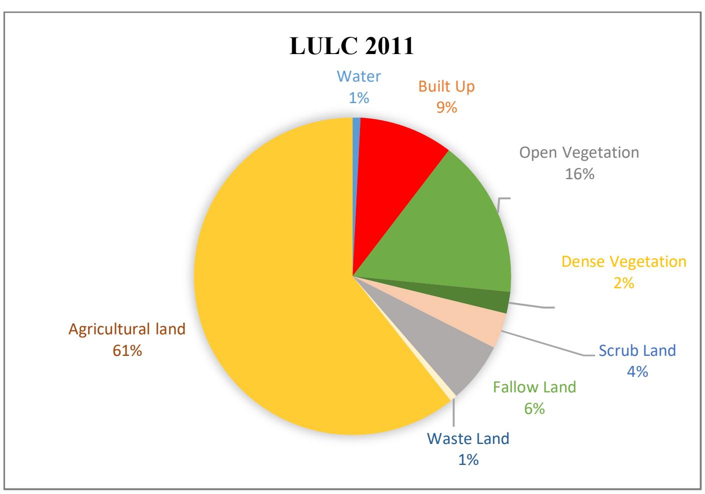


Figure 3.8 Pie chart showing distribution of Land use and Land cover classes in NCR (2011)

Table 3.15 Total estimated area (ha) of each land use category in National Capital Region, and changes in land-use from 1991-2011

LULC classes	Total area (ha)			Area in %		
	1991	2001	2011	1991	2001	2011
Water Bodies	18292.7	19436.0	25224.8	0.54	0.57	0.74
Built Up	160651.9	193058.3	327971.0	4.70	5.65	9.61
Open Vegetation	439977.5	577841.2	556900.5	12.88	16.92	16.32
Dense Vegetation	65227.8	23516.4	71784.8	1.91	0.69	2.10
Scrub Land	99814.9	144315.1	121558.2	2.92	4.23	3.56
Fallow Land	317764.1	184503.7	210278.1	9.31	5.40	6.16
Waste or Barren Land	12182.0	14410.2	25421.5	0.36	0.42	0.74
Agricultural Land	2300886.8	2257712.2	2073951.0	67.38	66.12	60.76
Total	**3414797.7**	**3414793.1**	**3413089.9**	**100**	**100**	**100**

Table 3.16 Land use change in hectares, growth rate and per year change in NCR from 1991-2011

LULC classes	1991-2001			2001-2011			1991-2011		
	ha	%	%/year	ha	%	%/year	ha	%	%/year
Water Bodies	1143.3	6.2	0.6	5788.8	29.8	3.0	6932.1	37.9	1.9
Built Up	32406.3	20.2	2.0	134912.7	69.9	7.0	167319.1	104.2	5.2
Open Vegetation	137863.7	31.3	3.1	-20940.6	-3.6	-0.4	116923.1	26.6	1.3
Dense Vegetation	-41711.4	-63.9	-6.4	48268.3	205.3	20.5	6557.0	10.1	0.5
Scrub Land	44500.2	44.6	4.5	-22756.9	-15.8	-1.6	21743.3	21.8	1.1
Fallow Land	-133260.4	-41.9	-4.2	25774.4	14.0	1.4	-107486.0	-33.8	-1.7
Waste or Barren Land	2228.2	18.3	1.8	11011.3	76.4	7.6	13239.5	108.7	5.4
Agricultural Land	-43174.5	-1.9	-0.2	-183761.2	-8.1	-0.8	-226935.7	-9.9	-0.5

LAND USE LAND COVER ANALYSIS ZONE-WISE IN NCR (1991-2011)

CORE

Table 3.17 Total estimated area (ha) of each land use category in Core region of NCR, and changes in land-use from 1991-2011

LULC classes	Total area (ha)			Area in %		
	1991	**2001**	**2011**	**1991**	**2001**	**2011**
Water Bodies	212.4	129.3	166.3	3.48	2.12	2.72
Built Up	3273.2	3540.4	3828.9	53.61	57.99	62.71
Open Vegetation	391.4	1178.7	1194.3	6.41	19.31	19.56
Dense Vegetation	1880.1	808.0	601.3	30.79	13.23	9.85
Scrub Land	47.2	0.0	0.5	0.77	0.00	0.01
Fallow Land	269.6	415.4	290.9	4.42	6.80	4.76
Waste or Barren Land	30.8	33.8	23.5	0.50	0.55	0.38
Agricultural Land	0.9	0.0	0.0	0.01	0.00	0.00
Total	**6105.5**	**6105.5**	**6105.5**	**100**	**100**	**100**

Table 3.18 Land use change in hectares, growth rate and per year change in Core region of NCR from 1991-2011

LULC classes	1991-2001			2001-2011			1991-2011		
	ha	%	%/year	ha	%	%/year	ha	%	%/year
Water Bodies	-83.0	-39.1	-3.9	36.9	28.6	2.9	-46.1	-21.7	-1.1
Built Up	267.1	8.2	0.8	288.5	8.2	0.8	555.7	17.0	0.8
Open Vegetation	787.3	201.2	20.1	15.6	1.3	0.1	802.9	205.1	10.3
Dense Vegetation	-1072.0	-57.0	-5.7	-206.8	-25.6	-2.6	-1278.8	-68.0	-3.4
Scrub Land	-47.2	-100.0	-10.0	0.5	-	-	-46.8	-99.0	-5.0
Fallow Land	145.7	54.1	5.4	-124.4	-30.0	-3.0	21.3	7.9	0.4
Waste or Barren Land	3.0	9.7	1.0	-10.3	-30.4	-3.0	-7.3	-23.7	-1.2
Agricultural Land	-0.9	-100.0	-10.0	0.0	-	-	-0.9	-100.0	-5.0

LAND USE LAND COVER ANALYSIS ZONE-WISE IN NCR (1991-2011)

RING 1 (REST NCT-DELHI)

Table 3.19 Total estimated area (ha) of each land use category in Ring 1 region of NCR, and changes in land-use from 1991-2011

LULC classes	Total area (ha)			Area in %		
	1991	**2001**	**2011**	**1991**	**2001**	**2011**
Water Bodies	1588.7	1211.2	1840.2	1.10	0.84	1.28
Built Up	39775.5	48914.5	68406.5	27.56	33.90	47.43
Open Vegetation	27988.7	38472.5	27847.3	19.39	26.66	19.31
Dense Vegetation	10066.9	5951.8	5837.3	6.98	4.12	4.05
Scrub Land	634.5	2506.1	1294.9	0.44	1.74	0.90
Fallow Land	22622.6	11178.4	13737.0	15.68	7.75	9.52
Waste or Barren Land	735.0	923.8	1598.2	0.51	0.64	1.11
Agricultural Land	40897.1	35150.9	23675.4	28.34	24.36	16.41
Total	**144309.1**	**144309.1**	**144236.9**	**100**	**100**	**100**

Table 3.20 Land use change in hectares, growth rate and per year change in Ring 1 region of NCR from 1991-2011

LULC classes	1991-2001			2001-2011			1991-2011		
	ha	%	%/year	ha	%	%/year	ha	%	%/year
Water Bodies	-377.6	-23.8	-2.4	629.0	51.9	5.2	251.4	15.8	0.8
Built Up	9138.9	23.0	2.3	19492.0	39.8	4.0	28630.9	72.0	3.6
Open Vegetation	10483.8	37.5	3.7	-10625.2	-27.6	-2.8	-141.4	-0.5	0.0
Dense Vegetation	-4115.1	-40.9	-4.1	-114.5	-1.9	-0.2	-4229.6	-42.0	-2.1
Scrub Land	1871.6	295.0	29.5	-1211.1	-48.3	-4.8	660.5	104.1	5.2
Fallow Land	-11444.2	-50.6	-5.1	2558.6	22.9	2.3	-8885.6	-39.3	-2.0
Waste or Barren Land	188.8	25.7	2.6	674.4	73.0	7.3	863.3	117.5	5.9
Agricultural Land	-5746.3	-14.1	-1.4	-11475.4	-32.6	-3.3	-17221.7	-42.1	-2.1

LAND USE LAND COVER ANALYSIS ZONE-WISE IN NCR (1991-2011)

RING 2 (DELHI METROPOLITIAN AREA)

Table 3.21 Total estimated area (ha) of each land use category in Ring 2 region of NCR, and changes in land-use from 1991-2011

LULC classes	Total area (ha)			Area in %		
	1991	**2001**	**2011**	**1991**	**2001**	**2011**
Water Bodies	3327.3	3218.7	4880.3	0.59	0.57	0.86
Built Up	36133.4	48143.3	101234.5	6.36	8.47	17.82
Open Vegetation	77132.6	113423.2	86975.6	13.57	19.96	15.31
Dense Vegetation	11749.4	4484.2	18054.7	2.07	0.79	3.18
Scrub Land	5967.3	16080.0	9672.1	1.05	2.83	1.70
Fallow Land	65523.3	33366.3	67815.8	11.53	5.87	11.94
Waste or Barren Land	3155.6	1885.9	5990.2	0.56	0.33	1.05
Agricultural Land	365349.8	347737.0	273383.4	64.28	61.18	48.13
Total	**568338.6**	**568338.6**	**568006.6**	**100**	**100**	**100**

Table 3.22 Land use change in hectares, growth rate and per year change in Ring 2 region of NCR from 1991-2011

LULC classes	1991-2001			2001-2011			1991-2011		
	ha	%	%/year	ha	%	%/year	ha	%	%/year
Water Bodies	-108.6	-3.3	-0.3	1661.6	51.6	5.2	1553.1	46.7	2.3
Built Up	12010.0	33.2	3.3	53091.1	110.3	11.0	65101.1	180.2	9.0
Open Vegetation	36290.6	47.0	4.7	-26447.6	-23.3	-2.3	9843.0	12.8	0.6
Dense Vegetation	-7265.2	-61.8	-6.2	13570.5	302.6	30.3	6305.3	53.7	2.7
Scrub Land	10112.7	169.5	16.9	-6407.9	-39.9	-4.0	3704.8	62.1	3.1
Fallow Land	-32157.0	-49.1	-4.9	34449.5	103.2	10.3	2292.6	3.5	0.2
Waste or Barren Land	-1269.8	-40.2	-4.0	4104.3	217.6	21.8	2834.5	89.8	4.5
Agricultural Land	-17612.8	-4.8	-0.5	-74353.6	-21.4	-2.1	-91966.4	-25.2	-1.3

LAND USE LAND COVER ANALYSIS ZONE-WISE IN NCR (1991-2011)

RING 3 (REST NCR REGION)

Table 3.23 Total estimated area (ha) of each land use category in Ring 3 region of NCR, and changes in land-use from 1991-2011

LULC classes	Total area (ha)			Area in %		
	1991	**2001**	**2011**	**1991**	**2001**	**2011**
Water Bodies	13162.5	14893.9	18336.2	0.49	0.55	0.68
Built Up	81466.7	92453.5	154497.6	3.02	3.43	5.73
Open Vegetation	334473.0	424773.0	440887.0	12.41	15.76	16.36
Dense Vegetation	41527.8	12271.0	47295.2	1.54	0.46	1.76
Scrub Land	93165.3	125728.3	110593.6	3.46	4.66	4.10
Fallow Land	229349.2	139770.5	128429.8	8.51	5.18	4.77
Waste or Barren Land	8283.4	11564.8	17830.5	0.31	0.43	0.66
Agricultural Land	1894614.5	1874603.0	1776868.9	70.27	69.53	65.94
Total	**2696042.3**	**2696058.0**	**2694738.9**	**100**	**100**	**100**

Table 3.24 Land use change in hectares, growth rate and per year change in Ring 3 region of NCR from 1991-2011

LULC classes	1991-2001			2001-2011			1991-2011		
	ha	%	%/year	ha	%	%/year	ha	%	%/year
Water Bodies	1731.5	13.2	1.3	3442.3	23.1	2.3	5173.7	39.3	2.0
Built Up	10986.8	13.5	1.3	62044.1	67.1	6.7	73030.9	89.6	4.5
Open Vegetation	90299.9	27.0	2.7	16114.1	3.8	0.4	106414.0	31.8	1.6
Dense Vegetation	-29256.8	-70.5	-7.0	35024.3	285.4	28.5	5767.5	13.9	0.7
Scrub Land	32563.0	35.0	3.5	-15134.7	-12.0	-1.2	17428.4	18.7	0.9
Fallow Land	-89578.8	-39.1	-3.9	-11340.7	-8.1	-0.8	-100919.5	-44.0	-2.2
Waste or Barren Land	3281.5	39.6	4.0	6265.7	54.2	5.4	9547.2	115.3	5.8
Agricultural Land	-20011.5	-1.1	-0.1	-97734.1	-5.2	-0.5	-117745.6	-6.2	-0.3

Water bodies increased from 18292.7 ha to 25224.8 ha with an annual growth rate of 1.9% while fallow land decreased marginally from 317764.1 ha to 210278.1 ha from 1991 to 2011 with an annual growth rate of 1.7%. Although dense vegetation and open vegetation increased from 65227.8 ha to 71784.8 ha and 439977.5 ha to 556900.5 ha, with an annual growth rate of 0.5% and 1.3% from 1991 to 2011 respectively.

The barren or waste land has shown an increase of 18.3% from 1991 to 2001 and 76.4% from 2001 to 2011, while scrub land has shown an increase of 21.8% from 1991 to 2011, with an annual growth rate of 1.1%.

II. Core

Core area is consisting of old and new central bussiness district (CBD) which includes, Karol Bagh, Pahar Ganj, Sadar Bajar, Daryaganj, Kotwali from old CBD and, Parliament Street, Caunnaught Place, Chanakya Puri from new CBD. It is also known as financial, commercial and bussiness capital of NCR. The land use dynamics of this region witnessed that the area under water bodies, dense vegetation, scrub land, fallow land, barren land and agricultural land is decreased from 1991 to 2011. Whereas built-up area and open vegetation is showing increase in the area from 1991 to 2011 (Table 3.17 & 3.18).

III. Ring 1 (Rest NCT-Delhi)

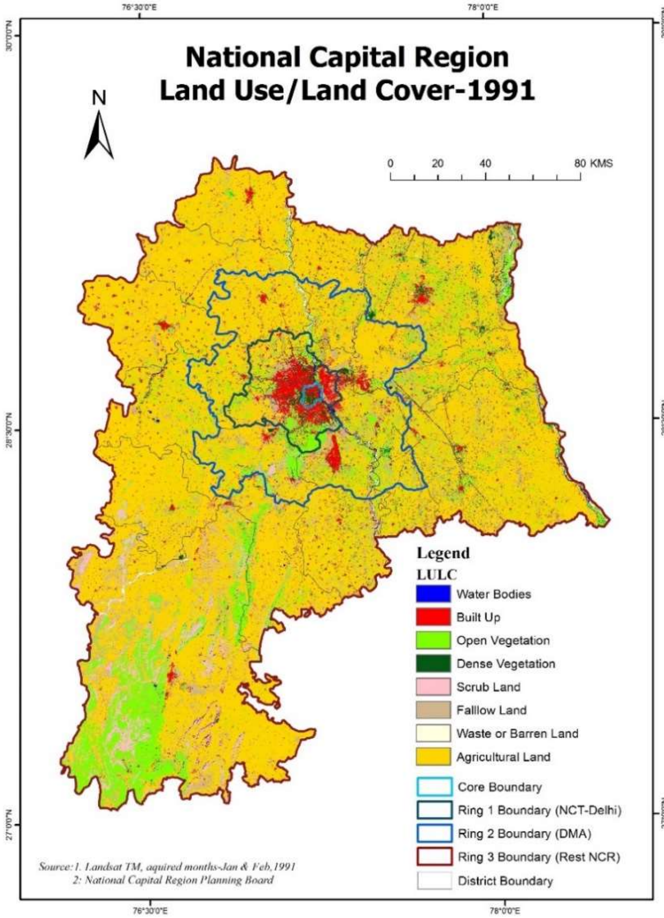
This region comprises of seven districts of NCT-Delhi vis. North West (Narela, Model Town, Saraswati Vihar); West Delhi (Punjabi Bagh, Patel Nagar, Rajauri Garden); South West (Najafgarh, Delhi Cantonment, Vasant Vihar); South Delhi (Hauz Khas, Kalkaji, Defence colony); East Delhi (Gandhi Nagar, Vivek Vihar, Preet Vihar); North East(Seelam Pur, Shahdara, Seema Puri); and North Delhi (Civil Lines). This region has expericed the tremendous change in the built up area . Built-up area is doubled from 27.5% in 1991 to 47.5% in 201. And the area under agricultural land has decreased that means with the implementation of new economic policy 1991, this region grows at the faster rate which resulted in the conversion of agricultural land into non-agricultural uses (Table 3.19 & 3.20).

IV. Ring 2 (Central National Capital region (CNCR) or DMA)

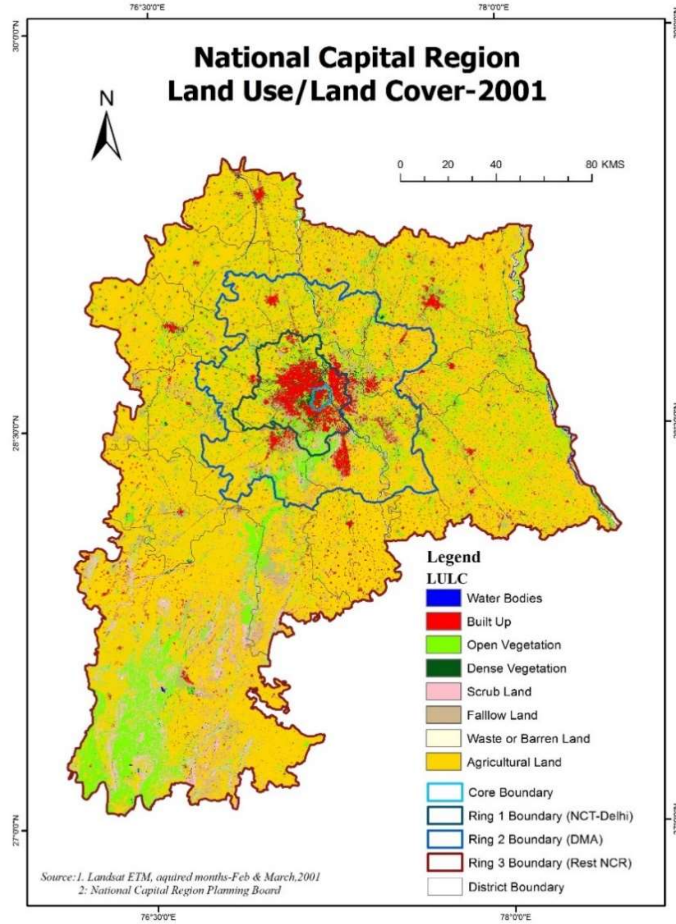
Under ring two, area consisting of ‘Delhi Metropolitian Area’, has experienced a remarkable change in land use categories with compare to other rings. This is an outcome of spill over effect of urbanisation around NCT-Delhi. This region is experienced higher increase in the non-agricultural area that are faster than the other regions or rings of NCR. This change in this category also be attributed to the post reform period. Gurgoan has wittnessed a highest growth rate in urban population as well as increased rate of built-up area expansion. Another important example we can see in the Uttar Pradesh sub-region of NCR i.e. Ghazizbad which also represents the highest change in the urban population and built-up area from 1991 to 2011. It can be argued that this changes that happened in this region is the result of implementation of new economic policy (1991). Noida has also witnessed the tremendous change in the built-up area. It has almost covered the entire urbanised area. In the north it is reached to the NH 24 bypass and in the south it is extented beyoned the Export Promotion Zone. The extension of built-up area in Faridabad reached beyoned the Agra canal in the east and also streches between the Agra canal and NH1 in the south. This whole area wittnesed a growth in built-up area by 180.2% from 1991 to 2011 and in contrary decline in agricultural land by 25.2 % from 1991 to 2011 (Table 3.21 & 3.22).

V. Ring 3 (Rest NCR region)

This region mainly a rurban in character having more than 50% of agricultural land. It consists of Alwar district from Rajasthan; Sonipat, Panipat, Rohtak, Rewari, Jajjar, Mewat and Palwal from Haryana sub region; Bhagpat, Meerut, Bulandshar, Jewar (Gautam Budh Nagar), Gurumukhteshwar and Hapur (Ghaziabad) from UP sub-region. From the analysis of land use land cover change , agricultural land has been decreased from 1894614.5 ha in 1991 to 1776868.9 ha in 2011. It was decreased by 6.2 percent. According to the NCR regional plan , Panipat, Rohtak, Rewari, Palwal, Alwar, Bhiwadi, Meerut, Hapur, Bulandshar and Khurja had been identified as a Priority towns in this ring 3. The land use dynamics of this region reveals that in upcoming decades it will influenced by Delhi Metropolitan towns and resulting into the enhancement in the built-up area as well population growth in these regional towns (Table 3.23 & 3.24).

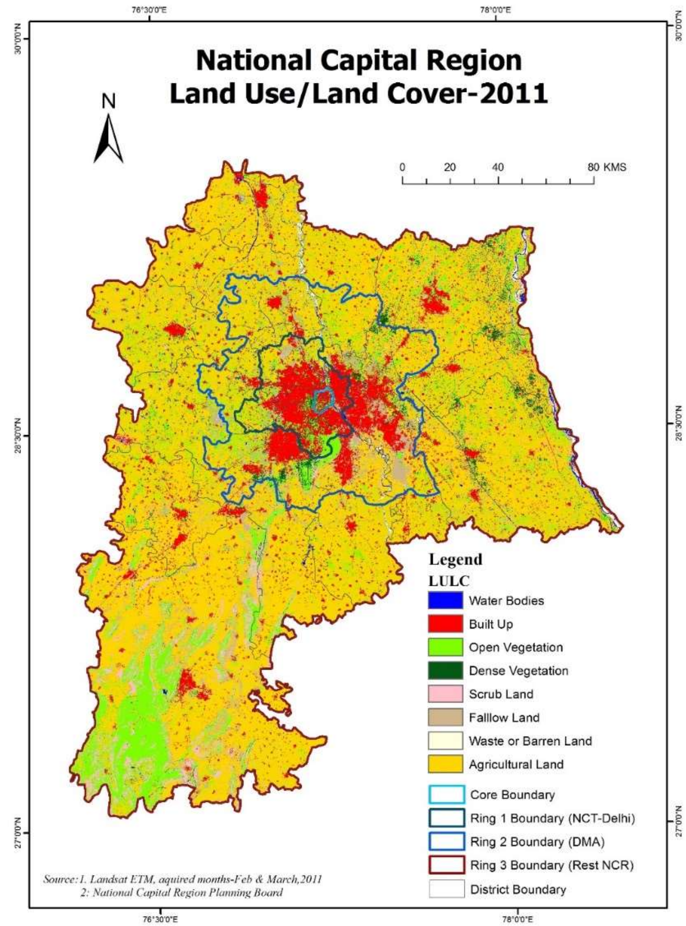


Map 3.8 Land Use/Land Cover Map of NCR -1991

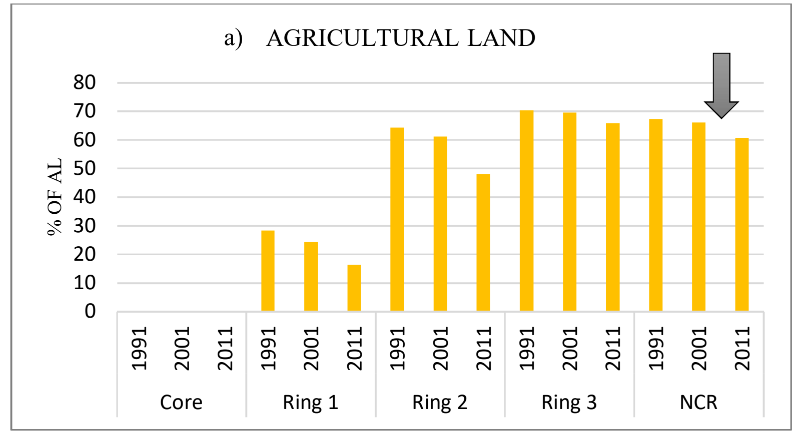


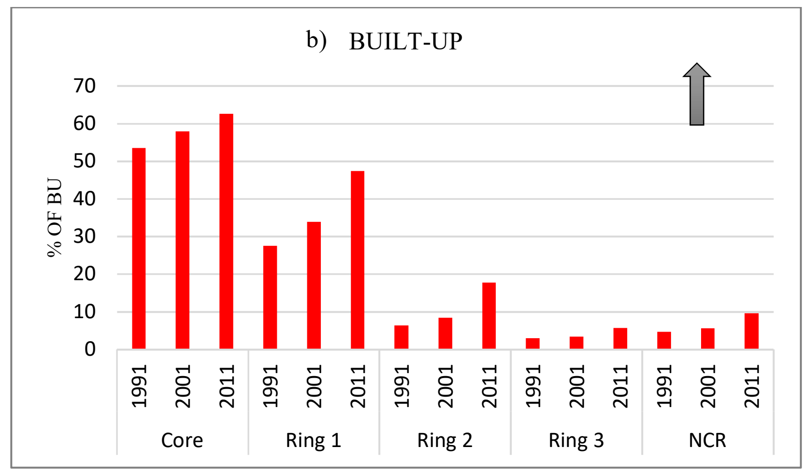
Map 3.9 Land Use/ Land Cover Map of NCR-2001

Map 1Land of NCR-2001



Map 3.10 Land Use/ Land Cover Map of NCR-2011





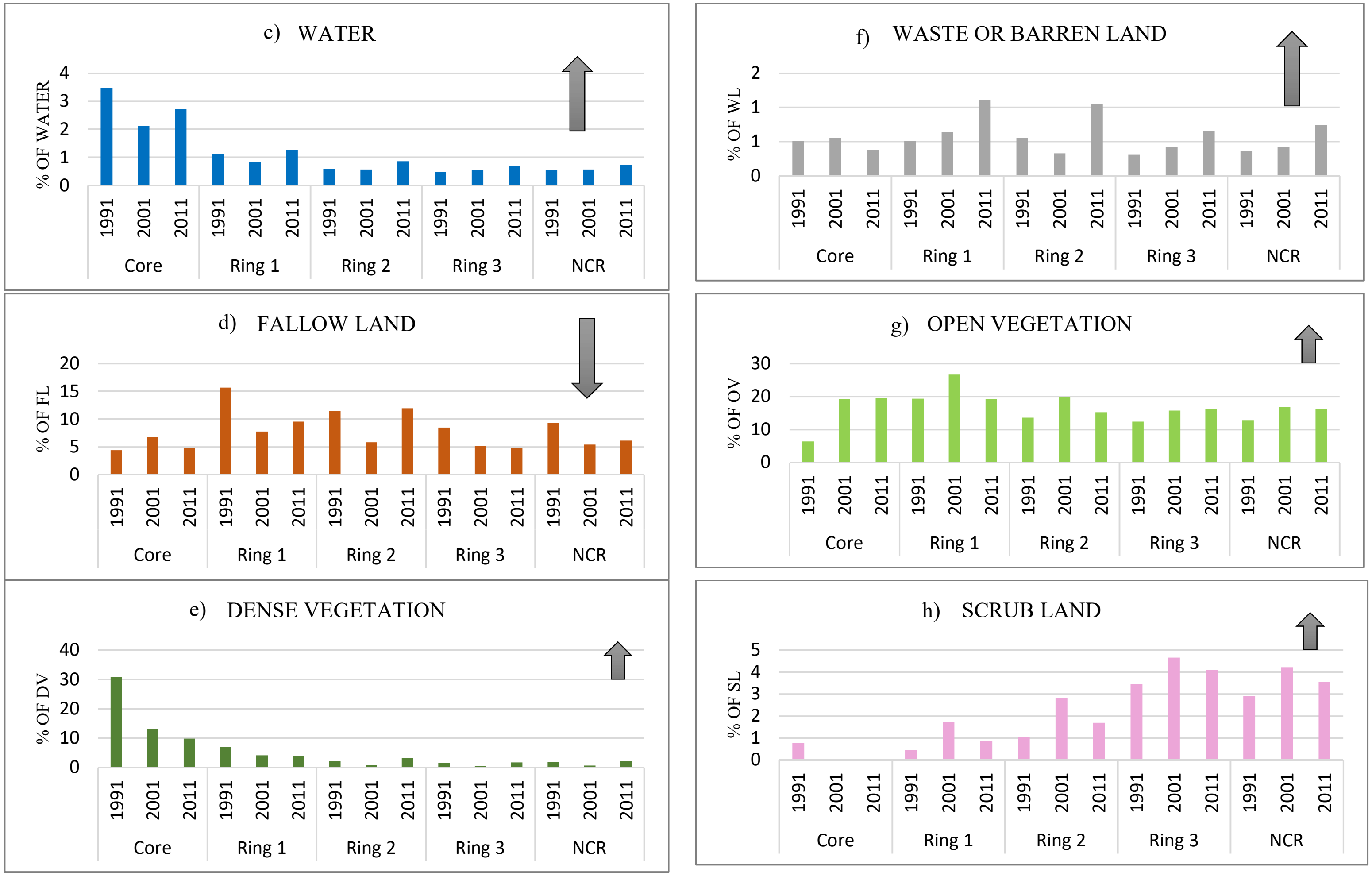


Figure 3.9 Ring-wise changes LULC classes in NCR from 1991-2011: a) Agricultural Land; b) Built-Up; c) Water; d) Fallow Land; e) Dense Vegetation; f) waste land; g) Open Vegetation; h) Scrub land

3.7.2.4. Ecosystem service valuation

Valution of ecosystem services firstly started with the notion for the sustainable use of natural capital. The study on this concept was not new it was strated dated back in the 1980s. The conception about ecosystem services was first postulated by the Westman in 1977, where much attention was drawn to the social value supplied by the ecosystem. And afterwards in 1981, the term 'ecosystem services' was disclosed for the first time by Ehrlich & Ehrlich and then it started to gain impulse in scientific literature through the seminal publications in the after decades (de Groot, 1992; Daily, 1997; Costanza et al., 1997).

The research on ecosystem services grown rapidly among academia and policy makers (Braat and de Groot, 2012; Costanza et a., 2014) but it has achieved broader attention through the publication of the Millennium Ecosystem Assessment report (MEA) in 2005 by the United Nations. UN Environment programme took another important step in 2010 under the name of 'The Economics of Ecosystems and Biodiversity' (TEEB) in 2010. Afterwards this concept has also entered into the convensional business and media and got active support in its development by 'The World Business Council for Sustainable Development' (WBCSD, 2011, 2012). Currently wide range of studies are being conducted on this topic at regional, national and global level.

The valuation approach in ecosystem services is important because it is useful to increase consciousness about the magnitude of those services to other human-built capital provided services at the contemporary time (Costanza et al., 2014) and also it can enforced at multiple scale to evaluate the dynamics resulting from various situations and policies. Therefore, this approach is adopted to see the magnitute of these services at regional level. The valuation method formulated by Costanza et al. (2014) was implemented here. He had given the same approach earlier in 1997 but due to the crictics on that paper and the changes in the land use/land cover he had updated estimates for ecosystem services values. In earlier paper he did not provide the value for the urban land use category whereas in revised 2014 paper, he assigned the coefficient value for urban land category. The importance of 'urban' category relative to measures of the economic output of 'natural' capital manifests primarily in the idea that human well-being is increased via the interaction of social, natural, built, and human capital and 'urban' is the spatial location of a significant fraction of built, human, and social capital (Costanza et al., 2014).

Hence, in this study same ecosystem services coefficients used as given in the 2014 paper of Costanza et al. And each land cover typed classified through the Landsat imagires were equated with the biomes as proposed by Costanza et al in their 'valuation method'. The representative biome was applied as a proxy for each and every types of land use/land cover due to it's difficulty for having perfect match, including farmingland for agricultural land and fallow land, forest for open and dense vegetation, grassland/rangelands for srub land, lakes and river for water bodies, urban for built-up, and desert for waste or barren lands.

With the coefficients of ecosystem services for each and every type of land use/land cover, the values of total ecosystem service were calculated in National Capital region for the years 1991, 2001, and 2011 as follows (eq.1).

$$ESV = \sum_{k=1}^{n} (\mathrm{Ak} \times \mathrm{VCk}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where ESV represents the total value of ecosystem service in the study area for a given particular year; A_k, the geographical area (ha), used for land use type k, whereas VC_k is the coefficient value (US \$ ha^{-1} $year^{-1}$) for land use type k, and n corresponds the total number of land use types (n=8 in this study area).

Table 3.25 Equivalent biomes and their Ecosystem Service coefficients

Land use land cover categories	**Equivalent biome identified in Costanza et al. (2014)***	**Ecosystem service coefficient (\$ ha^{-1} $year^{-1}$)[a]**
		2011
Water Bodies	Lakes/Rivers	12512
Built-Up	Urban	6661
Open Vegetation	Forest	3800
Dense Vegetation	Forest	3800
Scrub Land	Grassland/rangelands	4166
Fallow Land	Cropland	5567
Barren land	Desert	0
Agricultural land	Cropland	5567

*Costanza et al. (2014); Changes in the global value of ecosystem services; Global Environmental change 26,152-158.

3.7.2.5 Changes in Ecosystem Services

The contribution of the area under each and every land use category and their values in NCR in 1991, 2001 and 2011 were demonstrated in Figure (3.9). The estimated changes were concorded in the extent of each and every type of land use together with the value of coefficient of ecosystem service as ecommended by Costanza et al. (2014). Here it has been found out that the changes in land use occur in the 3414797.7 ha of the total study area which had resulted into a net annual decline of US$ 100.67 million on an average in ecosystem services from 1991 to 2011. From this, it's very clear that the cumulative loss of $ 1006.7 million in the ecosystem services since past 20 years of study assumed a linear decrease in ecosystem services. nevertheless, from 1991 to 2001, the rate of decline was detected in values of ecosystem service way much higher than that of the period from 1991 to 2011. Taking into account the decline in ecosystem services during those two periods, a cumulative loss of ecosystem of $ 1006.1 million has been found.

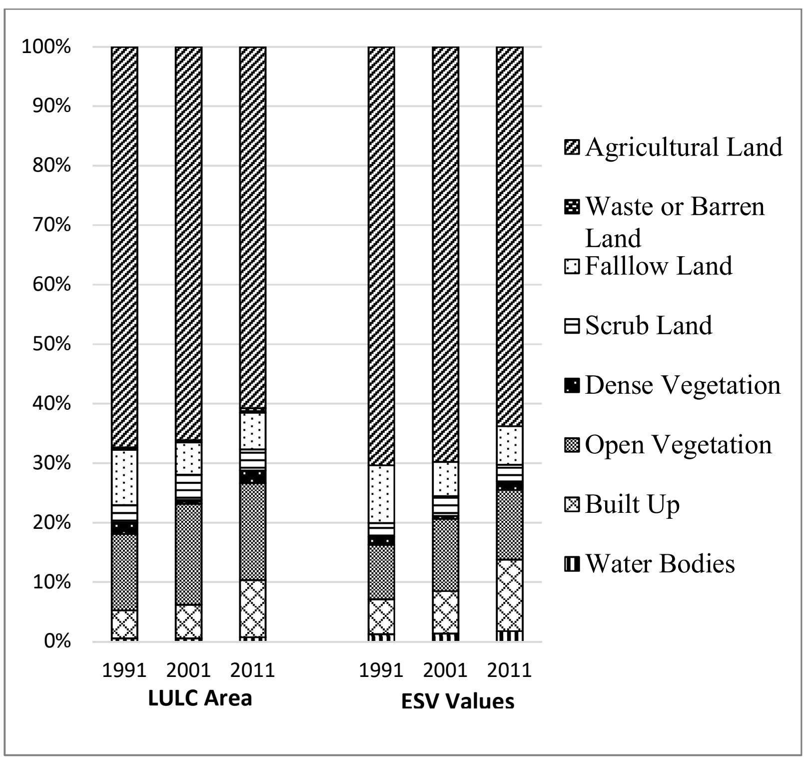


Figure 3.9 Area and Ecosystem Service value contribution of eight land use categories in NCR

By and large, the calculated 226935.7 ha loss of arable land (i.e. 67.3% of the total area in the year 1991) through it's conversion into built up, fallow land & other land uses, seems to result into a monolithic loss per annum in total ecological values of the

National Capital Region along with the accompaning deprivation in the ecosystem services.

I. Core

The core is the area which has the maximum density of population as well built-up area. This is also called as the central bussiness district of New Delhi. We found that land use change in 6105.53 ha of the core region of NCR had resulted a net decline of $ 1.24 million per annum on an average in ecosystem services over the 20 years study. However, the rate of decrease in ecosystem value from 1991 to 2011 was $ 0.18 million per year.

II. Ring 1

The assessment of valuation in ecosystem services in this region witness that area is losted maximum number of agricultural land at the cost of built up area as it was also evident from the land use/land cover analysis. The estimates for the analysis of ecosystem services in this region shows that there was a loss of US$ 7.55 million of ecosystem services from 1991 to 2001 but if we compare this value to the change from 1991 to 2011 was found to be slightly increased which means that the values under the urban category of ecosystem services get involved in total value of ecosystem services which resulted in an increase in these services because of built-up or urban area assigned coefficient value is relatively higher than the agriculture land coefficient value. The net rate of change 1991 to 2011 was $ 0.22 million per year.

III. Ring 2

It is the zone of showing maximum dynamics in most of aspects of this region, say urban population growth, migration, conversion of arable land for non-agricultural uses, establishment of new real estate developers projects etc. because of the diverting of the pressure of core region of delhi towards its counterparts. This region (Ring 2) got highly effected in terms of land use/land cover change and followed by loss in ecosystem services in this region. This region shows the highest number of loss in the crop land ecosystem which is US$ 511.98 millions from 1991 to 2011. Net decline from 1991 to 2011 was 25.17 percent. According to the census 2011, Gurugram accounted highest urban population growth rate among other tehsils of this region which resulted in the development of the new companies such as DLF cyber city, Gurgoan Info. Space limited etc that aquired the arable and fertile land for the establishment of these compaines and further it has resulted in the maximum loss in the cropland category.

IV. Ring 3

Ring 3 is an area of NCR outside the designated CNCR(' Central National Capital Region') or DMA and Highway Corridor zone, comprising both urban and rural areas. This region has largest land cover amongst other rings. The changes in land use in the 2696042.30 ha of this region had resulted into an annual net decline of US$167.22 million on an average in ecosystem services between 1991 to 2011. Consequently, a cumulative loss of $ 1672.1 million has been identified in ecosystem services since the past 20 years study., assuming the linear decline in ecosystem services.

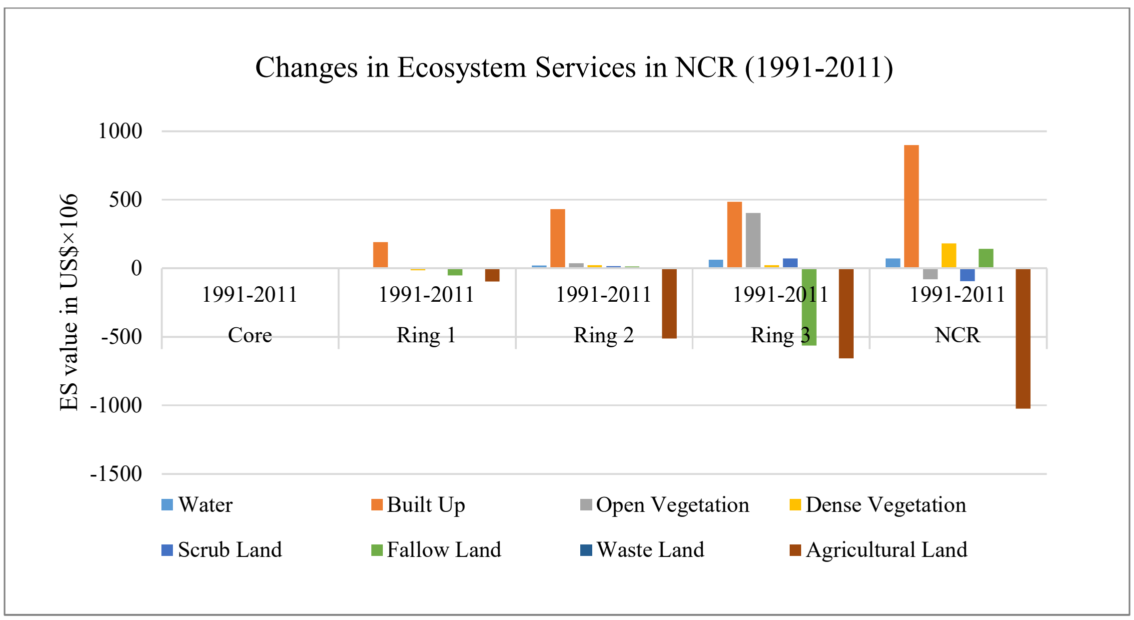


Figure 3.10 Changes in Ecosystem Services from 1991-2011 in National Capital Region

ECOSYSTEM SERVICES VALUATION IN NCR, ZONE-WISE (1991-2011)

NCR

Table 3.26 Total ESV estimated for each LULC category over NCR (1991, 2001 & 2011) by using Costanza et al., 2011 coefficients

(NCR) LULC classes	ESV (US$×$10^6$ per year)			Difference in Ecosystem Service Value (ESV) between the first and last year of each time period and the annual change rate that this difference represents								
	1991	2001	2011	1991-2001			2001-2011			1991-2011		
				$× 10^6	%	%/year	$× 10^6	%	%/year	$× 10^6	%	%/year
Water Bodies	228.88	243.18	315.61	14.30	6.25	0.62	72.43	29.78	2.98	86.73	37.90	1.89
Built Up	1070.10	1285.96	2184.61	215.86	20.17	2.02	898.65	69.88	6.99	1114.51	104.15	5.21
Open Vegetation	1671.91	2195.80	2116.22	523.88	31.33	3.13	-79.57	-3.62	-0.36	444.31	26.57	1.33
Dense Vegetation	247.87	89.36	272.78	-158.50	-63.95	-6.39	183.42	205.25	20.53	24.92	10.05	0.50
Scrub Land	415.83	601.22	506.41	185.39	44.58	4.46	-94.81	-15.77	-1.58	90.58	21.78	1.09
Fallow Land	1768.99	1027.13	1170.62	-741.86	-41.94	-4.19	143.49	13.97	1.40	-598.37	-33.83	-1.69
Waste or Barren Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Land	12809.04	12568.68	11545.69	-240.35	-1.88	-0.19	-1023.00	-8.14	-0.81	-1263.35	-9.86	-0.49
Total	**18212.62**	**18011.34**	**18111.95**	**-201.28**	**-1.11**	**-0.11**	**100.61**	**0.56**	**0.06**	**-100.67**	**-0.55**	**-0.03**

(source: author’s computation)

Table 3.27 Total ESV estimated for each LULC category over Core region of NCR (1991, 2001 & 2011) by using Costanza et al. 2011 coefficients

CORE LULC classes	ESV (US$×10^6 per year)			Difference in Ecosystem Service Value (ESV) between the first and last year of each time period and the annual change rate that this difference represents								
	1991	2001	2011	1991-2001			2001-2011			1991-2011		
				$× 10^6	%	%/year	$× 10^6	%	%/year	$× 10^6	%	%/year
Water Bodies	2.66	1.62	2.08	-1.04	-39.10	-3.91	0.46	28.57	2.86	-0.58	-21.70	-1.08
Built Up	21.80	23.58	25.50	1.78	8.16	0.82	1.92	8.15	0.82	3.70	16.98	0.85
Open Vegetation	1.49	4.48	4.54	2.99	201.16	20.12	0.06	1.32	0.13	3.05	205.13	10.26
Dense Vegetation	7.14	3.07	2.28	-4.07	-57.02	-5.70	-0.79	-25.59	-2.56	-4.86	-68.02	-3.40
Scrub Land	0.20	0.00	0.00	-0.20	-100.00	-10.00	0.00	-	-	-0.19	-99.05	-4.95
Fallow Land	1.50	2.31	1.62	0.81	54.05	5.41	-0.69	-29.96	-3.00	0.12	7.89	0.39
Waste or Barren Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00
Agricultural Land	0.00	0.00	0.00	0.00	-100.00	-10.00	0.00	-	-	0.00	-100.00	-5.00
Total	34.79	35.06	36.03	0.27	0.77	0.08	0.97	2.76	0.28	1.24	3.55	0.18

(source: author's computation)

Table 3.28 Total ESV estimated for each LULC category over Ring 1 region of NCR (1991, 2001 & 2011) by using Costanza et al. 2011 coefficients

RING 1 (NCT-DELHI) LULC classes	ESV (US$×10^6 per year)			Difference in Ecosystem Service Value (ESV) between the first and last year of each time period and the annual change rate that this difference represents								
	1991	2001	2011	1991-2001			2001-2011			1991-2011		
				$× 10^6	%	%/year	$× 10^6	%	%/year	$× 10^6	%	%/year
Water Bodies	19.88	15.15	23.02	-4.72	-23.76	-2.38	7.87	51.93	5.19	3.15	15.82	0.79
Built Up	264.94	325.82	455.66	60.87	22.98	2.30	129.84	39.85	3.98	190.71	71.98	3.60
Open Vegetation	106.36	146.20	105.82	39.84	37.46	3.75	-40.38	-27.62	-2.76	-0.54	-0.51	-0.03
Dense Vegetation	38.25	22.62	22.18	-15.64	-40.88	-4.09	-0.44	-1.92	-0.19	-16.07	-42.01	-2.10
Scrub Land	2.64	10.44	5.39	7.80	294.98	29.50	-5.05	-48.33	-4.83	2.75	104.10	5.20
Fallow Land	125.94	62.23	76.47	-63.71	-50.59	-5.06	14.24	22.89	2.29	-49.47	-39.28	-1.96
Waste or Barren Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Land	227.67	195.68	131.80	-31.99	-14.05	-1.41	-63.88	-32.65	-3.26	-95.87	-42.11	-2.11
Total	785.69	778.14	820.35	-7.55	-0.96	-0.10	42.21	5.42	0.54	34.66	4.41	0.22

(source: author's computation)

Table 3.29 Total ESV estimated for each LULC category over Ring 2 region of NCR (1991, 2001 & 2011) by using Costanza et al. 2011 coefficients

RING 2 (DMA) LULC classes	ESV (US$×$10^6$ per year)			Difference in Ecosystem Service Value (ESV) between the first and last year of each time period and the annual change rate that this difference represents								
	1991	2001	2011	1991-2001			2001-2011			1991-2011		
				$× 10^6	%	%/year	$× 10^6	%	%/year	$× 10^6	%	%/year
Water Bodies	41.63	40.27	61.06	-1.36	-3.26	-0.33	20.79	51.62	5.16	19.43	46.68	2.33
Built Up	240.68	320.68	674.32	80.00	33.24	3.32	353.64	110.28	11.03	433.64	180.17	9.01
Open Vegetation	293.10	431.01	330.51	137.90	47.05	4.70	-100.50	-23.32	-2.33	37.40	12.76	0.64
Dense Vegetation	44.65	17.04	68.61	-27.61	-61.83	-6.18	51.57	302.63	30.26	23.96	53.66	2.68
Scrub Land	24.86	66.99	40.29	42.13	169.47	16.95	-26.70	-39.85	-3.99	15.43	62.09	3.10
Fallow Land	364.77	185.75	377.53	-179.02	-49.08	-4.91	191.78	103.25	10.32	12.76	3.50	0.17
Waste or Barren Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Land	2033.90	1935.85	1521.93	-98.05	-4.82	-0.48	-413.93	-21.38	-2.14	-511.98	-25.17	-1.26
Total	3043.60	2997.59	3074.25	-46.00	-1.51	-0.15	76.66	2.56	0.26	30.65	1.01	0.05

(source: author's computation)

Table 3.30 Total ESV estimated for each LULC category over Ring 3 region of NCR (1991, 2001 & 2011) by using Costanza et al. 2011 coefficients

RING 3 (REST NCR) LULC classes	ESV (US$×$10^6$ per year)			Difference in Ecosystem Service Value (ESV) between the first and last year of each time period and the annual change rate that this difference represents								
	1991	2001	2011	1991-2001			2001-2011			1991-2011		
				$× 10^6	%	%/year	$× 10^6	%	%/year	$× 10^6	%	%/year
Water Bodies	164.69	186.35	229.42	21.66	13.15	1.32	43.07	23.11	2.31	64.73	39.31	1.97
Built Up	542.65	615.83	1029.11	73.18	13.49	1.35	413.28	67.11	6.71	486.46	89.65	4.48
Open Vegetation	1271.00	1614.14	1675.37	343.14	27.00	2.70	61.23	3.79	0.38	404.37	31.82	1.59
Dense Vegetation	157.81	46.63	179.72	-111.18	-70.45	-7.05	133.09	285.42	28.54	21.92	13.89	0.69
Scrub Land	388.13	523.78	460.73	135.66	34.95	3.50	-63.05	-12.04	-1.20	72.61	18.71	0.94
Fallow Land	1276.79	778.10	714.97	-498.69	-39.06	-3.91	-63.13	-8.11	-0.81	-561.82	-44.00	-2.20
Waste or Barren Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agricultural Land	10547.32	10435.92	9891.83	-111.40	-1.06	-0.11	-544.09	-5.21	-0.52	-655.49	-6.21	-0.31
Total	14348.37	14200.75	14181.15	-147.62	-1.03	-0.10	-19.60	-0.14	-0.01	-167.22	-1.17	-0.06

(source: author's computation)

3.7.2.6 Influence of Land use change on individual Ecosystem Functions

Ecosystem functions diversly include the habitat along with the biological or system properties or process of ecosystems. On the other hand, ecosystem goods (i.e. food) and services (i.e. waste assimilation) constitute of the benefits human populations obtain, direct or indirect, from ecosystem functions. Because of simpilcity, we willdenote ecosystem goods and services jointly as ecosystem services (Costanza et al. 1997). As per Costanza's examination ecosystem services sorted into 17 main classes that incorporated renewable ecosystem services and disqualified non-renewable minerals and fuels and the atmosphere. Same categorization were used for analysing individual ecosystem function or services in the study area. These groups are listed in Table 3.31

Effects of change of such land use on the individual ecosystem function change within National Capital Region throughout the last 20 years were calculated by following equation 2:

$$ESVf = \sum (\mathrm{Ak} \times \mathrm{VCfk}) \text{…………………….(2)}$$

Where ESV_f represents the calculated value of ecosystem service of function *f*, A_k is the area (ha) and VC_{fk} is the value coefficient of function *f* (\$/ha/year) for land use grouping. The offerings of ecosystem purpose to overall ecosystem services value per annum were graded on the basis of estimated ESV_f for the years 1991, 2001 and 2011, although the overall grading of individual function was on the basis of the mean value of each and every ESV_f for those three years. The inclination in the input of each and every ecosystem function to the total ecosystem services value is numbered in Table 3.31 by an rising arrow for growing, descending arrow for declining in input.

As revealed in table, food production, genetic resources and recreation were added 60% to the total ecological significance or even more. Each of climate regulation, water supply, soil formation and waste treatement has a 5 % contribution or more to the importance of total services from the ecosystem. The contribution of erosion control, biological control, habitat/refugia and raw materials has a a 5 % to 1% function value to the total ecological value. The input of other ecosystem purposes (i.e. regulation of garbage, water regulation, disturbance regulation, pollination, cultural services and nutrient cycling,) was minimal (less than 1%).

The contribution of food production to total value of ecosystem service decreasd from 1991 to 2011. It is fascinating that, while the input of food yeild to the total ecological values decreased from 34.84% in 1991 to 31.08% in 2011, it is placed one rank over three time periods. Among the overall rank of ecosystem functions, the input of recreation, climate regulation, disturbance regulation, water regulation and nutrient cycling has improved over 20 years of time period in NCR, while the contribution of food production, genetic resources, soil formation, waste treatment, water supply, erosion control, gas regulation, raw materials, biological control and habitat/refugia declined through these two decades.

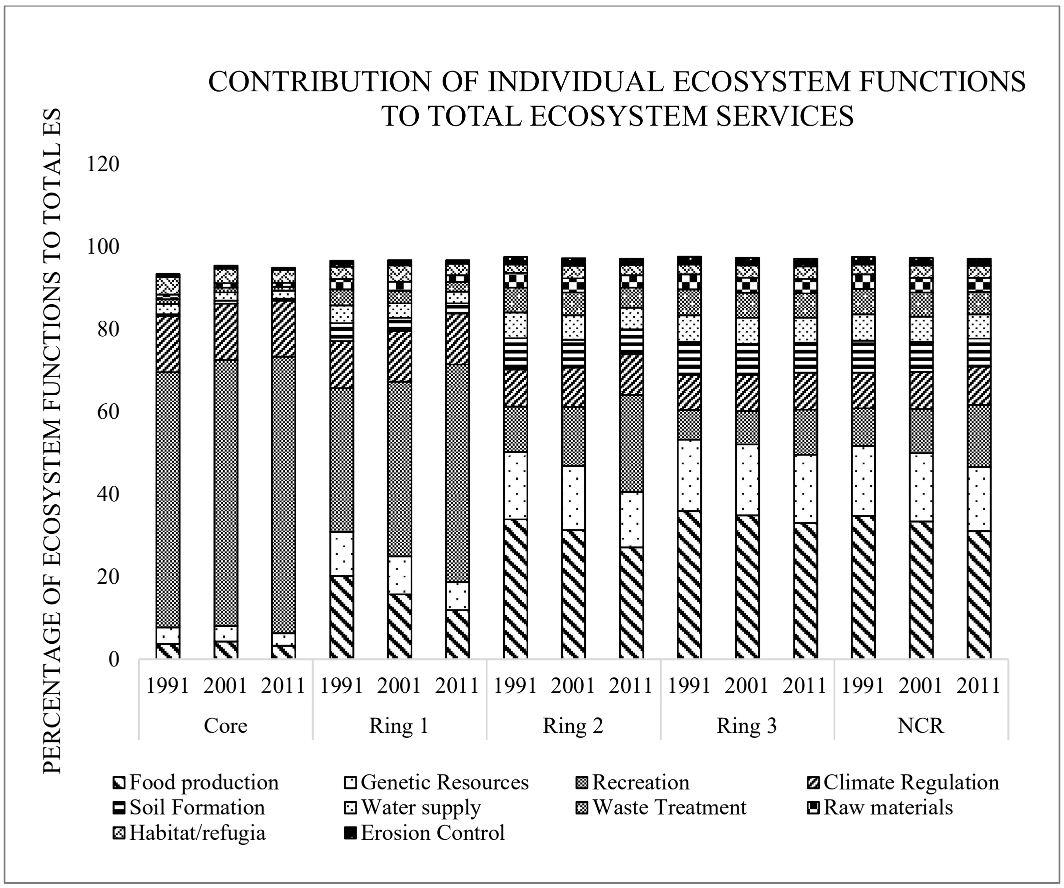


Figure 3.11 Ring-wise contribution of individual Ecosystem Services to total ecosystem services in NCR

If we see the picture (Figure 3.11) of individual ecosystem funtioning at different levels of the NCR region i.e. Core region, Ring 1, 2 and 3, it is overall showing the decline in the food production services resulting question for food security, unequal distribution of services from urban to peri-urban area and also leading pressure on per capita consumption in the study region. Analysis of ecosystem functioning in NCR at zone level is given below:

Core: Among major top ten ecosystem services to total 17 ecosystem services suggested by the Costanza at el methodology, it is found that in core area the recreational services accounted the highest value ($21.44 million) in 1991 and further it has been increased in 2001 and 2011 as well i.e. $22.53 million and $24.07 million respectively. Recreational functions are contributes more than 60% services in the core region that is considered fully urban and highly densified (see table 3.32).

Ring 1: The average of 20 years contribution of individual ecosystem functions in this region shows that recreational services (43.3%), food production (16%) and climate regulation (12%) contributing together more than 60% of services in this region. But the tendency of distribution of these services shows that food production has been in declining trend from 1991 to 2011 whereas recreational services has increased. Other ecosystem functions which contributes more than 5 to 3 % of services are genetic resources, habitat/refugia, waste treatment, soil formation, and water supply in this region. But the tendency of these all these services showing that declining trend (see table 3.33).

Ring 2 In Central National Capital region (CNCR), the average of 20 years ecosystem functioning of this region shows that more than 60% contribution is gaining by the food production services (30.8%), recreation (16.2%) and genetic resources (15%). Ecosystem services flows more than 5% are providing by the climate regulation, waste treatment, soil formaton and water supply in this ring 2. However, the tendency of these services from 1991 to 2011 depicting the decling trend in food production, genetic resources, water supply, soil formation, waste treatment etc. whereas the increasing trend of tendency of ecosystem services is found in recreational services and climate regulation (see table 3.34).

Ring 3: Similar to the other rings this region also showing declining trend in the food production, water supply, soil formation, waste treatment and genetic resources whereas recreational services and climate regulation showing the upward or increasing trend that may be attributed to increasing rate of urbanisation in the NCR. But this region providing the highest food production services among other rings because in these areas like, covering Bhagpat, Meerut, Bulandshar are highly productive areas in context to the crop production such as wheat, rice, sugarcane etc. Also tehsils from Haryana sub region such as Panipat, Rohtak, Jhajjar, Rewari are good producers of the grain crops. The average of 20 years of food production services in this region showing 34.6 % contribution that is highest among other rings but having same decling trend (see table 3.35).

Table 3.31 Estimated annual value of ecosystem functions (ESVf in US$ × 106 /year) over NCR

Ecosystem Function **NCR**	1991			2001			2011			Overall Rank	Tendency
	ESV_f	%	Rank	ESV_f	%	Rank	ESV_f	%	Rank		
Gas regulation	2.92	0.02	17	3.70	0.02	17	3.61	0.02	17	17	⬇
Climate Regulation	1584.73	8.71	4	1611.69	8.96	4	1687.38	9.33	4	4	⬆
Disturbance Regulation	9.60	0.05	16	11.43	0.06	16	11.95	0.07	16	16	⬆
Water Regulation	141.83	0.78	12	151.36	0.84	12	197.03	1.09	11	12	⬆
Water supply	1158.73	6.37	6	1106.65	6.15	6	1056.46	5.84	6	6	⬇
Erosion Control	335.09	1.84	10	327.78	1.82	10	312.61	1.73	10	10	⬇
Soil Formation	1400.35	7.69	5	1307.92	7.27	5	1224.21	6.77	5	5	⬇
Nutrient Cycling	33.34	0.18	14	39.69	0.22	14	41.49	0.23	14	14	⬆
Waste Treatment	1109.33	6.10	7	1054.27	5.86	7	993.65	5.49	7	7	⬇
Pollination	65.61	0.36	13	64.15	0.36	13	60.12	0.33	13	13	⬇
Biological Control	174.77	0.96	11	186.58	1.04	11	185.29	1.02	12	11	⬇
Habitat/refugia	433.89	2.38	9	547.42	3.04	9	536.71	2.97	9	9	⬇
Food production	6340.44	34.84	1	6009.71	33.39	1	5623.57	31.08	1	1	⬇
Raw materials	655.53	3.60	8	633.92	3.52	8	602.26	3.33	8	8	⬇
Genetic Resources	3076.07	16.90	2	2989.32	16.61	2	2809.32	15.53	2	2	⬇
recreation	1660.39	9.12	3	1927.20	10.71	3	2726.64	15.07	3	3	⬆
Cultural	17.17	0.09	15	24.70	0.14	15	20.93	0.12	15	15	⬇
Total	18199.79	100	-	17997.50	100	-	18093.23	100	-	-	-

(source: author's computation)

Table 3.32 Estimated annual value of ecosystem functions (ESVf in US$ × 106 /year) over Core region of NCR

Ecosystem Function **Core**	1991			2001			2011			Overall Rank	Tendency
	ESV_f	%	Rank	ESV_f	%	Rank	ESV_f	%	Rank		
Gas regulation	0.01	0.03	17	0.01	0.02	16	0.01	0.02	16	16	↓
Climate Regulation	4.69	13.55	2	4.79	13.69	2	4.86	13.54	2	2	↑
Disturbance Regulation	0.04	0.12	14	0.04	0.11	14	0.03	0.10	14	14	↑
Water Regulation	1.65	4.78	3	1.03	2.96	6	1.32	3.67	3	4	↑
Water supply	0.82	2.37	7	0.68	1.96	7	0.67	1.88	7	7	↓
Erosion Control	0.26	0.75	11	0.24	0.70	12	0.21	0.59	11	11	↓
Soil Formation	0.18	0.51	12	0.25	0.71	11	0.18	0.50	12	12	↓
Nutrient Cycling	0.15	0.43	13	0.13	0.38	13	0.12	0.33	13	13	↑
Waste Treatment	0.40	1.16	9	0.42	1.19	8	0.35	0.96	8	8	↓
Pollination	0.03	0.08	15	0.03	0.08	15	0.02	0.06	15	15	↓
Biological Control	0.39	1.14	10	0.35	1.00	10	0.31	0.87	10	10	↓
Habitat/refugia	1.46	4.23	4	1.23	3.52	5	1.11	3.10	5	5	↓
Food production	1.32	3.81	6	1.51	4.33	3	1.18	3.28	4	3	↓
Raw materials	0.41	1.18	8	0.39	1.12	9	0.34	0.94	9	9	↓
Genetic Resources	1.36	3.92	5	1.32	3.78	4	1.11	3.09	6	6	↓
recreation	21.44	61.92	1	22.53	64.45	1	24.07	67.07	1	1	↑
Cultural	0.01	0.03	16	0.00	0.01	17	0.00	0.01	17	17	↓
Total	34.62	100.00		34.96	100.00		35.89	100.00		-	-

(source: author's computation

Table 3.14 Estimated annual value of ecosystem functions (ESVf in US$ × 106 /year) over Ring 1 region of NCR

Ecosystem Function **Ring 1(NCT-Delhi)**	1991			2001			2011			Overall Rank	Tendency
	ESV_f	%	Rank	ESV_f	%	Rank	ESV_f	%	Rank		
Gas regulation	0.16	0.02	16	0.20	0.03	17	0.15	0.02	17	17	↓
Climate Regulation	89.18	11.37	3	94.99	12.22	3	101.28	12.37	2	3	↑
Disturbance Regulation	0.72	0.09	15	0.84	0.11	15	0.64	0.08	15	15	↑
Water Regulation	12.69	1.62	10	10.02	1.29	10	15.03	1.83	9	10	↑
Water supply	33.76	4.30	6	27.22	3.50	6	23.19	2.83	5	5	↓
Erosion Control	10.63	1.35	11	9.51	1.22	11	7.43	0.91	11	11	↓
Soil Formation	34.33	4.38	5	25.27	3.25	7	20.38	2.49	7	6	↓
Nutrient Cycling	2.51	0.32	13	2.93	0.38	13	2.22	0.27	13	13	↑
Waste Treatment	29.98	3.82	7	24.02	3.09	8	19.16	2.34	8	8	↓
Pollination	1.76	0.22	14	1.50	0.19	14	1.17	0.14	14	14	↓
Biological Control	8.54	1.09	12	9.11	1.17	12	6.97	0.85	12	12	↓
Habitat/refugia	24.33	3.10	8	30.54	3.93	5	22.42	2.74	6	7	↓
Food production	158.76	20.24	2	122.73	15.79	2	97.74	11.94	3	2	↓
Raw materials	19.73	2.51	9	17.03	2.19	9	13.38	1.63	10	9	↓
Genetic Resources	84.00	10.71	4	71.22	9.16	4	55.65	6.80	4	4	↓
recreation	273.24	34.83	1	329.59	42.41	1	431.84	52.74	1	1	↑
Cultural	0.14	0.02	17	0.46	0.06	16	0.25	0.03	16	16	↓
Total	784.45	100		777.21	100		818.88	100		-	

(source: author's computation)

Table 3.15 Estimated annual value of ecosystem functions (ESVf in US$ × 106 /year) over Ring 2 region of NCR

Ecosystem Function **Ring 2 (DMA)**	1991			2001			2011			Overall Rank	Tendency
	ESV_f	%	Rank	ESV_f	%	Rank	ESV_f	%	Rank		
Gas regulation	0.41	0.01	17	0.62	0.02	17	0.51	0.02	17	17	⬇
Climate Regulation	273.20	8.98	4	284.66	9.50	4	306.89	9.99	4	4	⬆
Disturbance Regulation	1.69	0.06	15	2.24	0.07	16	2.00	0.06	15	15	⬆
Water Regulation	25.86	0.85	12	25.36	0.85	12	38.63	1.26	11	12	⬆
Water supply	191.43	6.29	6	176.08	5.88	6	160.90	5.24	6	6	⬇
Erosion Control	55.25	1.82	10	53.27	1.78	10	47.43	1.54	10	10	⬇
Soil Formation	230.47	7.58	5	204.42	6.82	5	183.00	5.96	5	5	⬇
Nutrient Cycling	5.87	0.19	14	7.78	0.26	14	6.93	0.23	14	14	⬆
Waste Treatment	182.46	6.00	7	166.94	5.57	7	149.22	4.86	7	7	⬇
Pollination	10.48	0.34	13	10.00	0.33	13	8.78	0.29	13	13	⬇
Biological Control	29.40	0.97	11	32.98	1.10	11	29.29	0.95	12	11	⬇
Habitat/refugia	62.26	2.05	9	92.50	3.09	9	76.75	2.50	9	9	⬇
Food production	1032.38	33.95	1	936.65	31.27	1	833.01	27.13	1	1	⬇
Raw materials	108.17	3.56	8	102.23	3.41	8	91.19	2.97	8	8	⬇
Genetic Resources	496.02	16.31	2	469.44	15.67	2	414.31	13.49	3	3	⬇
recreation	334.78	11.01	3	427.32	14.27	3	719.96	23.45	2	2	⬆
Cultural	1.09	0.04	16	2.80	0.09	15	1.72	0.06	16	16	⬇
Total	3041.23	100		2995.30	100		3070.54	100			

(source: author's computation)

Table 3.16 Estimated annual value of ecosystem functions (ESVf in US$ × 106 /year) over Ring 3 region of NCR

Ecosystem Function Ring 3 (Rest NCR)	1991			2001			2011			Overall Rank	Tendency
	ESV_f	%	Rank	ESV_f	%	Rank	ESV_f	%	Rank		
Gas regulation	2.34	0.02	17	2.88	0.02	17	2.95	0.02	17	17	↓
Climate Regulation	1217.64	8.49	3	1227.25	8.65	3	1274.33	8.99	4	4	↑
Disturbance Regulation	7.14	0.05	16	8.30	0.06	16	9.28	0.07	16	16	↑
Water Regulation	101.61	0.71	12	115.08	0.81	12	142.04	1.00	12	12	↑
Water supply	932.71	6.50	6	902.69	6.36	6	871.69	6.15	6	6	↓
Erosion Control	268.95	1.88	10	264.76	1.87	10	257.54	1.82	10	10	↓
Soil Formation	1135.36	7.92	4	1077.98	7.60	5	1020.64	7.20	5	5	↓
Nutrient Cycling	24.82	0.17	14	28.84	0.20	14	32.22	0.23	14	14	↑
Waste Treatment	896.48	6.25	7	862.90	6.08	7	824.91	5.82	7	7	↓
Pollination	53.34	0.37	13	52.61	0.37	13	50.15	0.35	13	13	↓
Biological Control	136.43	0.95	11	144.14	1.02	11	148.72	1.05	11	11	↓
Habitat/refugia	345.84	2.41	9	423.15	2.98	9	436.43	3.08	9	9	↓
Food production	5147.93	35.90	1	4948.83	34.87	1	4691.58	33.11	1	1	↓
Raw materials	527.22	3.68	8	514.27	3.62	8	497.34	3.51	8	8	↓
Genetic Resources	2494.66	17.40	2	2447.35	17.25	2	2338.23	16.50	2	2	↓
recreation	1030.91	7.19	5	1147.77	8.09	4	1550.76	10.95	3	3	↑
Cultural	15.93	0.11	15	21.43	0.15	15	18.96	0.13	15	15	↓
Total	14339.33	100		14190.24	100		14167.76	100			

(source: author’s computation)

3.7.3 Loss of agricultural land and ecosystem services

Agriculture is a dominant land use in India, which is 60.41% (World bank, 2014) to total area and it has a agro-based economy. India is urbanising rapidly which putting pressure on agricultural land. Similariliy, National Capital Region showed the shrinkage of agricultural land. As from the analysis of ecosystem services valuation also confirmed that agricultural land has been declined which can recognized to the enhance in the built up area and also increase in the popultaion in this region.Before analysing loss in agricultural land , it is vital to study the agro ecosystem services and disservices from agriculture.

Agriculture ecosystem supply humans with food, bio-energy, pharmaceuticals and forage and are necessary for human well being (Power, 2010). Those ecosystem services from cultivation, assorted as purveying services by the current 'Milleninnum Ecosystem Assessment'. It also produces a range of ecosystem services, like regulation of water quality, soil, carbon sequestration, climate regulation through green house gas emmission, flood control, disease regulation, waste treatment, cultural services and sustain biodiversity. It also recives ecosystem dis-services that diminish productivity or enhance production costs (Zang et al., 2007). The following figure (3.12) dipicting the secosystem services and dis-services to and from cultivation.

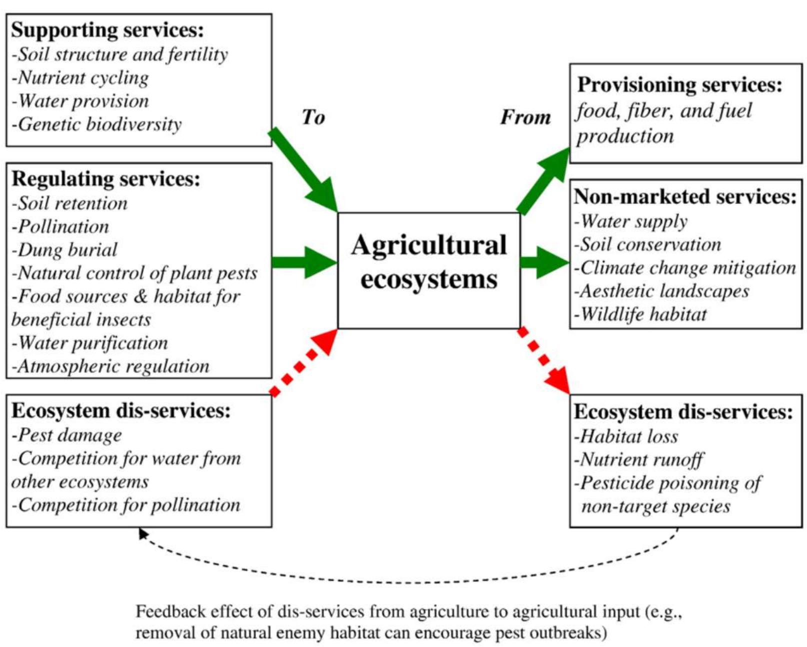


Figure 3.12 Ecosystem services and dis-services to and from agriculture

Source: adopted from Zang et al., 2007

3.7.3.1 Ecosystem services to agriculture

Soil ferlity and structure play an important role in shaping where diverse kinds of agriculture happenand the amount and quality of farming output. Earthworms as well as macro- and micro-invertebrates enhance soil structure through burrows or casts and improve soil fertility via limited communition and absorption of organic matter in soil (Edwards, 2004). *Crop Pollination* is important ecosystem service which is performed by insects. The cultivation of 75% or more of the most significant crops of the world that supply humanity and 35% of the food farmed is reliant on animal pollination (Klein et al., 2007). *Water purification* and *provision* fulfill necessities for water of adequate amount, purity and timing for agrarian production (Zang et al., 2007). 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). Forests also can soothe soil to diminish sediment load in rivers. Another important service is *Natural control of plant pest*. The arthropod predators, insectivorous birds and birds eat the non-crop inhabitants and thus operate as natural foes to agrarian pests and supply biological pest control in agricultural ecosystems (Tscharntke et al., 2005). In the short run, this ES inhibits pest harm and amends yield, although in the long-run preserves an ecological stability that prohibits herbivore insects from getting pest status. *Genetic biodiversity* supplies the raw substance for natural assortment to create evolutionary adaptation. It is not only significant to avoid catastrophic fatalities, but also amending or taking care of agrarian output (Zhang et al., 2007). *Landscape influences* is extremely reliant on the construction of the land with the agroecosystem entrenched in it. Water availability is affected due to flow patterns of landscape and diversion of water for other uses (Power et al., 2010). Agrarian intensification can endanger many of the ecosystem services supplied by the land (Matson et al., 1997).

3.7.3.2 Ecosystem dis-services to agriculture

Agroecosystems are necessary sources of purveying services but relying on their arrangement and managing, they may also supply to dis-services like agrochemical pollution and sedimentation of waterways, loss of biodiversity, pesticide intoxication of non-target organisms, and discharge of greenhouse gase and pollutant (Dale &

Polasky, 2007; Zang et al, 2007). The agriculture ecosystem can increase or decrease supply of these services. Today the world is rapidly growing in population size so to gather the increasing demands of population there are two ways to increase productivity : intensification or extensification. Intensification may be manifested in the form of additional production per unit area via capital investment or raise in labour inputs' (Scoones, 1998). On the other hand , processses of agricultural extensification entails bringing of more land under cultivation (Scoones, 1998). Intensification of agriculture signifies the more chemical inputs and other services for getting more production that leading to decreases nutrients in an ecosystem by affecting biogeochemical cycles. The two nutrients that most bound biological construction in natural and agrarian ecosystems are phosphorus and nitrogen, and also they are greatly functional in agroecosystems. Phosphorus and nitrogen fertilizers have deeply enlarged the quantity of new phosphorus and nitrogen in the biosphere and resulted into compound, often destructive, results on natural ecosystem (Vitousek et al., 1997; Power, 2010).

3.7.3.3 Intensification of Agriculture in National Capital Region, India

Extension of arable land is broadly accepted as one of the most important human modifications to the environment in the global scale (Meyer & Turner 1992; Matson et al., 1997). The world's cultivated area has grown by 12 percent over the last 50 years whereas the pace of development has slowed down, yields (crop produced per unit land area) have improved drimatically over these years (FAO). This remarkable change is based upon the intensification of agricultural land via the apply of high-yielding kind of crop, pesticides and chemical fertilizers, mechanization and irrigation. In India, this amplification has began in the late 1960's with the introduction of high-yielding variety seeds into agriculture. This face in India generally known as 'the Green Revolution'. The growth in this period was qualified by output-led development. Soon negative exteriorities of the technological modifications began growing in diverse forms (Deshpande et al., 2004, Bhalla, 2007).

However, the consequenses of intensification have developed a concerns over long term sustainability of agriculture systems and environment. It has negative consequences at the local level, such as lower soil fertility, worse erosion, and declined biodiversity; negative consequences at the regional level like pollution of ground water and eurthopication of lakes and river; and negative consequences in global level counting affects on climate and atmospheric constituent (Matson et al., 1997; Chakravorty et al., 2007; Firbank et al., 2008).

Arable land is gradually more being deprived owing to urbanisation and land abandment, for economic causes and owing to deprivation of productivity (Millennium Ecosystem Assessment, 2005b). The conversion of natural to arable land was mostly fulfilled several decades ago all over NCR. The following (Table 3.36) available land use data from 'Directorate of Economics and Statistics', Department of Agriculture for National Capital Region showing land use dynamics from 2001 to 2011.

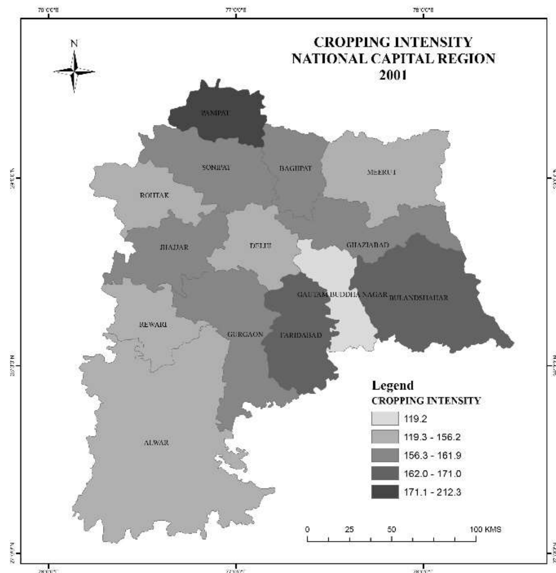
Table 3.36 Land use categories and cropping intensity in sub-regions of NCR for 2001 and 2011.

Region	Year	National Capital Region					
		% Forest	% Land not available for agriculture	% Other Uncultivable land excluding fallow	% Fallow	% Net Sown Area	Cropping Intensity
Haryana	2001	2.1	14.3	2.7	3.6	77.3	163.5
	2011	3.3	16.7	1.7	4.9	73.4	163.5
NCT Delhi	2001	0.7	60.8	7.6	7.8	23.1	155.2
	2011	1	62.9	7.5	13.6	15	200.9
Rajasthan	2001	9	17.4	4.3	4.3	65	154.2
	2011	10.7	16	4	4.5	64.7	169.4
UP	2001	3.3	14.3	2.9	4	75.5	155.9
	2011	0.7	17.8	3.2	2.6	75.6	170.6
Total	2001	4	17	3.3	4.1	71.5	158.7
	2011	3.9	19	3.1	4.3	69.7	168.2

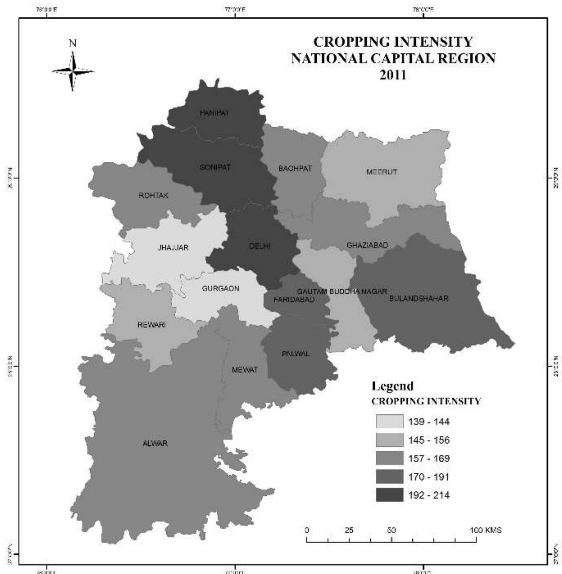
(Soucre: Directorate of Economics and Statistics, Department of Agriculture)

This table showing the dynamics of land use change from 2001 and 2011. It is demostrated that in the whole NCR percentage of forest cover has slightly declined from 4% to 3.9% in ten years. Area under uncultivated land has increased from 17% to 19% which may be attributed to the area under built up and other non-agricultural uses. Whereas from 2001 to 2011, fallow land is increased marginally from 4.1 percent to 4.3 percent. The important category under this classification of land use is net sown area which is the physical extent to which land has been brought under cultivation. So it is important to see how its proportion to total area in respective areal units has changed over time. From 2001 to 2001, net sown area in whole NCR has declined from 71.5% to 69.7%. The highest decline is accounted in the NCT-Delhi 23.1% in 2001 to 15% in 2011 followed by Haryana sub-region 77.3% in 2001 to 73.4%. Rajasthan and Uttar Pradesh sub-region shows slight decline in net sown area from 2001 to 2011.

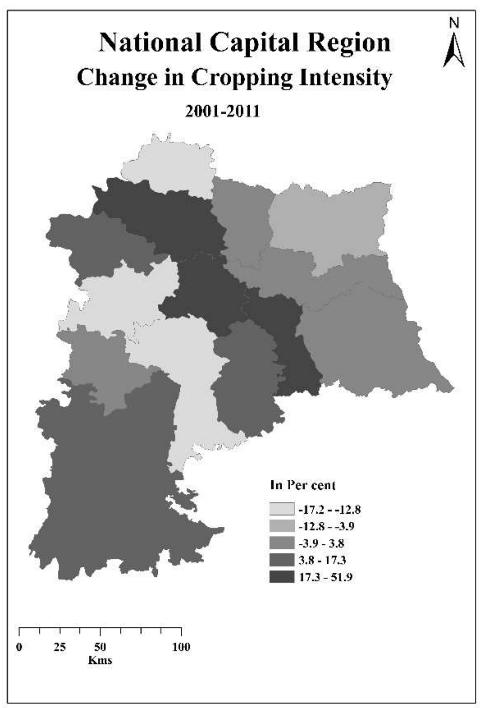
It is clear from the above results that net sown area is declining due to a pressure on agricultural land for production of crops to fullfill the demands of residing population. Therefore, for getting maximum output and fulfilling the demands, agriculture intensification is seen in National Capital Region. As we can see from the Table 3.36 and Map 3.11, it is very clearly shown that cropping intensity has increased by 9.2 percent in these ten years. From the Map 3.11 spatial pattern of cropping intensity shows that the maximum intensification was in the northern part of Haryana sub-region and NCT-Delhi. In 2001, cropping intensity was highest in Panipat district whereas in 2011 the highest intensity found in Sonipat, Panipat and NCT-Delhi followed by other districts Faridabad, Bulandshar, Ghazizbad.



Map 3.11 Cropping Intensity over NCR (2001)



Map 2.12 Cropping Intensity over NCR (2011)



Map 3.13 Change in Cropping Intensity over NCR (2001-2001)

Futhermore, the increasing consumption of fertilizers leading to a degradation in the nutrients of the soil which also effecting the surface and groundwater conditions. A common consequence of agrarian fertilization with N is the discharge of nitrates from soils to water arrangements, which leads to improved absorption of nitrates in downstream surface water systems and drinking water as well (Maston et al., 1997).

The below table shows that per hectare amount of the nutrients being applied to agriculture is increasing over the time in NCR. This practice has increased crop productivity on one hand

Table 3.37 Consumption of Fertilizers in NCR (2001-2005)

Consumption of Fertilizers (Kg/ha) in NCR				
	N	P_2O_5	K_2O	Total
2001-02	1589.21	505.34	26.96	2121.52
2003-04	1632.97	519.38	51.42	2203.73
2004-05	1661.63	518.71	63.41	2243.74

Source:https//www.indiastat.com/

but on other, it 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 the 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.

Another importand aspect of changing in cropping intensities are changing in the cropping pattern. In India, the modification in the pattern of land use and cropping is immensely impacted by swift urbanisation. The major dynamic in cropping pattern, observed in India, is a extensive area transfer from cereals to non-cereals crops (Singh, 2000). The status of horticulture in NCR also reveals that the area plus output has rapidly increasing. With the available data on horticulture for the year of 2013-14 and 2014-15 from the Department of Agriculture Cooperation & Farmers Welfare (http://agricoop.nic.in/), also confirmed that the practice of growing fruits and vegetables in most part of the NCR has increasing.

Table 3.38 Area of crops under horticulture in hectares A) 2013-14, and B) 2014-15

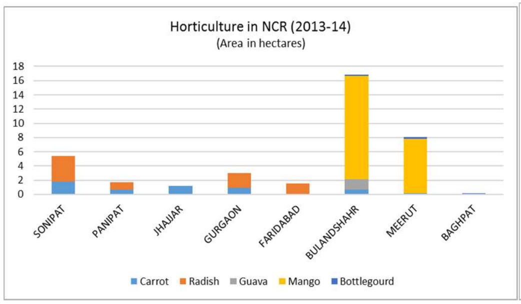
A

DISTRICTS	2013-14 Area (in hectares)				
	Carrot	Radish	Guava	Mango	Bottlegourd
SONIPAT	1.8	3.62	0	0	0
PANIPAT	0.69	1.02	0	0	0
JHAJJAR	1.19	0	0	0	0
GURGAON	0.951	2.072	0	0	0
FARIDABAD	0	1.55	0	0	0
BULANDSHAHR	0.63	0	1.528	14.489	0.185
MEERUT	0.182	0	0	7.621	0.228
BAGHPAT	0	0	0	0	0.136

B

DISTRICTS	2014-15 Area (in hectares)				
	Carrot	Radish	Guava	Mango	Bottlegourd
SONIPAT	2.86	3.4	0	0	0
PANIPAT	2.24	2.03	0	0	0
JHAJJAR	1.208	0	0	0	0
GURGAON	1.075	2.04	0	0	0
FARIDABAD	0	1.52	0	0	0
BULANDSHAHR	0.922	0	1.559	14.496	0.262
MEERUT	0.266	0	0	7.625	0.322
BAGHPAT	0	0	0	0	0.191

A



B

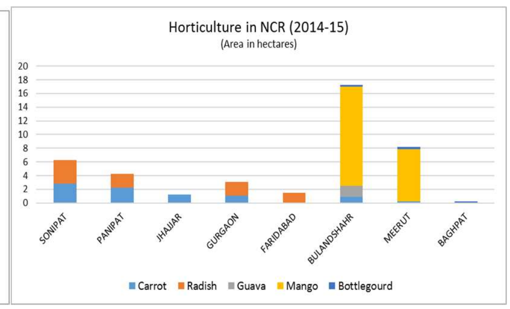


Figure 3.13 Area of crops under horticulture in hectares A) 2013-14, and B) 2014-15

Table 3.39 Production of crops under horticulture in mt A) 2013-14, and B) 2014-15

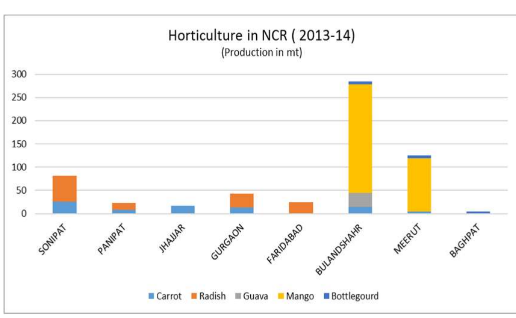
A

DISTRICTS	2013-14 Production (In metric ton (MT)				
	Carrot	Radish	Guava	Mango	Bottlegourd
SONIPAT	25.5	55.7	0	0	0
PANIPAT	7.95	15.2	0	0	0
JHAJJAR	16.85	0	0	0	0
GURGAON	12.97	29.75	0	0	0
FARIDABAD	0	24.05	0	0	0
BULANDSHAHR	15.068	0	29.095	234.401	5.394
MEERUT	4.34	0	0	114.751	6.632
BAGHPAT	0	0	0	0	3.967

B

DISTRICTS	2014-15 Production (In metric ton (MT)				
	Carrot	Radish	Guava	Mango	Bottlegourd
SONIPAT	30.4	61.8	0	0	0
PANIPAT	25.6	20.54	0	0	0
JHAJJAR	17.77	0	0	0	0
GURGAON	13.3	29.4	0	0	0
FARIDABAD	0	23.05	0	0	0
BULANDSHAHR	22.874	0	30.127	251.911	7.614
MEERUT	6.588	0	0	123.323	9.362
BAGHPAT	0	0	0	0	5.599

A



B

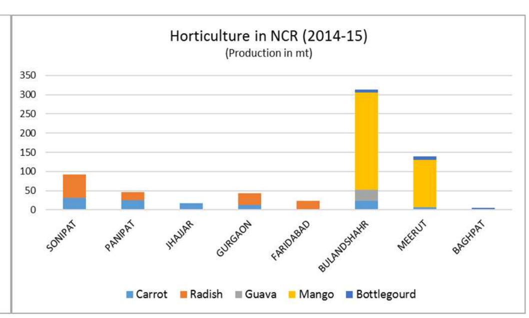


Figure 3.14 Production of crops under horticulture in mt A) 2013-14, and B) 2014-15

In NCR, from 2013-14 to 2014-15, there is 57.5% increament in the area of Carrot followed by Bottlegourd (41.2%) , Radish (8.8%) , Gauva (2%) and Mango. Similarily, the production of these crops has increased. Carrot shows 40.9% increase in the production followed by Bottlegourd (41.2%), Radish (8.1%), Mango (7.5%) & Gauva. Overall, we can say that the rise in cropping intensities has been one of the factors responsible for increasing the risk of degradation of other ecosystems including land, water, air and threatining sustainability.

Hopefully, this chapter could contribute to an improved consciousness of the ecosystem services which could further add to an additional resource-efficient city arrangement and planning. The understanding of effects of urbanisation on ecosystem services also could refer that undeveloped urban areas can be preserved or even stretched out. As haphazard urban growth in NCR cities are anticipated to develop at a swift pace in the upcoming decades which maintaining stress on environment, it is significant that the ecosystems and its services in urban areas, provide them, are realized and appreciated by political decision makers and city planners (Bolund et al. 1999).

In the next chapter, the assessment of ecosysetm services will be better understood by the InVEST derived crop production and water yield modeling in order to see the variations in the provisoning ecosystem services across districts of National Capital Region. Further it expalins the limitations of Costanza et al. 2014 methodology which expained in this chapter and provide better results at spatial and temporal scale in NCR in terms of assessment of ecosystem services.

Chapter-4

MODELLING OF ECOSYSTEM SERVICES AND ITS LOSSES

4.1 Introduction

Ecosystem services are the benefits we obtain from ecosystem for well-being of mankind. These are provisioning, supporting, regulating and cultural services including provision of water, food supply, wood, pollination of crops, wildlife-based tourism and climate regulation. Ecosystem services are product of three fields: conservation of biology i.e. reflection of biodiversity, development (sort of poverty alleviation crowd) and, ecological economics (people who are valuing and monetizing the different types of externalities. It is an interesting to see that how these three fields come together to create this new field of Ecosystem Services including its own vocabulary, its own methods, and own frames of reference so in a view these methods are trans-disciplinary phenomena. Ecosystem services field originated in the biodiversity field but it is increasingly allowing for nurturing the sustainable development. Linking ecosystem services, natural capital and human being is the cascade model. Only benefits can be evaluated. Throughout the past decade, progress has been completed to understand how ecosystems supply services and how service condition got translated into economic significance (Daily, 1997; NRC, 2005; MA, 2005; Nelson et al., 2009). Some international bodies that are conducting research on this area are the UK 'National Ecosystem Assessment' (NEA), 'The Economics of Ecosystems and Biodiversity' (TEEB), 'Common International Classification of Ecosystem Services' (CICES), 'Millennium Ecosystem Assessment' (MEA) etc. The 'Millennium Ecosystem Assessment' has accounted a widespread decrease in ecosystem services throughout the world. Research done by MEA has accented the critical need to integrate services into the process of decision making in order to make sure human well-being, at present and in future. The recent initiative that have been taken by the Future Earth's Mission is to proceed Global Sustainability Science, put together capacity in this swiftly growing area of research and supply an international study agenda to direct natural as well as social scientists functioning in the world. In this context, the Future Earth's Mission recognized a plan related to global strategy for biodiversity including the targets like restoration and protection of ecosystem services needs to get accomplished by 2025.

Economists are increasingly recognizing that environmental functions or 'ecosystem services' support and protect economic activity and thus have an economic value (Aylward and Barbier, 1992). The economic valuation of ecosystem services is becoming an effective way to understand the multiple benefits provided by ecosystems (Guo et al., 2001). A few studies have tried to estimate the values of a variety of ecosystem services. Peters et al., (1989) presented an assessment of the economic value of a tropical Amazon rainforest in Brazil and proposed a strategy for sustainable use of rainforest in the region. Most notably, Costanza et al., (1997) attempted to estimate the global biosphere values of 17 ecosystem services provided by 16 dominant global biomes. Thereafter, Kreuter et al., (2001), Zhao et al., (2004), Wang et al., (2006) and Li et al., (2007) used the generalized coefficient to evaluate ecosystem services at regional level in their studies.

The modelling and representation of ecosystem services through maps are significant components in process of decision-making with the aims to advance recognition and relevance of services (Daily & Matson 2008). Importance of using different models at various scales and region is an important topic to study nowadays. The number of researchers had been engaging to find out the best summarizing models that could link ecosystem services to the society and sustainability of these services at global level. Recently research on linking change in land use and ecosystem services has grown rapidly (Qui et al., 2013; Costanza et al., 2014; Seto, 2016 etc.), but understanding their relationship with society has always been challenging. Therefore, there is need to understand the model perspective part of ecosystem services for balancing human well-being with the maintenance of critical ecological processes (Perrings et al., 2011). Modelling is an essential tool for the development of strategies that will ensure their future supply, provision and quantification (Horea, 2015) and also important for decision makers and institutions, enabling them to spatially identify which areas should be maintained due to their high or low supply of ecosystem services (Balvanera et al., 2001). Examples of models that have been used these days are IMPACT (computes demand, trade, global food supply and international food costs for regions and countries. Rosegrant et al., 2002); WaterGAP (computes global water use, availability, stress, and return flows along a river basin scale. (Alcamo et al., 2003); AIM (calculates land cover and other indices of worldwide global change, with an focus on Asia (Kainuma et al., 2002); IMAGE 2.2 (calculates global land cover and climate on arid level and numerous other indices of change at global level (Alcamo et al.,1998 and IMAGE-team 2001); Ecopath with Ecosim (calculates vibrant changes in selected marine ecosystems as a purpose of fishing labors (Pauly et al., 2000); model of Terrestrial Biodiversity (calculates combined dynamics in terrestrial biodiversity as a purpose of habitat loss, nitrogen deposition, introduction of alien variety and climate change (Sala et al., 2005) etc.

4.1.1 Approaches to model Ecosystem Services

In the recent past, given the paramount importance of ecosystem services for decision making, there was a rapid addition in numerous studies that map their spatial distribution. These mapping approaches can be broadly divided into three main categories: **1)** Valuation of ecosystem services through **benefit transfer** that implements a financial importance to a map of land cover on the basis of preceding studies from sites with alike types of land cover (Costanza et al., 1997; Kreuter et al., 2001; Sutton and Costanza, 2002; Wang et al., 2006; Troy and Wilson, 2006; Turner et al., 2007; Costanza et al., 2014); **2) Community value methods** that have included spatial measures of social importance and other perceptual experience of place obtained through preference surveys of ecosystem services maps that systematically integrate these perceptions with biophysical data (Brown, 2005; Raymond and Brown, 2006; Raymond et al., 2009; Sherrouse et al., 2011), and **3) Social-ecological assessments** of the ES supply that have modelled the relationship between measurable ecological (e.g., field samples of services, climate, land cover, hydrological, remote sensed data) and social variables (e.g., population, census data, road layers etc.) to enumerate and mapping the amount of ecosystem services supplied through space (Chan et al., 2006; Naidoo et al., 2008; Nelson et al., 2009; Eigenbord et al., 2010a). For example, spatially precise modelling tool, on the basis of ecological invention functions and economic assessment methods, called 'Integrated Valuation of Ecosystem Services and Tradeoffs' (InVEST) is worn by researchers (Nelson et al., 2009).

4.1.2 Nature of Models

The nature of models that are being used for valuation of services from ecosystem can be separated into parametric and non-parametric models. Parametric models are those models which capture all its information about the data within its parameters or say these models assumes limited set of parameters and by given data, future anticipations are autonomous of the experiential data. For example, with context to valuation of ecosystem services models, benefit transfer models or market-based approach and spatially explicit models are parametric in nature where a set of indicators are available and determined the future scenario. Conversely, community value methods are non-parametric that accept the data allocation cannot be distinct in terms of such a restricted set of parameters.

4.1.3 Relevance of InVEST model in study area and limitations

The current studies on modelling and mapping the ecosystem services are determined in limited countries and are still missing in research on Asian countries. However, arable land or loss of habitat and consequential biodiversity loss is considered to be a problem in global scale and it is also more important in the Asian countries as the increasing demand for food supply and increasing population leading to the pressure on arable landscape which resultantly impacted the productivity capacity (via intensification and land degradation) of ecosystem and polluted the environment, impacting socio-ecological sustainability and livelihood security and thus exacerbating existing social and economic vulnerability. Furthermore, the workings that sought to analyze the overlie between areas providing services and areas that turning into built landscape are still emergent and have conflicting results (Chan et al., 2006; Naidoo et al., 2008). This proposes a need to expand this sort of research, typically in spaces where present human action can harm the natural capital conservation.

Here, study of the National Capital Region in earlier chapter showing the results of negative impacts of urbanisation on ecosystem services like loss of food production, genetic resources, soil formation, water supply, raw materials, gas regulation etc. Thus, in NCR, the human need for economic insistences and services on environment demonstrate the necessity to include economic externalities and human well-being into preservation science. Henceforth, I have used InVEST model for my study due to the open access and efficient model for analysing crop yield and water yield in the study region. This model is significant for the purpose to enables decision makers to assess quantified trade-offs associated with alternative management choices and to identify the areas where investment in natural capital can enhance human development and conservation (see www.naturalcapitalproject.org).

Limitations: The present edition of the model is a common global model determined typically by climate and unusually by management. Therefore, this model is not capable to detain the deviation in output that occurs throughout heterogeneous landscapes. As for example, a rocky hill gradient and a fruitful river valley, whenever they distribute the similar climate, would be allotted the same acquiesce in the present model. This will be a problem if the query of concern is there: where to give priority to future habitat adaptation; or where cultivation is most fruitful and least critical.

Spatial downscaling of the present common global model is needed to create the crop model further helpful in land-use decisions in local level. Our move will be toward acquiring local output data which can be equated to the regression model outcomes to establish where the model is overrating output and where it is underrating. The consequential deviations can be connected to different variables such as slope, elevation, aspect, soil depth and soil fertility and any important associations can be worn to purify the present model. Still the common model will be worn to appear at the general degree of output for a given intensification level and climate, and the finer-scale departures will fundamentally tune the common model up or down. To do that we require:

- Field-level (or improved) yield data throughout an extensive demonstration of climate, soils and topographies.
- Topographic data and Soil at the similar level of declaration as the acquiesce data

This chapter basically deals with an assessment of ecosystem services for crop yield and water yield modelling by using InVEST.

4.2 MATERIALS AND METHODS

4.2.1 Data used

The data for this chapter has been taken from the Project work funded by ESPA (Ecosystem Services for Poverty Alleviation) on 'Risk and Responses to Urban Future' in India, conducted by the research team of STEPS Centre, UK; IWMI International Water Management Institute, India & Nepal; Centre for Studies in Science Policy, Centre for Social Medicine, Community Health, and Centre for Studies in Regional

Development, Jawaharlal Nehru University, India; University of Sussex, UK; Department of Botany, Banaras Hindu University, India during 2014 to 2016.

4.2.1.1 Data used for crop production modelling

According to the InVEST software requirement for the modelling of crop production, firstly, land use and land cover data has been acquired from MODIS EVI 16-day product (MOD13Q1) for the 2002-03, 2004-05 and 2011-12 years. Secondly, data for fertilizer were acquired from the Monfreda Global Dataset (Monfreda et al., 2008 Mueller et al., 2012). Further observed yield data was collected from Directorate of Economics and Statistics, Ministry of agriculture, GOI. Another requirement for the model was nutrient content table that is given already in the InVEST model sample dataset. And lastly, Economics Table (CSV) is used that contains the information related to market price of a given crop and the costs involved with producing that crop, acquired from the Directorate of Economics and Statistics, MoA, GOI.

4.2.1.2 Data used for water yield modelling

Data that has been used for the water yield modelling is given below in table:

Table 4.1 Data used for the water yield modelling

Data used	Source	Year
Precipitation (mm)	India Water portal	2001-2011
Reference Evapotranspiration	India water portal	2001-2011
Root restricting layer depth (mm)	FAO	2001
Plant available water fraction (mm)	FAO	2001
Land use and land cover	USGS	2001-02, 2011-12
Watersheds	UNU-INWEH	2011

4.2.2 Methods

4.2.2.1 Crop Production Modelling using InVEST

From the existing data, the crop production model i.e. InVEST has produced estimations about the crop yield. For existing or modelled crop yields, the estimates about the crop value can also be generated by the model. The output provided by this model includes Crop Yield Map (tons per-hectare yield for a given crop) and Crop

Production Map (total production in tons per pixel or cell's area). The following steps are representing the process for building crop production maps:

i) Crop mapping: Crop cycle phenology information generated using MODIS EVI 16-day product (MOD13Q1) & integrated contextual information from local crop calendar. MOD13Q1 is 16-day composite of enhanced vegetative relative product with 250 m spatial resolution.

ii) Temporal smoothing out of EVI data using Savitzky-Golay filter

The extracted crop pixels of each individual 16 day EVI composites were stacked together to develop an image hypercube with 23 layers from Julian Day 129 (May; Kharif) of 2011 to Julian Day 113 (April; Summer) of 2012. The spectral profile of each and every pixel from that hypercube shows the EVI time signal, recorded throughout all 23 layers. The progression of this time signal although showing periodic pattern, but are perturbed with random effect over the entire time span due the effect of thick cloud and aerosol. Despite of the fact that the present EVI data were adjusted to avoid the influence of aerosol, the existence of thick layer of cloud in a pixel across the composite period which includes 16 days, make the surface reflection difficult to reconstruct (Sakamoto et al., 2005).Savitzky-Golay filter for temporal smoothing has been used to get smoothened curve with the help of reduction in the random effect (Chen et al., 2004; Mingwei et al.,, 2008). The filter replaces each data value I_i, i = 1,……N by a linear combination of nearly value in the moving window. Unlike moving average, it approximates each data values by fitting least square polynomials. For each data value, it fits a quadratic polynomial (Eq. 1) to approximate the value.

$$F(t) = \beta_0 + \beta_1 t + \beta_2 t^2 \quad \text{……………………… (Eq 1)}$$

F(t) is the reconstructed EVI value and β_0, β_1, and β_2 are the coefficients and t is the time series signal of EVI. Since crop shows distinctive seasonal pattern, this fitted smoothed signal of EVI is used to trace the phonological matrices.

iii) Fourier Analysis

The intensity of the signal dispensation of Fourier analysis was tackled by numerous authors to examine the vegetation phonology using only the phase term and amplitude of the most significant periodic constituent (Azzali & Menenti, 2000; Canisius, Turral & Molden, 2007; Galford et al.,, 2008; Jakubauskas, Legates, & Kastens, 2002;

Menenti, Azzali, Verhoef, & Van Swol, 1993; Mingwei et al.,, 2008; Son, Chen, & Cru, 2012). The phase term and amplitude, conveying the maximum number of EVI in a given crop cycle and the time of its occurrence can easily be calculated through distinct Fast Fourier Transformation (FFT). When observed discrete data is recorded at a regular interval t times, the interval from origin time to end is go with the progression t_i, i = 1,…..N. For this uniformly sampled data, N is the total length of the period. The Fourier transform of that distinct series is articulated as

$$y(t) = a_0 + \sum_{k=1}^{m} \left(A_k \cos\frac{2\pi kt}{N} + B_k \sin\frac{2\pi kt}{N} \right) \quad \text{…………………(Eq 2)}$$

$y(t)$ is the fitted signal, a_0 is constant, K is integer frequency or order of the harmonic term, A_k and B_k are the Fourier coefficients of real and imaginary part and can be computed as follows:

$$A_k = \frac{2}{N} + \sum_{t=1}^{N} y(t) Cos(\frac{2\pi t}{N}) \quad \text{………………………………..(Eq 3)}$$

$$B_k = \frac{2}{N} + \sum_{t=1}^{N} y(t) Sin(\frac{2\pi t}{N}) \quad \text{…………………………………(Eq 4)}$$

We used Fourier transform subroutines here embedded in ENVI 5.1 implemented by Interactive Data Language (IDL, Research System Inc, Boulder, USA).

The phase term and amplitude derived from Fourier analysis were linked with information of crop type (Jakubauskas et al., 2001). The extracted phase term and amplitude of all the selected harmonic orders were merged together and after that unsupervised ISODATA clustering has been done. We have initiated the clustering with 50 classes which later merged into 6 classes under different crop systems. The estimated area under selected cropping systems was validated with reported area under the same crops by Ministry of Agriculture. Finally, time series EVI pixels classified as six crop system.

iv) Observed Regional yield: The crop yield model provisions experimental yields, based on sub-national datasets and FAO for 175 crops in tonnes/ha (Monfreda et al., 2008). Whenever, a type of crop presented by the user which is not developed in that region, then, the model will not provide information for these pixels; crops can be displaced around within an area in which they got developed, but major cropping systems cannot be enclosed in minimum mode. Likewise, the model will deliver accessible inputs for that particular crop (in that particular region), as the share of irrigated land (for 15 crops with available data), and quantity of N, K and P applied/ha (for 140 crops with available data). The model can present nutrition data for each crop and economic output if data related to supplementary cost is supplied for fertilizer, nutrients, machinery, seed, and labor (in 2012, this data is formerly included in the model for 12 staple crops: wheat, barley, rice, maize, potato, sugar cane, rapeseed, oil palm, rye, soybean, sunflower, and sugar beet).

Crop Production Modelling

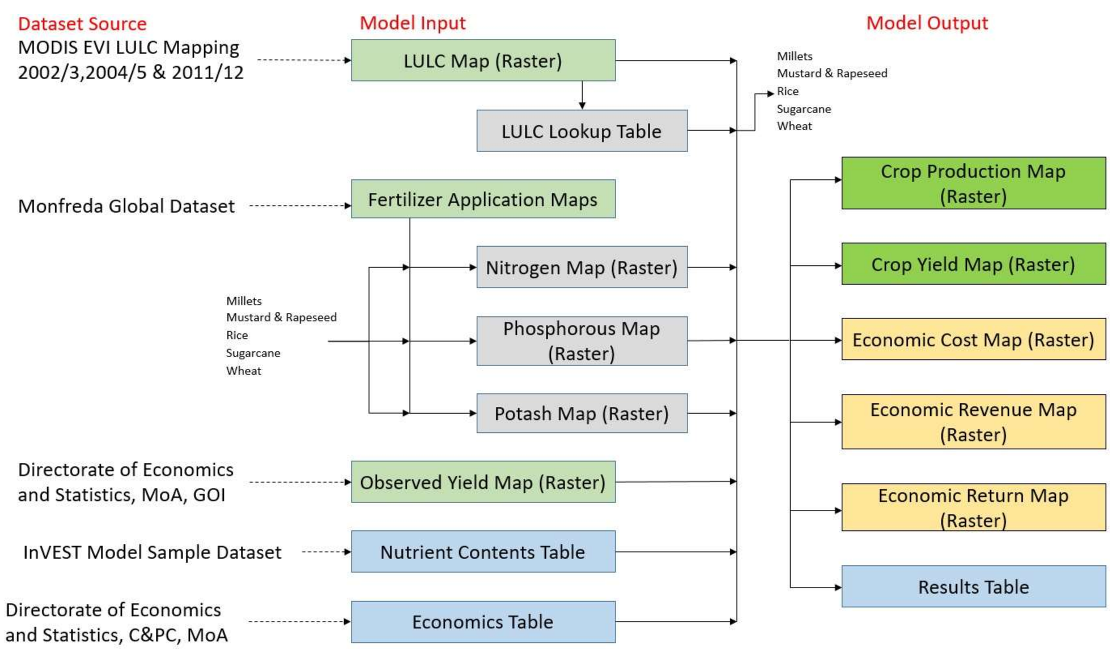
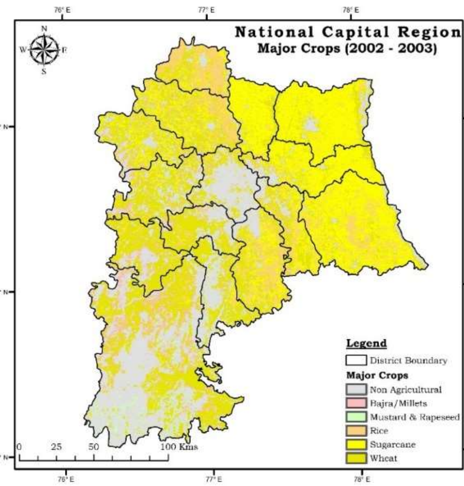


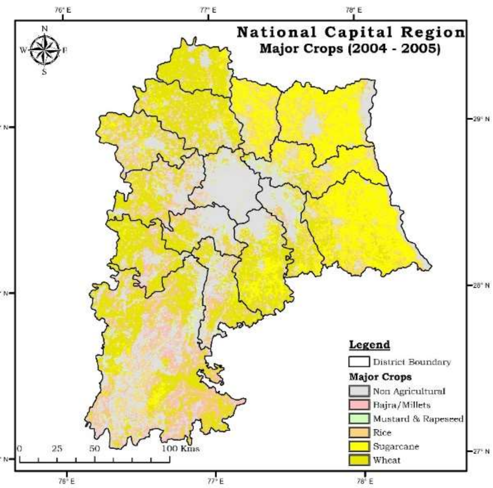
Figure 4.1 Schematic diagram of Crop production model

v) Inputs required for crop production modelling

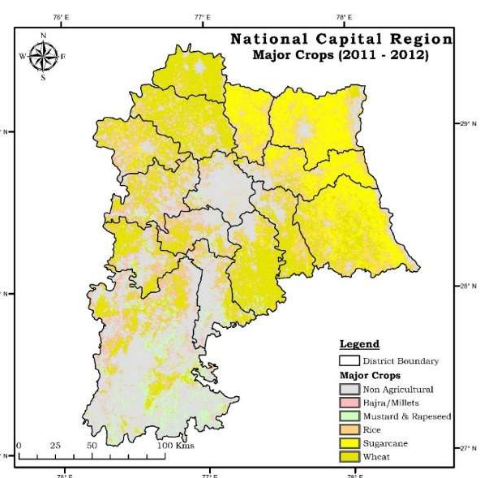
a)



b)



c)



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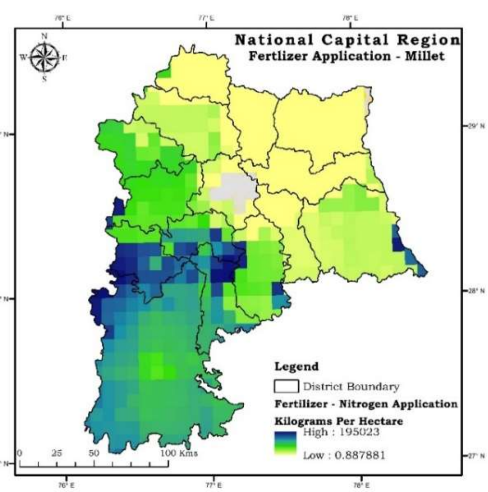
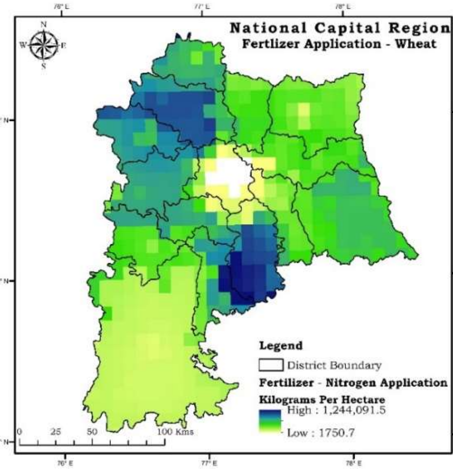
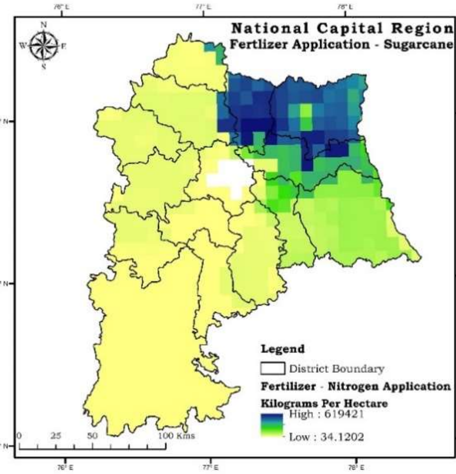


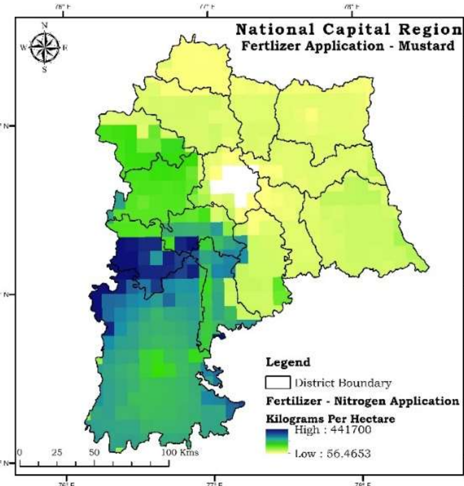
e)


National Capital Region
Fertlizer Application - Wheat
Legend
District Boundary
Fertilizer - Nitrogen Application
Kilograms Per Hectare
High : 1,244,091.5
Low : 1750.7
0 25 50 100 Kms

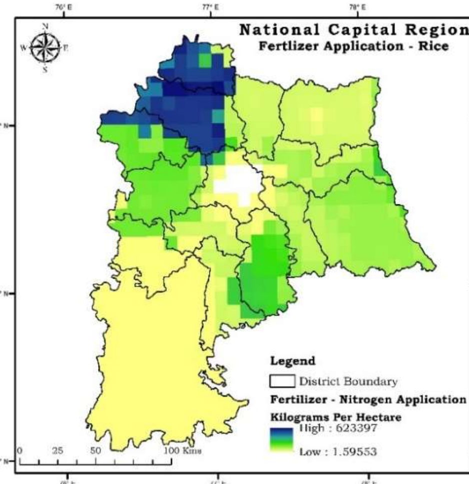
f)


National Capital Region
Fertlizer Application - Sugarcane
Legend
District Boundary
Fertilizer - Nitrogen Application
Kilograms Per Hectare
High : 619421
Low : 34.1202
0 25 50 100 Kms

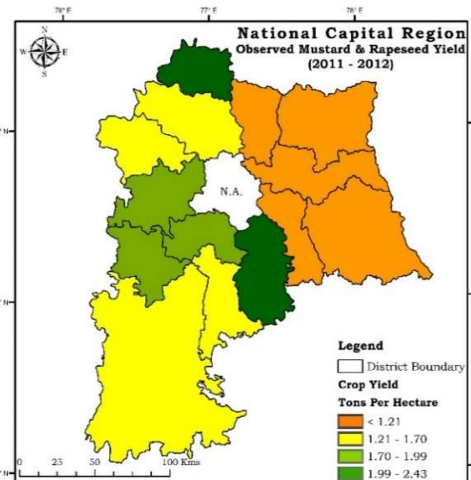
g)


National Capital Region
Fertlizer Application - Mustard
Legend
District Boundary
Fertilizer - Nitrogen Application
Kilograms Per Hectare
High : 441700
Low : 56.4653
0 25 50 100 Kms

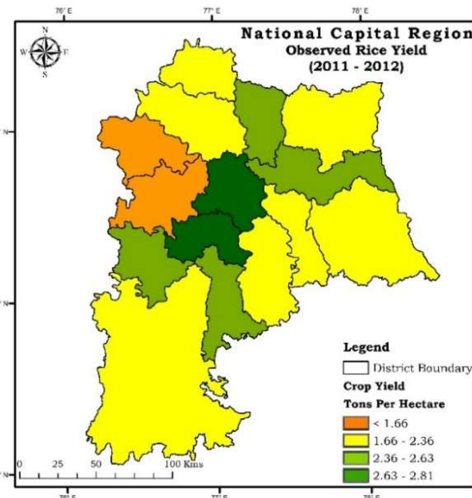
h)


National Capital Region
Fertlizer Application - Rice
Legend
District Boundary
Fertilizer - Nitrogen Application
Kilograms Per Hectare
High : 623397
Low : 1.59553
0 25 50 100 Kms

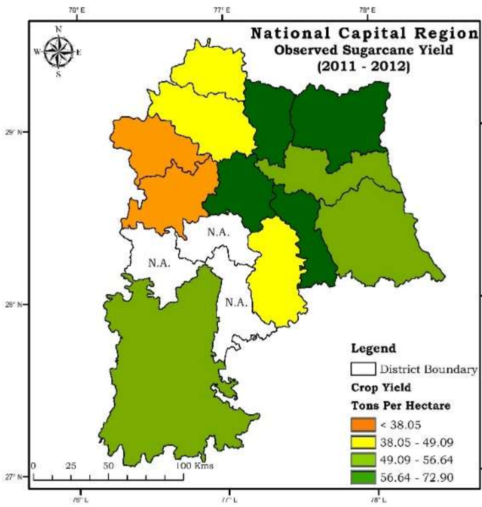
i)

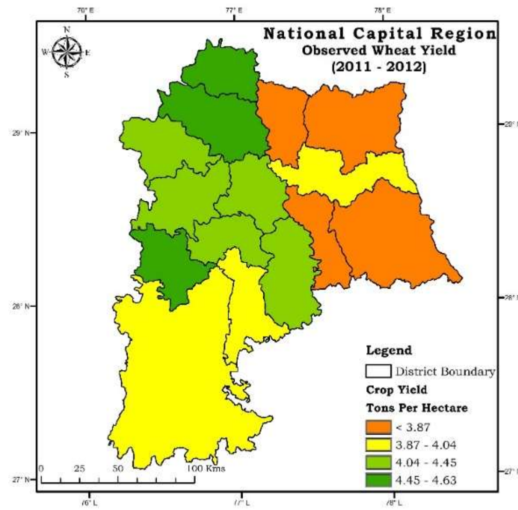

National Capital Region
Observed Mustard & Rapeseed Yield
(2011 - 2012)
N.A.
Legend
District Boundary
Crop Yield
Tons Per Hectare
< 1.21
1.21 - 1.70
1.70 - 1.99
1.99 - 2.43
0 25 50 100 Kms

j)


National Capital Region
Observed Rice Yield
(2011 - 2012)
Legend
District Boundary
Crop Yield
Tons Per Hectare
< 1.66
1.66 - 2.36
2.36 - 2.63
2.63 - 2.81
0 25 50 100 Kms

k) l)





Map 4.1 Inputs for InVEST crop production modeling a) Major crops (2002-2003), b) Major crops (2004-2005), c) Major crops (2011-2012), d) Fertilizer-Millet, e) Fertilizer- Wheat, f) Fertilizer-Sugarcane, g) Fertilizer-Mustard, h) Fertilizer-Rice i) Observed Mustard and Rapeseed Yield (2011-2012), j) Observed Rice Yield (2011-2012), k) Observed Sugarcane Yield (2011-2012), l) Observed Wheat Yield (2011-2012).

Table 4.2 Nutrient contents Table

Nutrients/Crop	Millet	Mustard	Rice	Sugarcane	Wheat
Fraction_refuse	0	0	0.22	0	0
Protein	110.2	0	77.2	0	117.28
Lipid	42.2	1000	28	0	18.54
Energy	15820	8840	15315	0	14050
Ca	80	0	280	0	312
Fe	30.1	0	16.35	0	39.7
Mg	1140	0	1430	0	1158
Ph	2850	0	2985	0	4092
K	1950	0	2455	0	4116
Na	50	0	25	0	20
Zn	16.8	0	45.2	0	32.46
Cu	7.5	0	2.77	0	4.45
Mn	16.32	0	37.43	0	37.23
Se	27	0	234	0	800.5
VitA	0	0	0	0	54000
betaC	0	0	0	0	50
VitE	0.5	0	12	0	10.1
Lutein	0	0	0	0	2200
Thiamin	4.21	0	4.07	0	63.15
Riboflavin	2.9	0	0.68	0	60.85
Niacin	47.2	0	47	0	98.82
Pantothenic	8.48	0	14.93	0	7.22
VitB6	3.84	0	5.09	0	65.24
Folate	850	0	200	0	402
VitK	9	0	19	0	19

Table 4.3 Economics Table

Crop	Price	Nitrogen Cost	Phosphorus Cost (Per Kg)	Potash Cost (Per Kg)	Labour Cost (Per Hect.)	Machine Cost (Per Hect.)	Seed Cost (Per Hect.)	Irrigation Cost (Per Hect.)
Millet	126	0.142857	0.401429	0.101429	57.10938	16.38567	3.127714	8.591429
Mustard	542.8571	0.142857	0.401429	0.101429	54.59967	22.94919	2.416857	19.30386
Rice	243.1429	0.142857	0.401429	0.101429	86.72643	20.55936	9.858571	22.76014
Sugarcane	44.28571	0.142857	0.401429	0.101429	165.4481	22.97371	46.42936	34.97771
Wheat	208.5714	0.142857	0.401429	0.101429	65.91738	36.35429	16.46943	32.18086

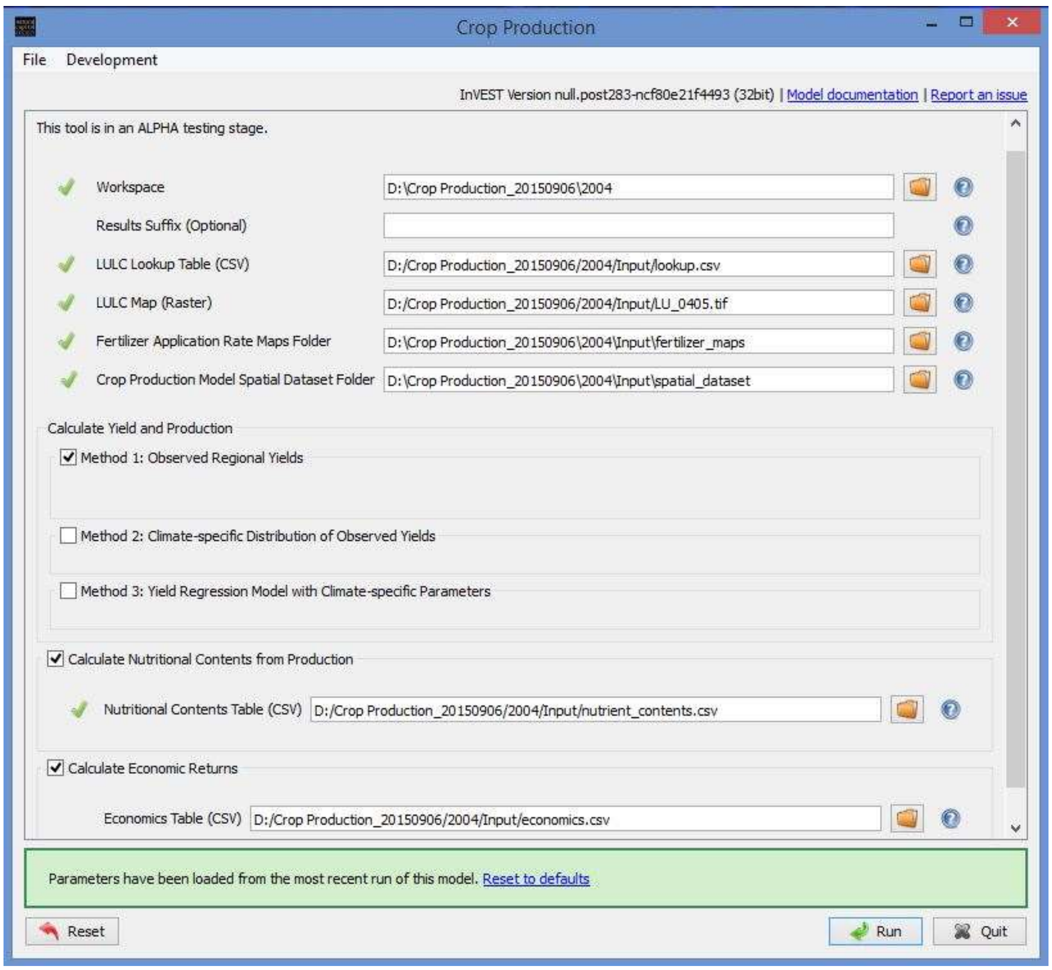


Figure 4.2 Steps and process for running crop production model

4.2.2.2 Water Yield Modelling using InVEST

The fresh water pays benefit to the society in many ways like hydropower generation which is one of the most commonly used renewable energy in the world. Much of the hydropower is generated from the watershed-fed reservoir systems that are designed in a way such as to account for annual variability in water volume. But these are considered vulnerable due to extreme variations caused by changes in LULC pattern of the region. The changes in land-use/land-cover affects the hydropower generation by affecting the pattern of evapotranspiration, infiltration and water preservation and also by changing its volume (World Commission on Dams 2000; Ennaanay 2006).

Landscape changes can gradually increase or decrease the capacity of hydropower generation. Maps showing usage of water yield for hydropower can assist to make decisions regarding maintaining production of power with balancing other uses like conservation and agriculture. These maps can also be used to inform investments for hydropower production companies by maintaining water yield for this one of the important environmental service. In case of large reservoirs where there are multiple reservoirs for generation of hydropower, areas upstream of power plants will have larger values for this environmental service. These maps can further help managers to avoid growth in the largest hydropower value areas. It will help to understand gain/loss of the value and also to identify the largest stake among hydropower producers in maintaining water yield of that region.

The InVEST Reservoir Hydropower model estimates the relative contributions of water from various parts of that region. It helps in understanding the affects of surface water yield and hydropower production caused by changes in LULC pattern in that region.

The concept of modelling the association among changes in landscape and the hydrological process (such as the WEAP model) is quite difficult and requires generous expertise. The InVEST maps and models the annual average water yield that is used for the hydropower generation. The InVEST estimates the relative contribution (value in terms of energy production) of each land parcel to annual average production of hydropower. It can also calculate net current value of hydropower generation over the life of the reservoir by making sum of discounted annual revenues.

i) How it works

The InVEST model runs on a gridded map and it calculates the amount and value of water used for hydropower production from each sub-watershed of the region. It has 3 mechanisms, which run sequentially. The first being that it regulates the amount of water running off each pixel. The model does not distinguish among surface, sub-surface and base flow while assuming that all of the water yield from a pixel is reaching the point of interest via one of these pathways. Further, sum and average of the water yield is done by this model to the sub-watershed level. These pixel-level calculations done by the model helps in representing the heterogeneity of the most important factors in the water yield like precipitation, vegetation, soil type etc. The second being it estimates the amount of surface water which is used for hydropower generation by deducting the surface water which is being consumed for other purposes. The third being it calculates the energy which is produced by the water reaching the hydropower reservoir. It also estimates the value of this energy over the reservoir's lifetime.

ii) Water Yield Model

The water yield model is based on the Budyko curve and annual average precipitation. Annual water yield $Y(x)$ for each pixel on the landscape x is calculated as follows:

$$Y(x) = \left(1 - \frac{AET(x)}{P(x)}\right) \cdot P(x)$$

where, $AET(x)$ is the annual actual evapotranspiration for pixel x and $P(x)$ is the annual precipitation on pixel x.

For vegetated LULC, the evapotranspiration partition of the water balance, $\frac{AET(x)}{P(x)}$, is an approximation of the Budyko curve developed by Zhang et al. (2001):

$$\frac{AET(x)}{P(x)} = \frac{1 + \omega(x)R(x)}{1 + \omega(x)R(x) + \frac{1}{R(x)}} \quad \text{....................(1)}$$

where, $R(x)$ is the dimension less Budyko Dryness index on pixel x, defined as the ratio of potential evapotranspiration to precipitation (Budyko 1974) and $\omega(x)$ is a modified dimensionless ratio of plant accessible water storage to expected precipitation during the year. As defined by Zhang et al. (2001), $\omega(x)$ is a non-physical parameter to characterize the natural climatic-soil properties.

$$\omega(x) = Z\frac{AWC(x)}{P(x)}$$

where $AWC(x)$ is the volumetric (mm) plant available water content. The soil texture and effective rooting depth define $AWC(x)$, which establishes the amount of water that can be held and released in the soil for use by a plant, estimated as the product of the difference between field capacity and wilting point and the minimum of root restricting layer depth and vegetation rooting depth. Root restricting layer depth is the soil depth at which root penetration is strongly inhibited because of physical or chemical characteristics. Vegetation rooting depth is often given as the depth at which 95% of a vegetation type's root biomass occurs. Z is a seasonality factor that presents the seasonal rainfall distribution and rainfall depths. In areas of winter rains, we expect to have Z on the order of 10, in humid areas with rain events distributed throughout the year or regions with summer rains the Z is on the order of 1. While we calculate $\omega(x)$, in some cases specific biome values already exist based on water availability and soil-water storage (Milly 1994, Potter et al. 2005, Donohue et al. 2007).

Finally, define the Budyko dryness index, where $R(x)$ values that are greater than one denote pixels that are potentially arid (Budyko 1974), as follows:

$$R(x) = \frac{K_c(\ell_x) \cdot ET_0(x)}{P(x)}$$

where, $ET_0(x)$ is the reference evapotranspiration from pixel x and $K_c(\ell_x)$ is the plant (vegetation) evapotranspiration coefficient associated with the LULC ℓ_x on pixel x. $ET_0(x)$ reflects local climatic conditions, based on the evapotranspiration of a reference vegetation such as grass of alfalfa grown at that location. $K_c(\ell_x)$ is largely determined by the vegetative characteristics of the land use/land cover found on that pixel (Allen et al. 1998). K_c adjusts the ET_0 values to the crop or vegetation type in each pixel of the land use/land cover map. K_c adjusts the ET_0 values to the crop or vegetation type in each pixel of the land use/land cover map, and is then used to estimate actual ET (AET) for the watershed, one of the model outputs.

For other LULC (open water, urban, wetland), actual evapotranspiration is directly computed from the reference evapotranspiration ET0:

$$AET(x) = K_c(\ell_x) \cdot ET_0(x) \qquad \text{(2)}$$

where $ET_0(x)$ is the reference evapotranspiration, and $K_c(\ell_x)$ is the evaporation factor for each LULC. Guidance for estimating the K_c factor is provided in the "Data sources" section.

The water yield model script generates and outputs the total and average water yield at the sub watershed level.

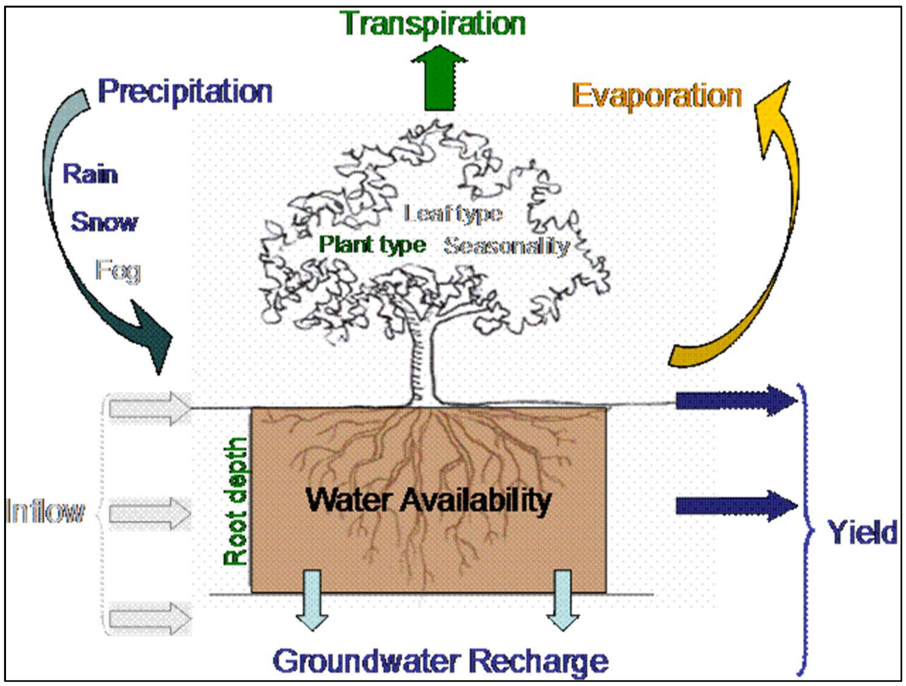


Figure 4.3 A schematic diagram of the water balance model used in the hydropower production model

iii) Limitations and simplifications of the model

The model is considered to have various limitations. It is not projected for proper planning of detailed water plans but rather for assessing the amount and the place where changes in the watershed might affects the hydropower production of the reservoir systems. It does not consider the temporal dimensions of the water supply. This model is assuming that all the amount of water produced in a watershed is arriving at watershed outlet without considering water capture by means other than primary human consumptive uses. The connections between surface water and ground water are highly ignored that may cause error. Further, this model did not consider the sub-annual patterns of the timing of water delivery. The timing of peak flows and distribution of minimum effective flows calculates the level of hydropower production and annual revenue. The landscape changes are considered to affect more the flow timing as compared to the annual water yield which is considered as the concerning factor for the climate change. But, this model is good in providing the useful information about the affect of landscape changes on the annual deliver of water to the hydropower production. The another limitation of the model is that it relates the consumptive demand by land-use/land-cover class. In fact, the water demand might differ largely among the parcels of the same land-use/land-cover class. Another limitation of the model is that it uses a single variable (gamma_d) to show the numerous aspects of water resource distribution that may pervert the complex distribution of water. Lastly, model assumes the pricing and hydropower production remain persistent over time. It does not document for seasonal changes in energy fluctuations or production in energy pricing that possibly impact the value of hydropower.

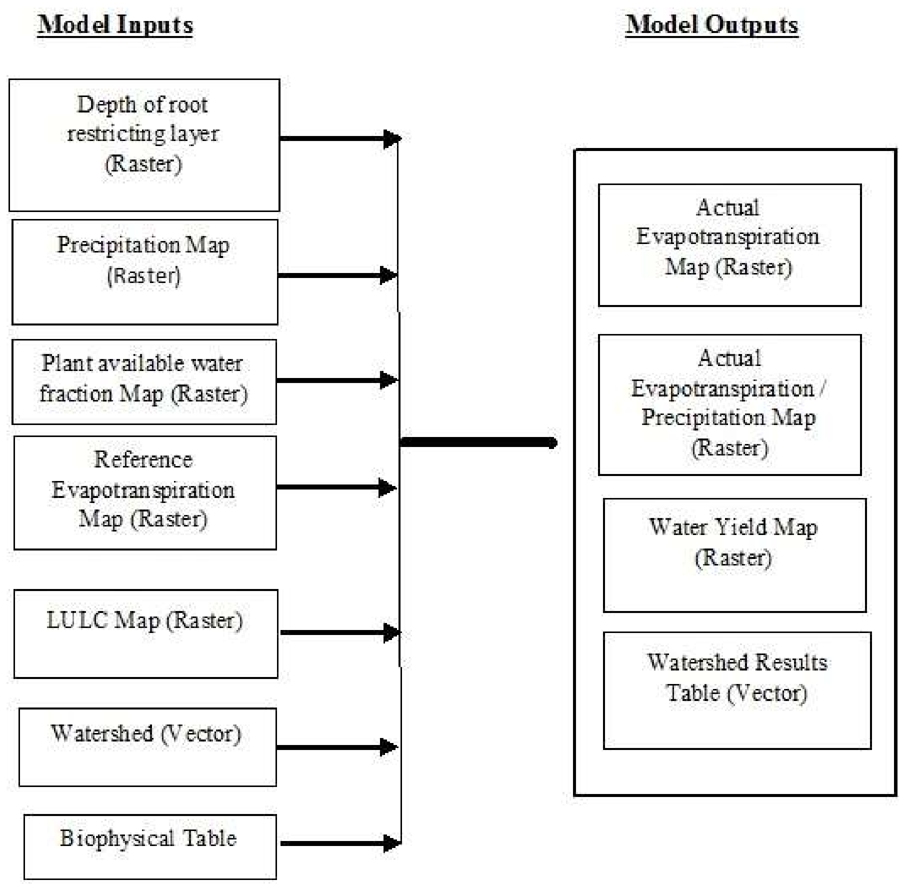
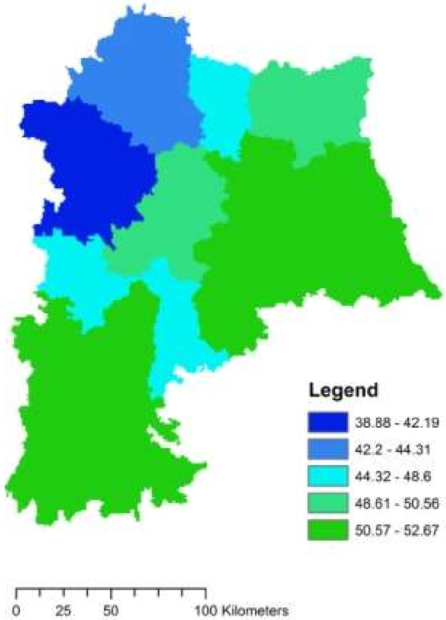


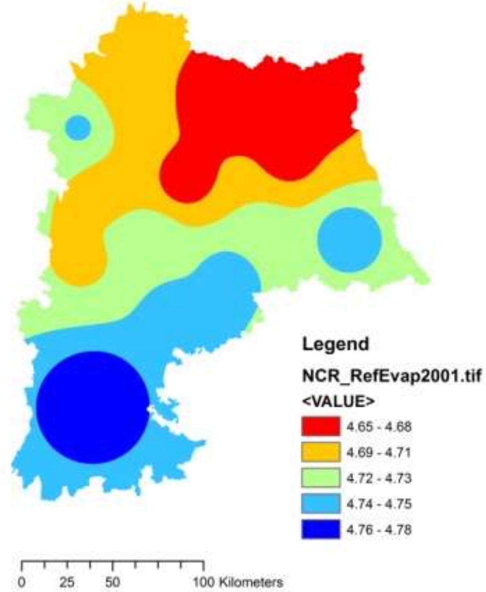
Figure 4.4 Water yield modelling

iv) Inputs required for water yield modelling

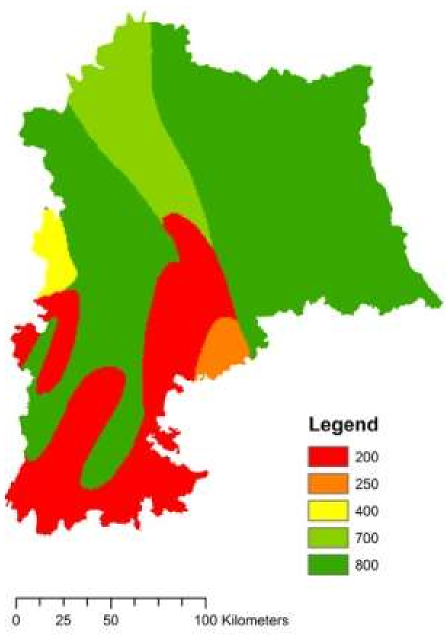
a)



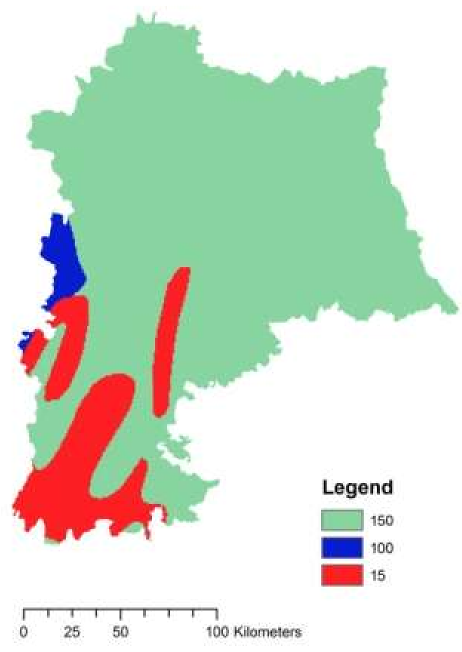
b)



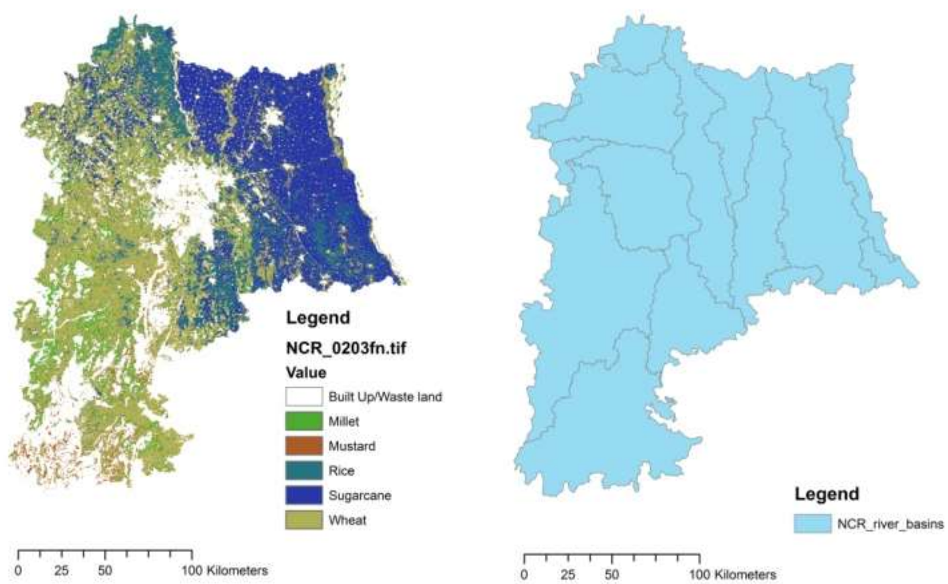
c)



d)



e) f)



Map 4.2 Inputs required for water yield modelling a) Precipitation (mm) b) Reference Evapotranspiration c) Depth to root restricting layer (mm) d) Plant available water fraction (mm) e) Land-use/Land-cover f)Watersheds

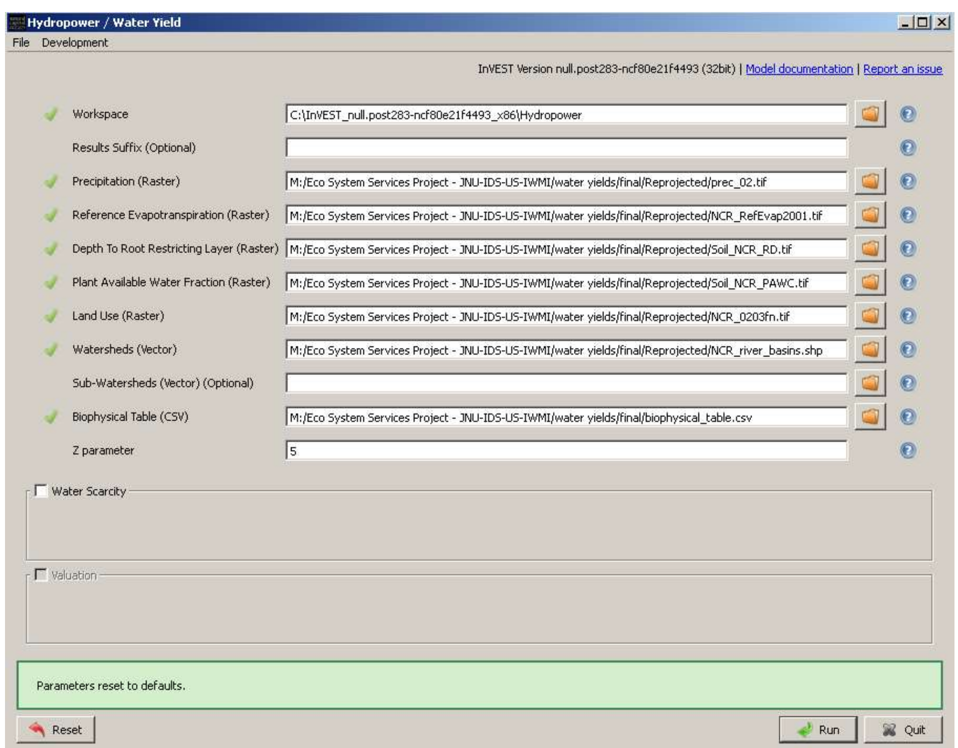


Figure 4.5 Steps and process involved in water yield model

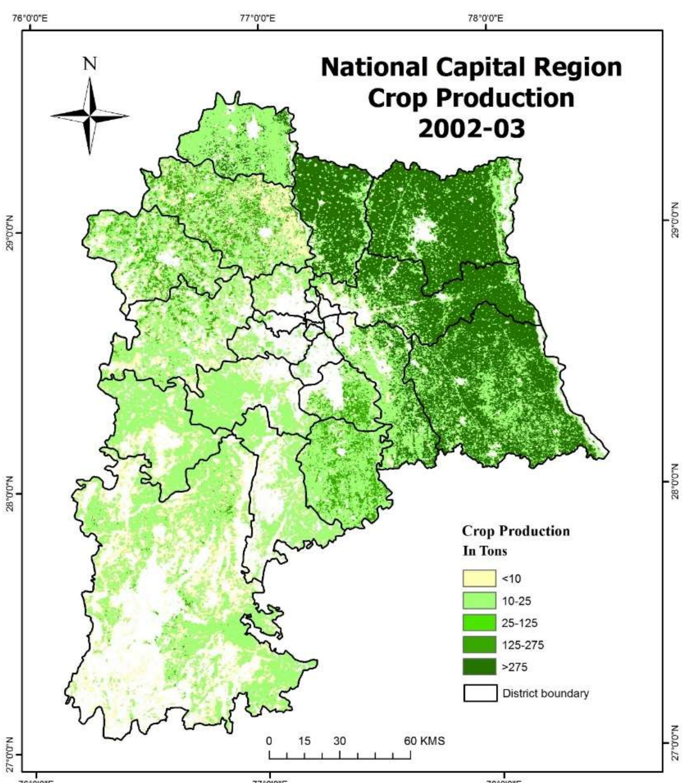
4.3 RESULTS AND DISCUSSION

4.3.1 Crop Production and Crop Yield in the National Capital Region

The crop model evaluates the impacts of land-use transitions and intensified crop production by incorporating natural capital values into economic estimations of crop yields.

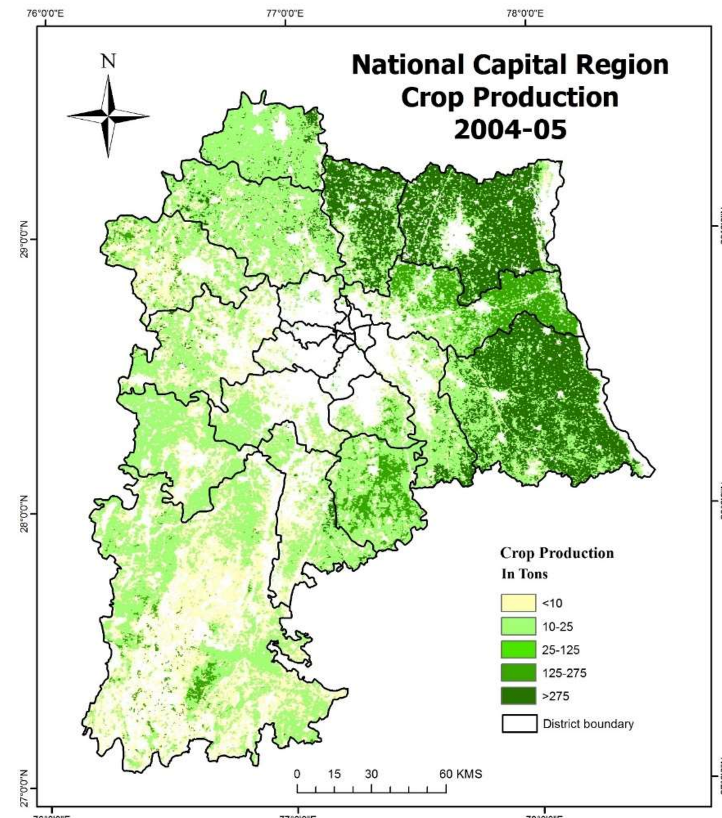
When we look at the LULC maps of NCR, the share of agricultural area is highest among all land use class but temporal images of LULC reveals that area under agricultural land has been decreased which is the result of conversion of crop land into built-up area, this may not only effect the reduction in the crop land, it also effects the soil productivity that has in returns affects the crop productivity and cropping pattern.

The given below crop production and crop yield maps derive from the InVEST modelling shows the district wise change in production in tons and yield in tons per hectares. Detailed discussion of the following maps is given below:



a)

b)



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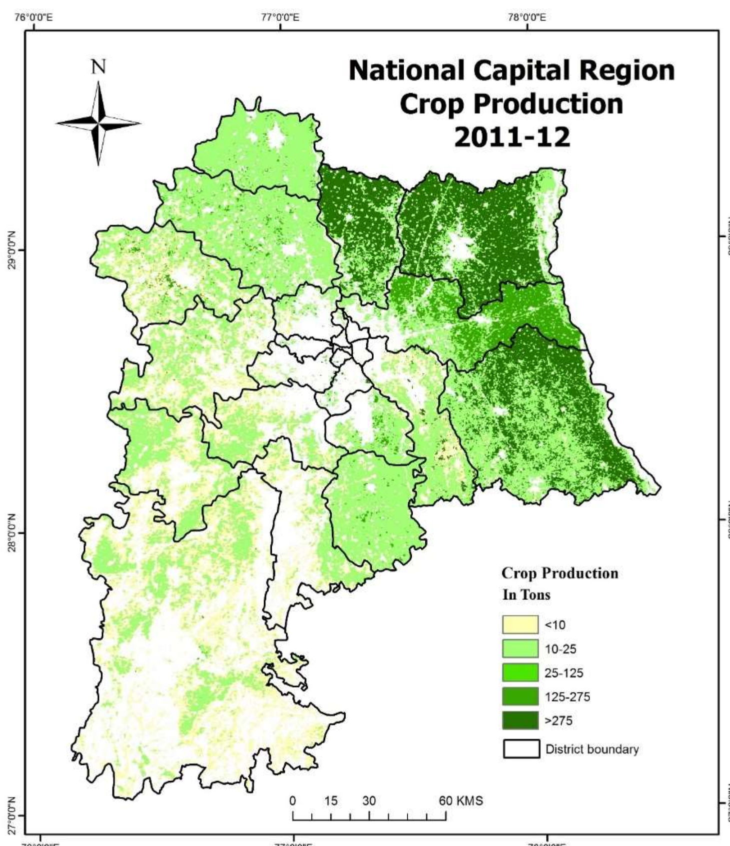


Map 4.3 Crop Production map of NCR. a) 2002-03 b) 2004-05 & c) 2011-12

Crop production maps of NCR indicates that from 2002 to 2012, production in crops in terms of tons per pixel has gone up. The major growing crops in NCR region are Sugarcane, Wheat, Millet, Rice and Mustard. Reason for the increase in a crop production may be associated with the increasing demand of food with increasing population.

In 2002-03 highest crop production i.e. > 275 tons per pixel found mostly in the north-east and south-east regions of NCR which includes Baghpat, Meerut, Ghaziabad and Bulandshahr districts of Uttar Pradesh. While in 2004-05, it is observed that >275 tons per pixel production mostly limited to the Meerut, Baghpat and Bulandshahr districts of NCR that indicates the decrease in the spatial distribution of production but accumulated to the specific regions.

From 2011-12 crop production map, it is noticed that >275 tons of production has gone shrink to limited regions of NCR i.e. Baghpat, Meerut & Bulandshahr. Crop production between 25 to 275 tons per pixel is accounted mostly in Ghaziabad, Faridabad, Panipat, Sonipat, Rohtak and Palwal in 2002-03. While in 2004-05, there is deduction in the production of crops (25 to 275 tons) in Rohtak, Sonipat, Gautam Budh Nagar districts. Similarly, in 2011-12, in this same category (25 to 275 tons) of crop production has now limited to some parts of NCR only i.e. in some parts of Ghaziabad, Bulandshahr, Faridabad etc. Districts which have shown crop productivity between 25 to 275 tons in 2002-03 & 2004-05, now they do not exist in 2011-12 in the same.

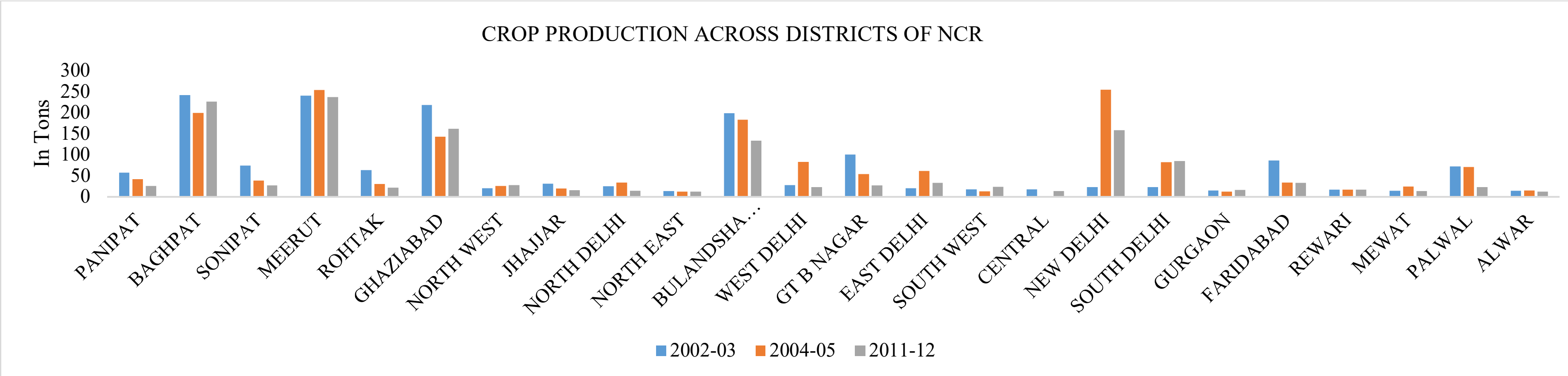


Figure 4.6 Crop production across districts of NCR (2002-2012)

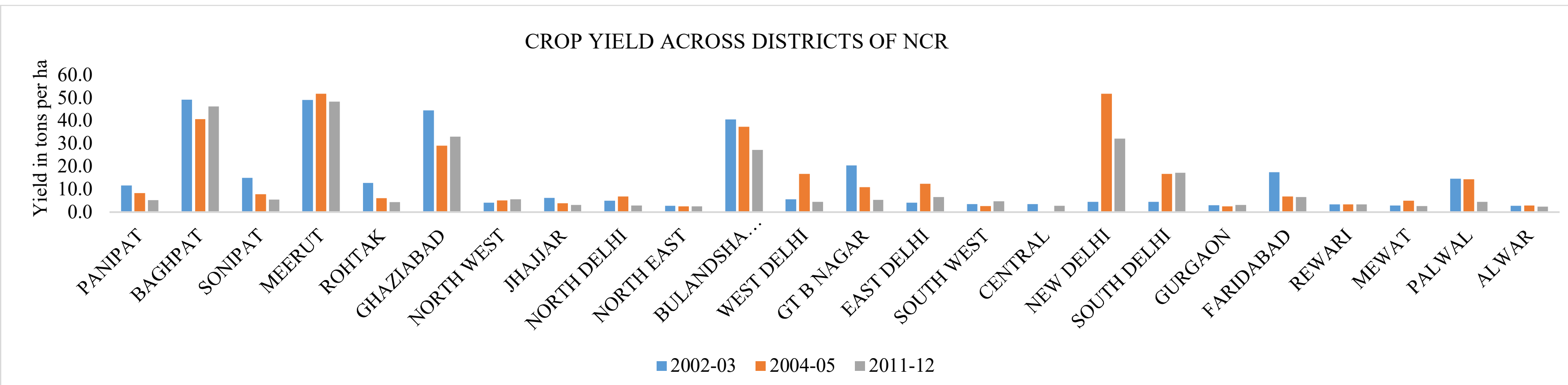
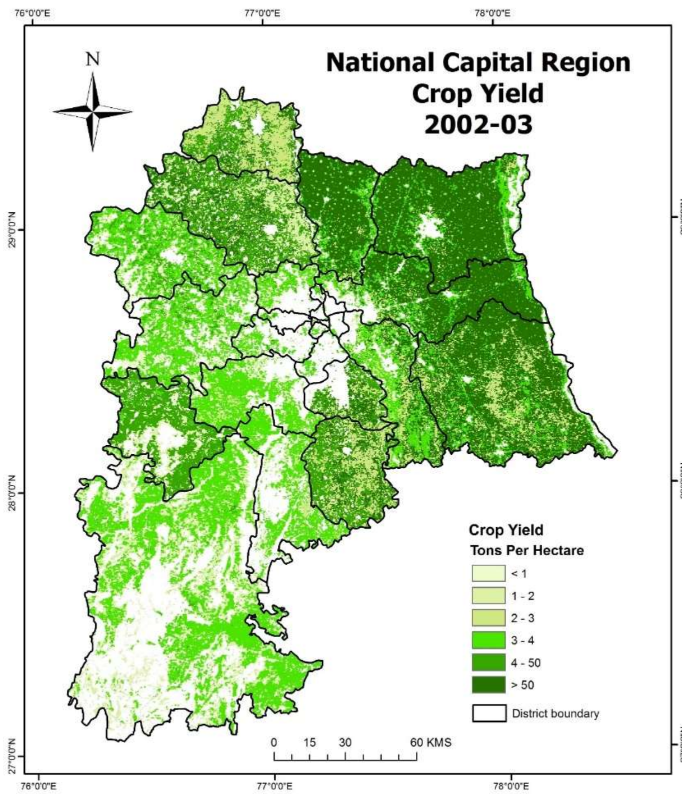


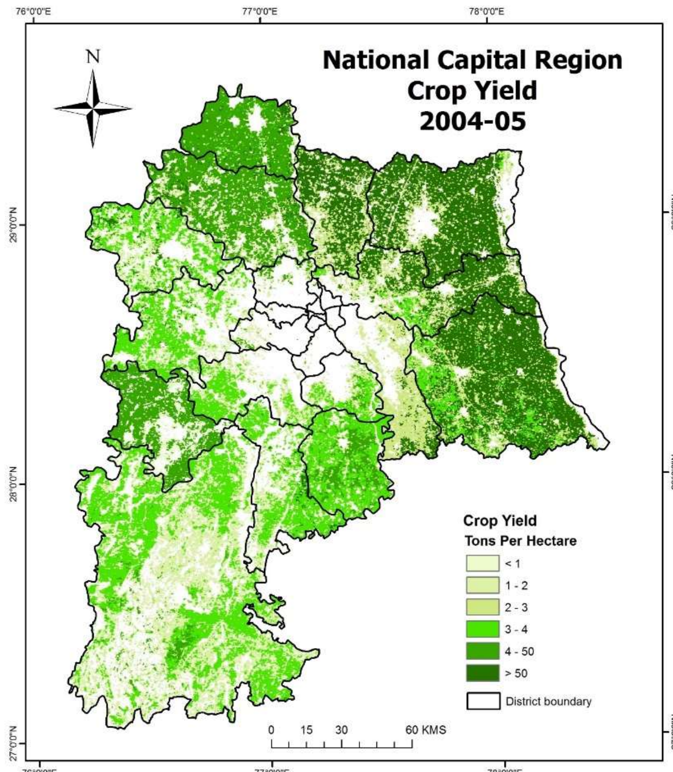
Figure 4.7 Crop yield across districts of NCR (2002-2012)

4.3.2 Crop Yield in the National Capital Region

Crop yield is a measure of agriculture output. As it is already revealed by crop production maps in NCR that productivity of crops has gone down through course of time due to the change in land use pattern in the region but on contrary the crop yield has increased per hectare wise. Reason behind this may be attributed with the diversification of cropping pattern in the region.



a)



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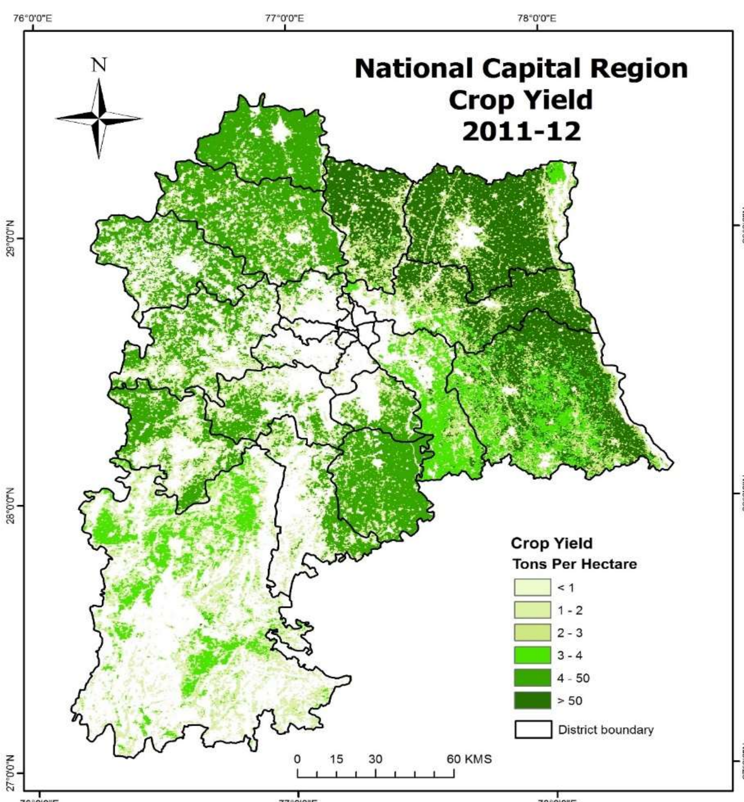


c)

Map 4.4 Crop Yield map of NCR. a) 2002-03, b) 2004-05 & c) 2011-12

It is indicated by maps of the crop yield that tons per hectare production has increased. From 2001-2012, highest crop yield i.e. > 50 tons per hectare is observed in most of the districts of Uttar Pradesh and Haryana. While it also been noticed that spatial distribution of crop yield changed from last ten years.

In 2002-03 crop yield seen highest i.e. > 50 tons per hectare in the Meerut, Bulandshahr, Baghpat, Ghaziabad, Sonipat, Faridabad and Rewari but in 2004-05 number of districts gone limited to Meerut, Baghpat and Bulandshahr. Further in 2011-12 Bulandshahr, Meerut, Baghpat and Ghaziabad shows spatial distribution change in the crop yields as it can be seen that in Bulandshahr, eastern part has shown high crop yield with compare to western part of it.

4.3.3 Analysis of output result table of Crop Production Model derive through InVEST

4.3.3.1 Crop Production in NCR

Crop production statistics drive through InVEST model shows that there is declining trend of producing sugarcane in the NCR. Production of sugarcane is decreased by 5.7 percent from 2002 to 2012. But production of wheat showing increasing trend from 2002 to 2012. It is increased by 3.2 percent. Oilseeds that includes mustard shows increase in the production from 0.41 percent during 2002-05 to 0.49 percent during 2011-12. Further, Millets production shows decline from 2002 to 2005 but it is increased again since 2005 and shows 0.99 percent increment in 2012.

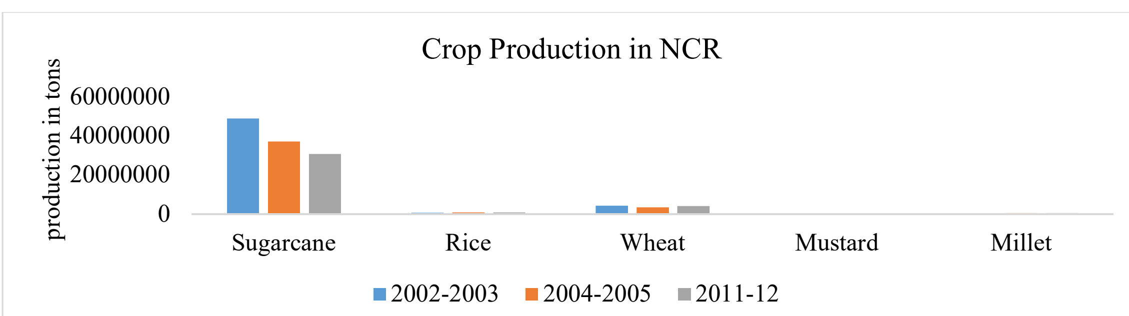
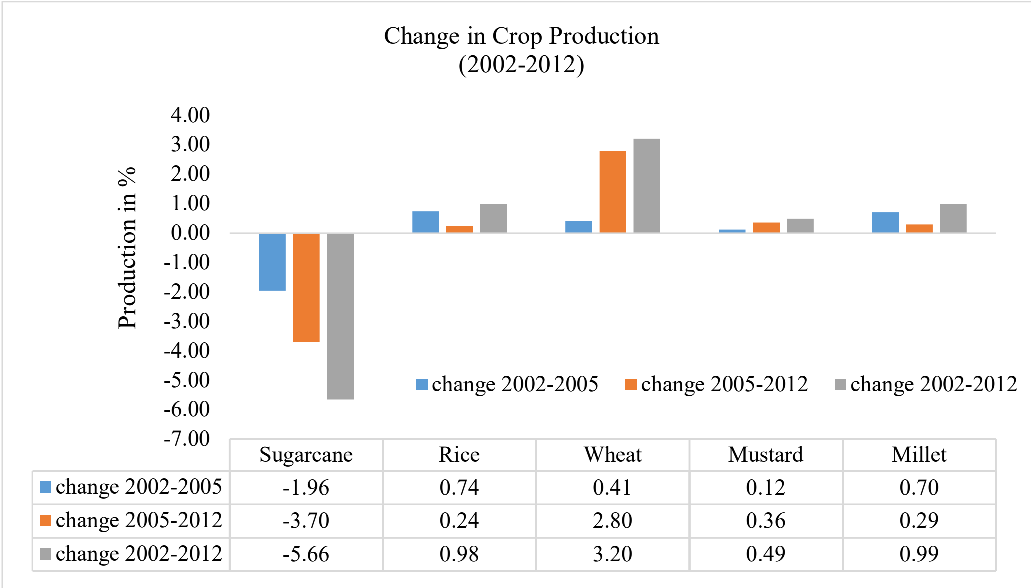


Figure 4.8 Crop production in NCR (2002-2012)

In addition, production of rice represents positive change as it has increased by 0.98 percent from 2002 to 2012. Regions that shows maximum rice production in NCR is Bulandshahr followed by Meerut, Ghaziabad, Baghpat, Sonipat , Rohtak etc.

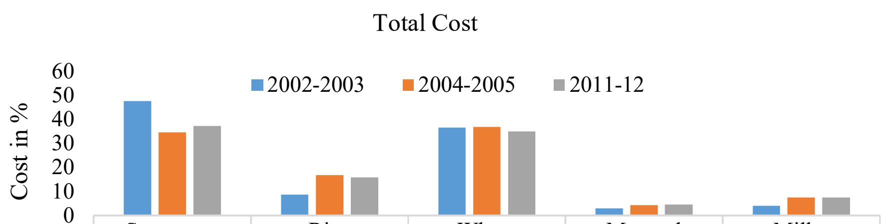


	Sugarcane	Rice	Wheat	Mustard	Millet
change 2002-2005	-1.96	0.74	0.41	0.12	0.70
change 2005-2012	-3.70	0.24	2.80	0.36	0.29
change 2002-2012	-5.66	0.98	3.20	0.49	0.99

Figure 4.9 Change in crop production (2002-2012)

4.3.3.2 Total Cost

Total cost represents total economic cost that sums all expenses paid to produce any product. According to input data and output results from the crop production model by using InVEST, shows variations (Figure 4.10) in cost in different major crops that has grown in NCR from 2002 to 2012. Sugarcane crop shows decline in the production therefore it is evident that the cost that put in producing sugarcane gone down but as it is noted from the variations through years, shows decrease in total cost from 47.7 percent to 34.6 percent but again from 2005 to 2012 it is increased to 37.3 percent that means it is increased by 3.3 percent by 2012. From the field visits of study locations also reveals that reason behind decline in growing sugarcane may be mainly increase of animal interference in crop fields and also effects of pathogens on sugarcane root systems. Further, other crops such as rice, wheat, mustard and millets shows increase in the total cost for production of these crops.

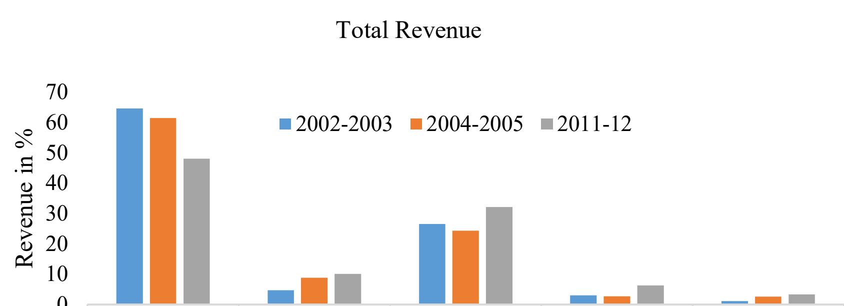


	Sugarcane	Rice	Wheat	Mustard	Millet
2002-2003	47.7	8.8	36.7	2.9	4.0
2004-2005	34.6	16.8	36.9	4.3	7.5
2011-12	37.3	15.8	35.0	4.5	7.5

Figure 4.10 Total cost derived from crop production model (2002-2012)

4.3.3.3 Total Revenue

Total revenue refers to the total income that is derive from the sale of given quantity of crop produce. According to the given results (Figure 4.11) from the crop production model, representing decline in the crop revenue from sugarcane. The estimated decline from 2002-2003 to 2004-2005 was 3.1 percent and from 2004-2005 to 2011-12 was 13.4 percent. Therefore, another reason for decline in sugarcane production may be decrease in the total revenue that farmers gets from production. However, other crops rice, wheat, mustard and millets, showing increase in the total revenue.

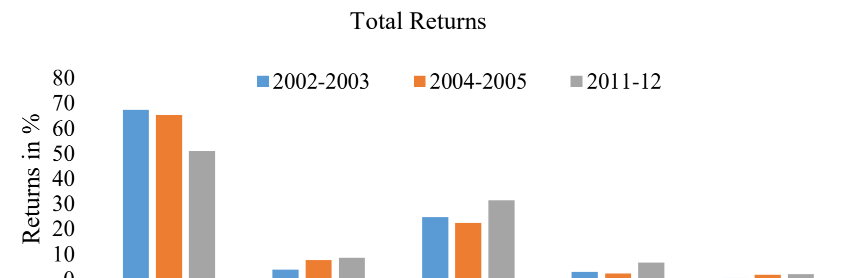


	Sugarcane	Rice	Wheat	Mustard	Millet
2002-2003	64.7	4.7	26.5	3.0	1.1
2004-2005	61.6	8.8	24.4	2.7	2.6
2011-12	48.2	10.2	32.2	6.2	3.3

Figure 4.11 Total revenue derived from crop production model (2002-2012)

4.3.3.4 Total Returns

Total returns (Figure 4.12) representing the economic returns generated by the crops. It is drive from total revenue minus total cost. The increase in total returns from different crops grown in the NCR, found in wheat crop. It is increased from 24.8 percent in 2002-2005 to 32.4 percent in 2011-12, followed by rice 4.7 percent to 10.2 percent, mustard 3 percent to 6.2 percent and millet shows 1.1 percent to 3.3 percent from 2002 to 2012. On contrary, sugarcane shows decrease in total returns with compare to other crops.



	Sugarcane	Rice	Wheat	Mustard	Millet
2002-2003	67.5	4.0	24.8	3.1	0.6
2004-2005	65.4	7.7	22.6	2.5	1.9
2011-12	51.1	8.7	31.4	6.7	2.2

Figure 4.12 Total returns derived from crop production model (2002-2012)

With the examination of crop production, crop yield, total cost, total, revenue, and total returns; derive from crop production model, shows the acceptability of the model in the NCR region for provisioning ecosystem services such as food, water etc. But due to constraint in the input data requirement, these results are limited to some extent.

4.3.4 Validation of Crop Production Model (InVEST) through DES Crop Production data in NCR

The purpose of validation of crop production InVEST model to DES (Directorate of Economics & Statistics) crop production data in NCR, is to evaluate the suitability and accuracy of the InVEST model outputs. The comparison at the district level of NCR, shows high degree of association between the InVEST derive crop production values and DES crop production values (Figure 4.13). The significant level of uncertainty is found in the districts of Bulandshahr and Meerut with root mean square error (RMSE) 0.37 and 0.12 respectively whereas other districts found less than 0.09 RMSE.

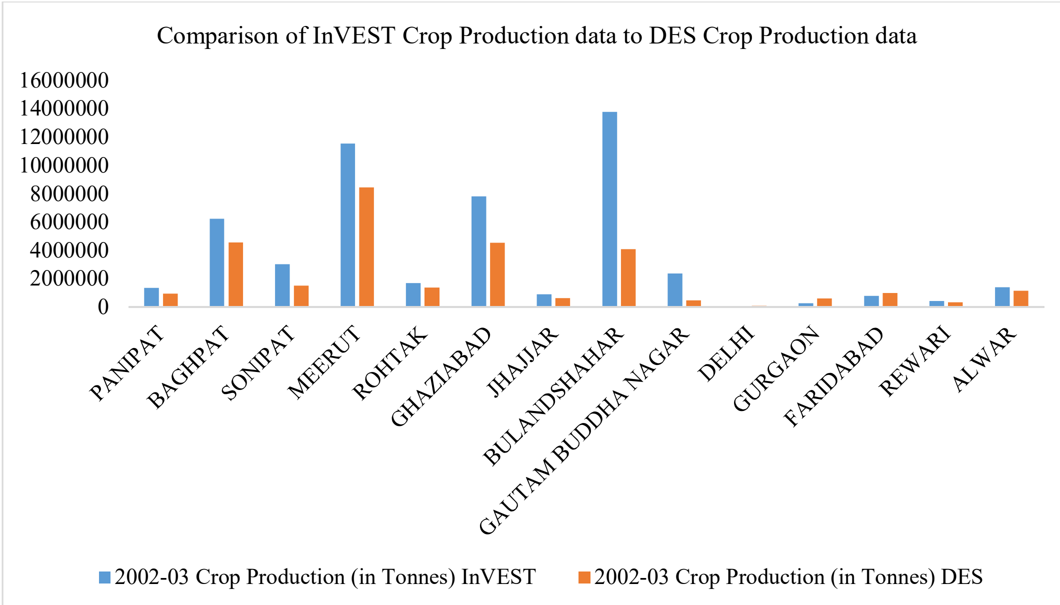


Figure 4.13 Comparison of InVEST crop production data to DES crop production data

Table 4.4 Regression analysis of InVEST model and DES data

Model Summary[1]				**ANOVA**[2]					
R	R^2	Adjusted R^2	Standard Error		*df*	*Sum of squares*	*Mean square*	*F*	*Significance*
0.872[a]	0.760	0.740	0.14648	Regression	1	0.815	0.815	37.979	0.00[b]
				Residual	12	0.257	0.021		
				Total	13	1.072			

Note: Significance level is 0.01,
[1]Predictors[a]: (Constant) InVEST_Crop Production; [2]Dependent Variable[b]: DES_Crop Production

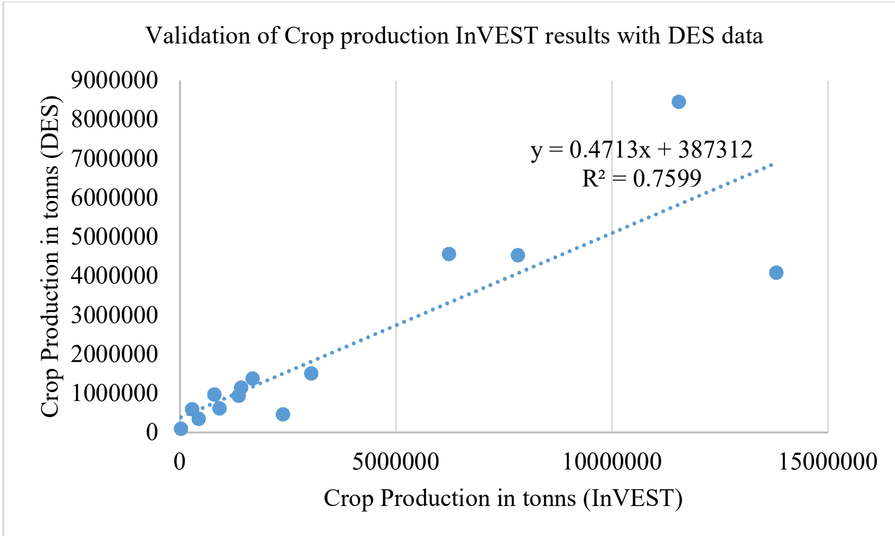


Figure 4.14 Validation of crop production InVEST results with DES data

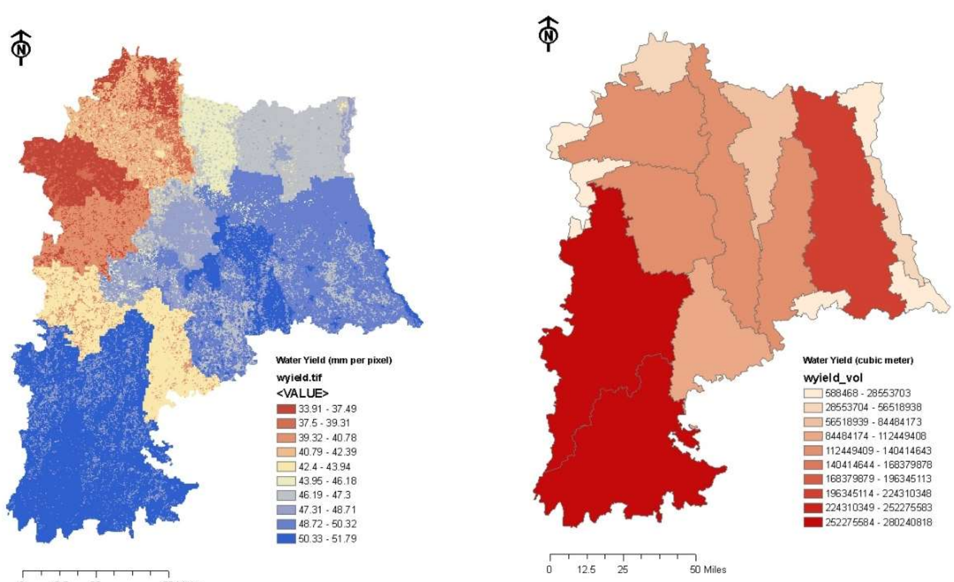
The analysis of variance (ANOVA) results (Table 4), shows crop production data explains that the computed R^2 value 0.760 is significant at a 0.01 significance level. Further, it shows that the linear relationship is not occur by any chance, rather a certain statistical relationship exists between the two data sets which shows the suitability of InVEST model with the DES data sets.

4.3.5 Water Yield in National Capital Region

The demand of water for various purposes is significantly increasing in the National Capital Region because of increased population, urbanisation, changing lifestyle and industrial growth. Due to limited availability of fresh water from the river Yamuna, the dependence on groundwater resources is increasing to cater the need of water for various purposes. Therefore, it was important to map and model the water yield of this region for the sustainable supply and management of such services.

Before going into the watershed level water yield discussion, it is important to discuss about watershed system of National Capital Region. NCR is drained by mainly three perennial rivers i.e. the Ganga, the Yamuna and the Hindon. The Ganga originated from the gangotri glacier, forms the easternmost boundary of the area and flows in south direction for the entire length of the area. Yamuna river i.e. originated from yamunotri glacier forming a boundary between Haryana and Uttar Pradesh, also flows in southerly direction and almost bisects the area. Hindon river which is a tributary of Yamuna river, originates in the Saharanpur district of U.P, also flows in southerly direction. There are also other small streams flowing in U.P sub-region are Karavan Nadi, Kali Nadi, Nim Nadi, all flowing towards south. The southern and south-western part of NCR is devoid of any perennial river. The line of natural drainage in this part is from south-west to north-east or north namely Sahibi Nadi, which is ephemeral, enters the area at about 5 kilometres south of Behror in Alwar district of Rajasthan. It flows in a north-est direction towards Rewari, in Haryana. It carries away the water of the western slope of the central range of Aravalli hills. Another ephemeral stream in the area is Ruparch which is in the extreme south of the area falling in Alwar district.

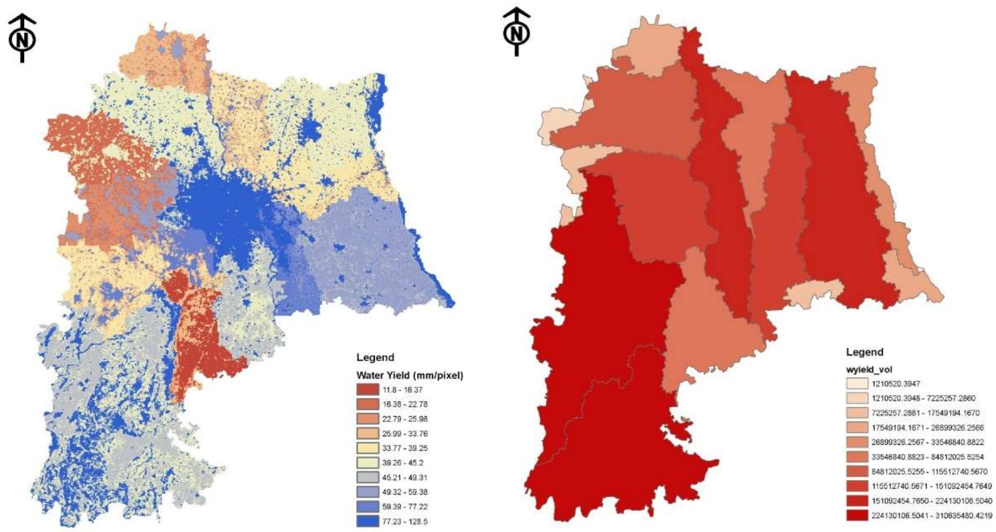
Water yield computing and mapping contribute a great significance to the planning of water resource and its management. A water yield model for National Capital Region based on InVEST showing that water yield has increased in some parts of regions namely Alwar, Bulandshahr, Gautam Budh Nagar, Ghaziabad and Faridabad that shows high level of water yield per pixel as compare to other regions of NCR. The total volume of water yield has increased from 1578919885.11 m^3 to 1736219072.20 m^3 in all the watersheds in NCR from 2001 to 2011.



a) b)

Map 4.5 Water Yield in NCR in 2001 a) Pixel based b) Watershed based

a) b)



Map 4.6 Water Yield in NCR in 2001 a) Pixel based b) Watershed based

Watershed based results shows increase in the water yield in Yamuna river watershed from 46.52 mm in 2001 to 63.44 mm in 2011. It is increased by 16.92 mm. It may be attributed to increase in the impervious surface in Yamuna watershed. Areas that fall under Yamuna watershed are eastern Part of Delhi, Faridabad, western Ghaziabad, east-Sonipat and Panipat, and western Baghpat, which shows increment in built-up area that may be resulted in the increase in water yield in Yamuna watershed region. Another important watershed in this region, which shows increase in water yield is Hindon watershed. Water yield is increased by 12.05 mm from 2001 to 2011. It includes the parts of Ghaziabad, Gautam Budh Nagar, Meerut etc. Water yield in Shahibi watershed also shows increase from 2001 to 2011. This may be associated with the undulating topography of this region and additional factor that responsible is possibly change in land use and land cover.

Pixel based results shows how value of water yield per pixel has changed from 2001 to 2011. The resulting maps indicate that there has been a relative increase in minimum water yield from 0.1 million m3 in 2001 to 1.2 million m^3 in 2011 at watershed level. Whereas maximum water yield varies from 310 million m^3 in 2011 to 282 million m^3 in 2001. This could be attributed to changes in LULC and possible increase in surface run-off. However, there are limitations in quality as well as the availability of input data.

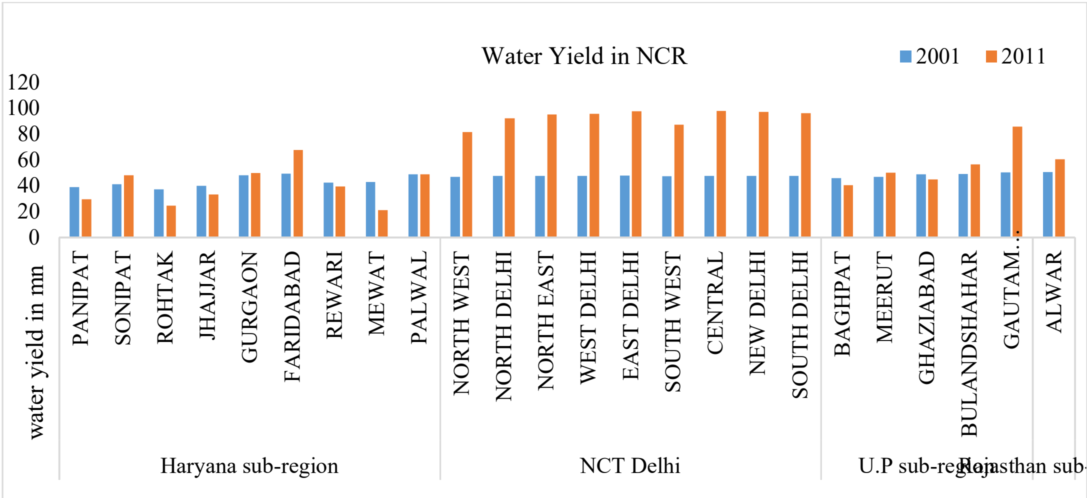


Figure 4.15 Water yield in NCR in 2001 and 2011

(Source: InVEST modelling for Water yield in NCR)

If we analyse region and district wise water yield variation in NCR from 2001 to 2011 it is revealed that in Haryana sub-region, Faridabad, Sonipat, and Gurugram show increase in the water yield whereas Panipat, Rohtak, Mewat, Rewari, and Jhajjar show decrease in water yield. Similarly, in U.P sub-region, Gautam Budh Nagar, Bulandshahr, Meerut shows increase in the water yield whereas Baghpat and Ghaziabad shows decrease in water yield. In Rajasthan sub-region, Alwar shows increase in water yield. However, NCT Delhi shows increment in water yield in all districts of Delhi.

In nutshell, we can say that water yield and crop yield calculation and mapping are of great importance to water and land resource planning and management. At the end, it concludes that in order to mitigate and minimize the detrimental effects associated with land use change on the ecosystem services and functioning, modeling approach would be a great tool in decision making process that aims to improve recognition and application of services.

Significance of crop yield and water yield modeling through InVEST represented at different scales, regions, and watersheds which demonstrated the variations within NCR in distribution of ecosystem services are enabling policy makers and planners in management and minimize adverse impacts on it due to land use land cover change. Further, it is at great importance at regional and as well as at local level with the study of urbanisation effects on land use land cover change and resultantly effecting the ecosystem services to assess further impacts on socio-economic characteristics and vulnerabilities of the communities. That means how change in these services would effect to livelihoods, in this connection next chapter would be focuses on the socio-economic characteristics and vulnerabilities in Faridabad and Gautam Budh Nagar at household level study.

4.4 Loss of agricultural land and ecosystem services

Land use and land cover analysis of NCR revealed reduction in the agricultural land and expansion in the urban landscape which further resulted in the change in the cropping pattern and land intensification in the region. Agroecosystems are the essential source of provisioning services but depending upon their structure and management, they may also generate dis-services such as agrochemical contamination, loss of biodiversity, sedimentation of waterways, emissions of greenhouse gases and pollutants (Dale et al., 2007; Zang et al., 2007). Crop intensification is the result of loss of agricultural land which has negative local consequences, such as lower soil fertility, reduced biodiversity, pollution of ground water, eutrophication of rivers and lakes.

As it is already discussed in chapter 3 (section 3.7.3.3) that cropping intensity in NCR has increased from 158.7 in 2001 to 168.2 in 2011. Here it is also important to mentioned that similar results have been found with the assessment of InVEST derived crop yields values. Per hectare production of crops has been increased in regions of Panipat, Sonipat, NCT-Delhi, Faridabad, Bulandshahr, and Ghaziabad. Ahlawat et al., 2016 analyzed cropping intensity in the Haryana region of NCR and found that Panipat Gurugram, Jhajjar and Rewari has showing increment in its values which further attributing to the land use change and urban expansion.

In addition, the consumption of fertilizers leads to the degradation in the nutrients of the soil which also effecting the surface and ground water conditions. Increased consumption of fertilizers over the decreased agricultural land will negatively effects the other ecosystem services such as ground water condition, contamination of surface water, and decline the nutrients in the soil.

Over all, this chapter dealt with the modelling of the provisioning ecosystem services and analyzed its losses across districts of NCR. This kind of work is significantly contributing to the management purpose and increased the awareness of the distribution of ecosystem services at spatial scale. In connection to this chapter, the next chapter of this study will be focusing on the impacts of ecosystem services at society in terms of the socio-economic characteristics and vulnerabilities of the region. It will basically assess the linkages of ecosystem services with the socio-economic characteristics of the households which will further discuss that how socio-economic condition of the household are responsible for depending upon ecosystem services for a livelihood. Further, socio-economic vulnerabilities of a household will be identified for the purpose to provide socio-economic and financial support by the regional and central government.

Chapter-5

SOCIO-ECONOMIC CHARACTERISTICS AND LIVELIHOOD VULNERABILITIES

5.1 Background

The term 'urbanisation' represents a complex process of socio-economic and ecological transformation of an area which is mainly driven by anthropogenic activities. Urban areas have been recognised as 'engines of inclusive economic growth.' After independence, urbanisation in India is increasing at very high pace, but at the same time, there are some problems, which are becoming barriers for balance, equitable, and inclusive development. The number of the total population has increased 4.3 times whereas the number of the urban population has increased more than 11 times since the last century which is mainly due to the natural increase of population, rural to urban migration, and reclassification of rural areas as urban. Urban population in India has mainly confined in class I cities, especially in the megacities where the urban population has concentrated and increased steadily over the last few decades (Kundu, 2006). Although the process of urbanisation in National Capital Region has been continuing from the Mughal era, it was accelerated after being designated as the capital region of India in 1901. The city Delhi experienced a sharp increase in population density after the independence and partition of the country in 1947 which led a huge number of refugees to migrate to the city. After the increasing pressure on NCT Delhi, the NCR Planning Board came up with its first Regional Plan in 1989 with the intention to deflect the population from Delhi, by 2001, through a multi-nodal regional growth pattern which could diverts the population to its priority towns that includes eleven dispersed growth centres namely Noida, Faridabad, Ghaziabad, Gurugram, and several others.

National Capital Region (NCR) has experienced rapid land-use changes during the last two decades. The expansion of area under non-farm activities is generally taking place at the cost of agriculturally productive land. The land use change is mainly influenced by two factors. The first is the inflow of migrants towards NCR for seeking employment opportunities. The second factor is the increased economic activities in

NCR. Due to a rapid increase in the development of industrial activities a considerable proportion of agricultural land is converted for residential and industrial uses along the corridors outside Delhi. As a result of the rapid land conversion, several problems like a gap in availability of essential provisioning ecosystem services e.g. water, food etc. are getting affected along with transport and also management of solid waste is increasingly needed. Moreover, the irrational land use of any area leads to environmental degradation and ecosystem services.

In order to identify land use and land cover of an area, the geospatial techniques have played an important role over the last couple of decades. Unlike the conventional methods of surveying, this technique has become popular for its robustness in data analysis, database management, and accuracy. It is also noteworthy that acquisition of satellite based data products does not require much time and cost in comparison with conventional field based methods of data collection (Da Costa,1999). Since remote sensing technique allows acquisition of spatial data in multi-resolution, multi-spectral, and multi-temporal form, it has been accepted as an essential tool for mapping and monitoring land use and land cover dynamics (Kushwaha et al., 1996). Remote sensing technique coupled with geographic information systems (GIS) has been proven to be an efficient and cost effective tool for determining land use and land cover change. It provides vivid scope to explore land features, vegetation dynamics, agricultural productivity, water quality, spatio-temporal changes in land use and land cover and their impact on the environment with good accuracy. While remote sensing is all about acquiring digital information based on spectral reflectance of earth surface, GIS is a computer based information system with having the capability to integrating data from various sources for providing the information necessary for effective decision-making (Han & Kim, 1989).

The main objective of this chapter is to see the influence of NCR urbanisation on Faridabad and Gautam Budh Nagar districts and the resultant impact on socio-economic characteristics of the regions. In order to achieve this aim, the following research questions have been framed in the present chapter:

i. What is the land use and land cover change and urbanisation in Faridabad and Gautam Budh Nagar districts of NCR?

ii. How urbanisation influenced socio-economic characteristics of a region and what is the impact on rural poor's?

5.2 Materials and Methods

This chapter is divided into two sections. First, **section A** deals with the land use and land cover change and an assessment of the influence of NCR urbanisation on Faridabad and Gautam Budh Nagar district. Second, **section B** deals with the socio-economic characteristics of the region. It also analyses the socio-economic caste census data for selected village, Kheri Kalan from Faridabad, and Bishada from Gautam Budh Nagar at the household level.

5.2.1 Data base

i. *DES data*

The LULC data has been taken from the Directorate of Economics and Statistics (DES), Ministry of Agriculture, Government of India. The data used for the analysis is for 2 time-periods of 2001 and 2011.

ii. *Census of India, 1991, 2001, and 2011*

For analysing urbanisation trends and socio-economic characteristics of the region, data such as urban population, total population, literacy, working population in the primary, secondary, and tertiary sector have been collected.

iii. *Socio-Economic Caste Census data, 2011*

Socio-Economic Caste Census (SECC) data has been collected from the block development office of Faridabad district and Gautam Budh Nagar district for Kheri Kalan and Bishada village that is also the selected study areas for primary field survey. SECC provided for automatic exclusion on the basis of 14 parameters, automatic inclusion on the basis of 5 parameters and grading of deprivation on the basis of seven criteria. The data addresses the multi dimensionality of poverty and provides a unique opportunity for a convergent, evidence based planning with Gram Panchayat as a unit. The data is an opportunity to make evidence based selection, prioritization, and targeting of beneficiaries in different programmes. It is useful for capturing the intensity of the poverty. Another important feature is the locational aspect of poverty, i.e., earlier poverty lines use to tell there are 70% people who are poor. This census will tell who accumulate among these 70%.

5.2.2 Methods

i. *Land use land cover change*

Simply, percentage, growth rate, and annual growth rates have been computed from the nine-fold classification of land use categories. This nine-fold classification of land use is given below:

Table 5.1 Nine-fold classification scheme[1] and a brief description of classes are as given hereunder

S.no	LULC CLASSES	DESCRIPTION
1.	Forest	It includes protected or reserved forest, forest camp, government forest, private forest, social forest and wild life sanctuary.
2.	Area under Non-agricultural uses	It includes all lands occupied by roads, buildings, railways or under water, e.g., rivers and canals and other lands put to uses other than agriculture.
3.	Barren and Unculturable land	Land which cannot be brought under cultivation except at an exorbitant cost should be classed as unculturable whether such land is in isolated or within cultivated holding.
4.	Permanent pastures and other grazing lands	It involves all grazing lands whether they are permanent pastures and meadows or not. Village common grazing land is included under this category.
5.	Miscellaneous tree crops and other groves, not included in net area sown	This includes all cultivable land which is not included in 'Net area sown but is put to some agricultural uses.
6.	Culturable waste	This includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last five years or more in succession including the current year for some reason or the other. Such land may be either fallow or covered with shrubs and jungles which are not put to any use.
7.	Fallow land other than current fallow	This includes all land which was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.
8.	Current Fallow	This represents cropped area which is kept fallow during the current year.
9.	Net area sown	This represents the total area sown with crops and orchards. The area sown more than once in the same year is counted only once.

ii. In order compute urban growth in Faridabad and Gautam Budh Nagar, the urban population decadal growth rate is calculated to present the increase in population in different census years.

$$\text{Percentage decadal growth rate of urban population} = ((P1 - P0)/ P0) * 100$$

Where, P1 = Urban population in the current year.

P0 = Urban population in the base year

iii. The level of urbanisation is analysed by calculating the percentage of urbanisation. It refers to the absolute or relative number of people living in the urban area at a specific point in time.

$$\text{Percentage Urban Population} = (Pu / Pt) * 100$$

Where, Pu = Urban population of the specific time

Pt = Total population of that specific time

iv. The concentration of urban population is computed 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

v. *Socio-economic vulnerabilities*

To look into the socio-economic characteristics, certain socio-economic development indicator is used like the education, basic amenities, occupation structure (NCO-3 DIGIT LEVEL), assessment of property and other socio-economic aspects. Further, at selected case studies (Kheri Kalan and Bishada), household level data has been analysed and socio-economic vulnerabilities have been computed on the basis of SECC committee criteria, Saxena Committee criteria and based on the main source of income groups i.e. farming and non-farming activity. The methodology that has been used to compute socio-economic vulnerability based on the source of income groups, includes a selection of households with specific indicators adopted from SECC Committee criteria and

Saxena Committee criteria then deprivation index has been calculated and household level scores were assigned, which varies between 0 to 7. Near to 7 score represents a high level of socio-economic vulnerability and near to 0 represents very low level of socio-economic vulnerability across a different source of income groups. The following methodologies will be discussed in detail in Section B of this chapter.

5.3 Results and Discussion

SECTION-A

5.3.1 Land Use and Land Cover Change (LULCC) in Gautam Budh Nagar and Faridabad district

5.3.1.1 Land use and land cover in Gautam Budh Nagar (2001-2011)

Land use and land cover change have been observed over the last few decades throughout India. Land use and land cover of Gautam Budh Nagar for two different time periods (2001 and 2011) are shown in Table 5.2 and Figure 5.1. The nine-fold classification of land use data has been used to analyse the land use and land cover distribution and land use change dynamics of this region. The total geographical area of this region is 144,200 ha in which reporting area for land utilisation is different for both time periods. Reporting area stands for the area for which data on land use classification is available. In areas where land utilization figures are based on land records, reporting area is the area according to village papers, i.e., the papers prepared by the village accountants. In 2001, the land use classification shows that 71.1% area was under agricultural land followed by land not available for agriculture (16.65%), fallow land (8.06%), other unculturable excluding fallow (3.93%), barren & unculturable (3.50%), culturable wasteland (2.33%), miscellaneous tree crops (1.25%), and forest (0.20%) (Figure no 5.1).

Table 5.2 Nine-fold classification of land use in Gautam Budh Nagar during 2001 and 2011

LULC classes (Gautam Budh Nagar)	Total area (ha)		Area in %		Change 2001-2011	
	2001	2011	2001	2011	%	%/year
Forest	400	2003	0.20	1.60	680.51	68.05
Agricultural Land/NSA	139097	65164	71.15	51.96	-26.98	-2.70
Fallow Land	15759	25175	8.06	20.07	149.00	14.90
Other Unculturable excluding fallow	7680	2970	3.93	2.37	-39.72	-3.97
Barren & Unculturable	6842	2136	3.50	1.70	-51.34	-5.13
Land not available for agriculture	32557	30110	16.65	24.01	44.15	4.42
Pasture &grazing	674	479	0.34	0.38	10.77	1.08
Miscellaneous tree	2451	540	1.25	0.43	-65.66	-6.57
Culturable waste	4555	1951	2.33	1.56	-33.24	-3.32

Note: Reporting Area for land utilization in 2001 is 195493 ha, and in 2011 is 125422 ha.
(Source: Calculated from the land-utilization statistics of Directorate of Economics & Statistics (DES), Ministry of Agriculture, GOI)

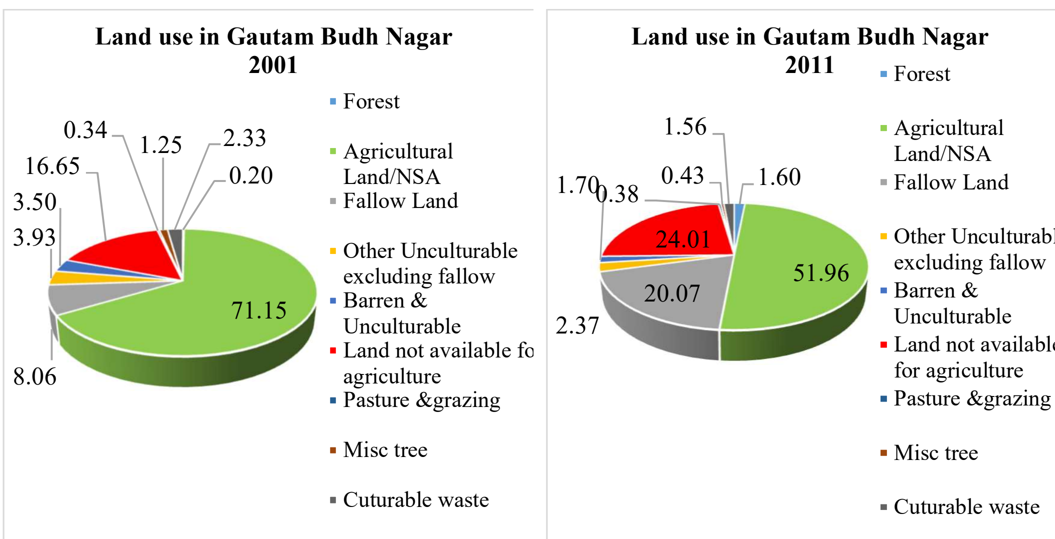


Figure 5.1 Pie chart of Land use in Gautam Budh Nagar during 2001 and 2011

Similarly, in 2011, land use classification shows that 51.96% area was under agricultural land followed by land not available for agriculture (24.01%), fallow land (20.07%), other unculturable excluding fallow (2.37%), barren & unculturable (1.70%), forest (1.6%), culturable wasteland (1.56%), miscellaneous tree crops (0.43%), and pasture & grazing land (0.38%).

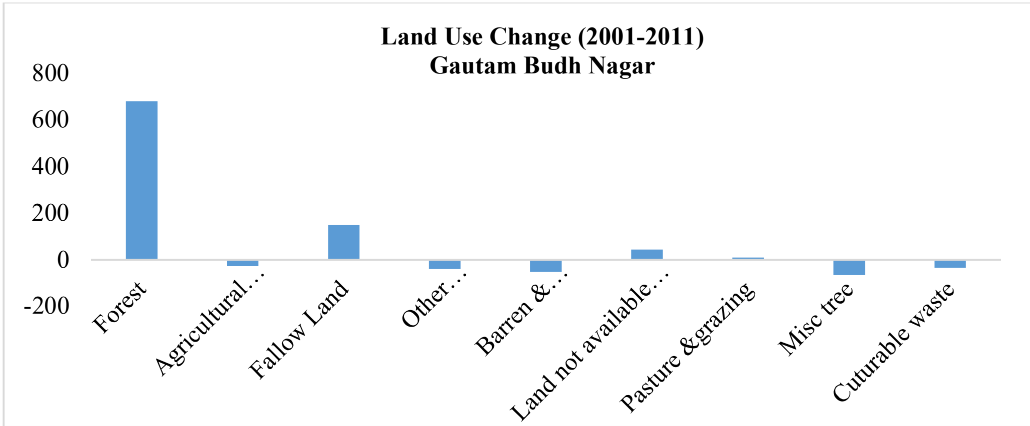


Figure 5.2 Land Use change in Gautam Budh Nagar during 2001-2011

However, when we see land use and land cover change from 2001 to 2011, it is found that the most dramatic change has occurred in agricultural land class which decreased from 71.15% in 2001 to 51.96% in 2011 and an increase in the land not available for agriculture (that basically denotes to built-up area) from 16.65% in 2001 to 24.01% in 2011. The annual rate of decrease in agricultural land from 2001 to 2011 is 2.70% per year whereas the annual rate of increase in non-agricultural land (built-up) from 2001 to 2011 is 4.42% per year.

The interesting change noted in the forest class, it has increased by 1.4% from 0.20% in 2001 to 1.60% in 2011. Although fallow land and pasture & grazing have also increased from 8.06% to 20.07% and 0.34% to 0.38%, with an annual growth rate of 14.9% and 1.08% from 2001 to 2011 respectively. On the other hand, barren land, culturable wasteland, miscellaneous tree, and other unculturable excluding fallow land have decreased with an annual decrease rate of 5.13%, 3.32%, 6.57%, and 3.97% from 2001 to 2011 respectively.

In Gautam Budh Nagar district, Noida and Greater Noida are urbanising very fast due to the availability of different means of earning livelihoods. Noida emerges as an industrial center of this region which attracts huge masses due to the availability of various necessary facilities such as educational facilities, shopping complexes, utilities and services, other recreational services along with employment.

5.3.1.2 Land use land cover change in Faridabad (2001-2011)

In any region, the urban phenomenon is associated with the expansion of built-up area and contraction of agricultural land. This phenomenon not only limited to the reduction of arable land but also decline in other land use categories such as water bodies, forest cover, barren land etc. The land use dynamics of Faridabad region of NCR also documented the same phenomena. In 2001, nine-fold land use classification shows that 76.90% area was under agricultural land followed by land not available for agriculture (20.52%), barren & unculturable land (3.61%), forest (1.30%), other unculturable excluding fallow, pasture & grazing (0.81%), and fallow land (0.47%). Similarly, in 2011, land use distribution showed both negative and positive changes in all categories. As agricultural land decreased to 48.42% whereas land not available for agriculture has increased to 49.68%. Negative changes have found in the category of forest cover, other unculturable excluding fallow, and pasture & grazing land. On the other hand, positive changes along with built-up area have been found in the land use category of fallow land.

Table 5.3 Nine-fold classification of land use in Faridabad during 2001 and 2011

LULC classes (Faridabad)	Total area (ha)		Area in %		Change 2001-2011	
	2001	2011	2001	2011	%	%/year
Forest	2705	323	1.30	0.45	-65.53	-6.55
Agricultural Land/NSA	159975	34897	76.90	48.42	-37.03	-3.70
Fallow Land	984	772	0.47	1.07	126.46	12.65
Other Unculturable excluding fallow	1686	271	0.81	0.38	-53.60	-5.36
Barren & Unculturable	7511	1800	3.61	2.50	-30.83	-3.08
Land not available for agriculture	42684	35808	20.52	49.68	142.15	14.22
Pasture &grazing	1686	271	0.81	0.38	-53.60	-5.36
Miscellaneous tree	0	0	0.00	0.00	0.00	0.00
Culturable waste	0	0	0.00	0.00	0.00	0.00

Note: Reporting Area for land utilization in 2001 is 208034 ha, and in 2011 is 72071 ha.
Source: Calculated from the land-utilization statistics of Directorate of Economics & Statistics (DES), Ministry of Agriculture, GOI.

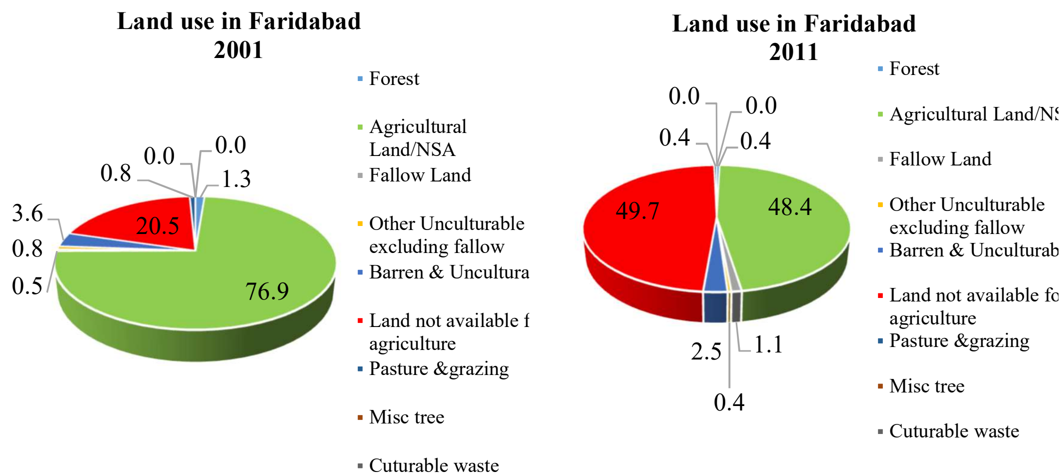


Figure 5.3 Pie chart of Land use in Faridabad during 2001 and 2011

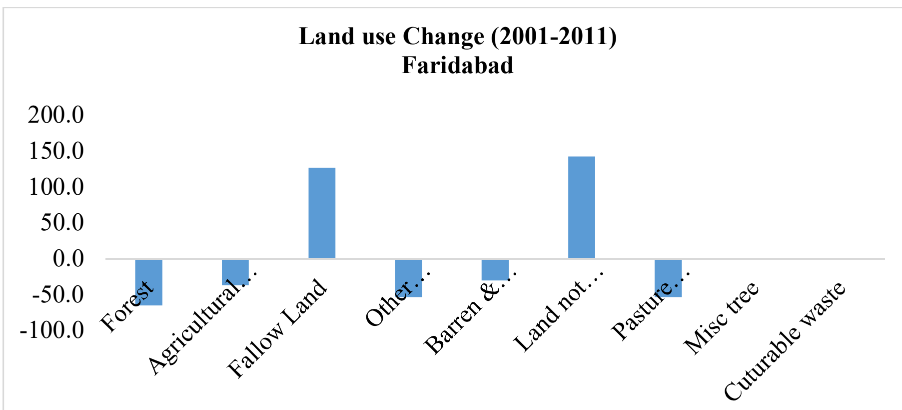


Figure 5.4 Land use change in Faridabad during 2001-2011

If we see the dynamics of land use categories, it is found that agricultural land is decreasing with an annual growth rate of 3.70% whereas land not available for agriculture (built-up) is increasing with an annual growth rate of 14.2%. Similarly, fallow land is also increasing with an annual growth of 12.65%. On the other hand, forest, other unculturable excluding fallow, barren & unculturable, and pasture & grazing land is decreasing with an annual growth rate of 6.5%, 5.3%, 3.08%, and 5.36% respectively.

5.3.2 Influence of NCR urbanisation on Gautam Budh Nagar and Faridabad district

Being influenced by various factors, urban centers of any region have evolved over a time period. This evolution is profoundly linked with the socio-economic-cultural-political and demographic set-up of this period. Well-known urban centers of historical days may have now decayed into a smaller and less important human settlement; whereas, some new centers have now emerged very prominently in the changing socio-economic and political spheres. But one thing is common throughout the time period: urban centers have always been the foci of these spheres. Therefore, the study of urbanisation of any region should begin with controlling processes and trends in order to finally reach in the identification of patterns. Ramachandran (1989)[1] has remarked that '*there are, in fact, not one but several processes of urbanisation at work at any given point of time and space*' (p.75). One cannot objectively determine which process is more predominant over another one. The above discussion on land use and land cover dynamics in sub-regions of NCR shows that most of the built-up expansion of NCT-Delhi, is spreading towards the Faridabad and Gurugram in Haryana Sub-region; and towards Ghaziabad and Noida (Gautam Budh Nagar) in UP sub-region. As it was also evident from land use and land cover map of NCR that Faridabad and Gurugram are growing very fast in Haryana sub-region, and Ghaziabad and Noida in UP sub-region. Therefore, this present section focuses on the growth and trend of urbanisation in Faridabad and Gautam Budh Nagar district. Further, it also looked into the working population scenario in both districts for two time periods 2001 and 2011. Data has been collected from available literature as well as from different volumes and tables of Census of India.

5.3.2.1 Gautam Budh Nagar

Gautam Budh Nagar district of UP sub-region of NCR was created in the year 1997. It was carved out from the Bulandshaher and Ghaziabad district. The Yamuna River separates the districts of Haryana state and Delhi to the west. It consists of three tehsils, i.e., Dadri, Gautam Budh Nagar, and Jewar. The total area of the district is 1,442 sq. km. The total population of the district as per 2011 census is recorded as 1,648,115 out of which 890,214 are males and 757,901 are females. The sex ratio in the district is 851 females per 1000 males. The density of population in the district as

[1] Ramachandran, R. 1989. Urbanisation and Urban systems in India. Delhi: Oxford University Press, 364 pp.

per 2011 census is 1,286 per sq. mt. The population growth rate is 37.11% and the average literacy rate is 80.12%. The rural and urban population is 40.88% and 59.12% respectively. District shows a tremendous change in both, land use and land cover pattern and urban population growth. It shows highest urban population growth in UP sub-region, and second highest in whole NCR. The level of urbanisation in Gautam Budh Nagar was 37.39% in 2001, while it has increased to 59.56% in 2011.In addition, the highest numbers of census towns in 2011 were observed in Dadri tehsil of Gautam Budh Nagar. Census towns increased by 150% from 2001 to 2011. Further, by 2011, more than 80% urban population of Dadri and Gautam Budh Nagar tehsils were living in census towns (Table 5.4 & 5.5).

Table 5.4 Level of Urbanisation in Faridabad and Gautam Budh Nagar

Districts	Total Population			Urban Population			% of Urbanisation		
	1991	**2001**	**2011**	**1991**	**2001**	**2011**	**1991**	**2001**	**2011**
Faridabad	1477240	2194586	1798954	717513	1221344	1429093	**48.57**	55.65	**79.44**
Gautam Budh Nagar		1202030	1674714		449415	997410		37.39	**59.56**

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

Table 5.5 Number of Census Towns at tehsil level in Faridabad and Gautam Budh Nagar

Tehsil	Total Urbanisation			Census Towns					% of CT Population to Tehsil Urban Population	
	Percentage Urban		**Rate of Change**	**Number of CT's**			**Percentage Increase**			
	2001	**2011**	**2001-2011**	**1991**	**2001**	**2011**	**1991-2001**	**2001-2011**	**2001**	**2011**
Gautam Budh Nagar										
Dadri	53.91	70.54	30.84	2	2	5	0	150	84.62	88.36
Gautam Budh Nagar	7.51	41.82	457	0	0	2	n/a	n/a	n/a	83.02
Jewar	22.65	26.55	17.18	0	0	0	n/a	n/a	n/a	n/a
Faridabad										
Faridabad	89.63	89.95	0.32	0	1	1	n/a	0	0.60	1.43
Ballabhgarh	0	2	n/a	0	0	1	n/a	n/a	n/a	100

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

Table 5. 6 Sector-wise workforce in Faridabad and Gautam Budh Nagar (2001)

District	**Primary Sector**	**Secondary Sector**	**Tertiary Sector**	**Total Workers**
Faridabad	359491 (45.75)	268460 (34.17)	157005 (19.98)	785762
Gautam Budh Nagar	162926 (44.78)	93206 (25.62)	105633 (29.03)	363814
NCR	**5839827 (45.02)**	**4099262 (31.60)**	**3224747 (24.86)**	**12972094**

(Source: Cemsus 2001) Note: figures in brackets are in percentage

Table 5.7 Decadal urban population growth rate and Concentration of urban population in Faridabad and GT B Nagar

Districts	% of Urbanisation			Decadal urban population growth rate		Location Quotient		
	1991	**2001**	**2011**	**1991-2001**	**2001-2011**	**1991**	**2001**	**2011**
Faridabad	**48.57**	55.65	**79.44**	70.2	17.8	**0.97**	0.99	**1.27**
Gautam Budh Nagar		37.39	**59.56**	-	93.0	-	0.66	**0.95**

(Source: Census of India 2001 & 2011)

Urban growth in Gautam Budh Nagar basically concentrated over two specific regions i.e. NOIDA (New Okhla Industrial Development Authority) and Greater Noida. Whilst the history of the development of the present day of these towns were traced back to 1972 when the Government of Uttar Pradesh, declared 50 villages of the former Bulandshar district as the 'Yamuna-Hindon-Delhi Border Regulated area' under the provision of U.P. Regulation of Building Operations Act, 1958. These villages were closely located to Delhi and had backward characteristics of development and that time there was no urban center in this region. For reducing the pressure on Delhi, the Interim General Plan was prepared in 1956 and then the first Master Plan of Delhi was prepared in 1962 that suggested for the planned decentralisation of large economic activities from Delhi to its surrounding regions. This paved ways for the development of industrial units in its surroundings resulted in speculative land dealings and potentials for unplanned and unauthorised development activities. Therefore, need for establishing planned urban centers in the close proximity of Delhi was felt to provide an alternative site for the planned development of small and medium size industrial units. Finally, on April 1976 the Government of Uttar Pradesh notified 36 villages of 'Yamuna-Hindon-Delhi Border Regulated Area' as New Okhla Industrial Development Area (NOIDA) under the provisions of U.P. Industrial Development Act, 1976. Therefore, the state government constituted a new statutory body, namely, the NOIDA to ensure planned development of the area for industrial and allied uses.

The urban population at particular this region have grown tremendously. If we see the population growth in Noida it is found that in 1981, when Noida was in its initial or say infant stage, region consisted of a population of around 37,000, which was basically the aggregate population of the rural and urban settlements that existed within the Noida notified area. The population of the city grew by nearly 400% during 1981-91 and 108% during 1991-2001 a further in 2011, it grew by 106% (Census, 1991, 2001 and 2011).

Moreover, looking at the surrounding regions of NOIDA and Greater Noida presented a growing picture of the increase in the population growth and resultant change in the occupation structure in this region (Figure 5.5). People are moving from primary sector to secondary and tertiary sector.

When looked at a total population of the district at village level scenario shows that regions that have located near the urban centers have grown rapidly. Towards the east of Noida, population growth has found high. The Southern region of the district also shows an increase in the population growth surrounded by the Jewar Nagar Palika region.

The impact of urbanisation can easily see in the district by the analysis of change in the net sown area, decrease in the ratio of cultivators to total workers as well agricultural labors.

The total net sown area in the district has declined. Agriculture is the main source of livelihood but when we look at the number of cultivators participation in the working population it shows a decline in its ratio. According to Census 2011, only 12.8% population is engaged in cultivation while 8.6% are agricultural labourers. 72.4% workers are engaged in another source of livelihood which includes secondary and tertiary activities. Further, only 6.2% workers are engaged in household industries.

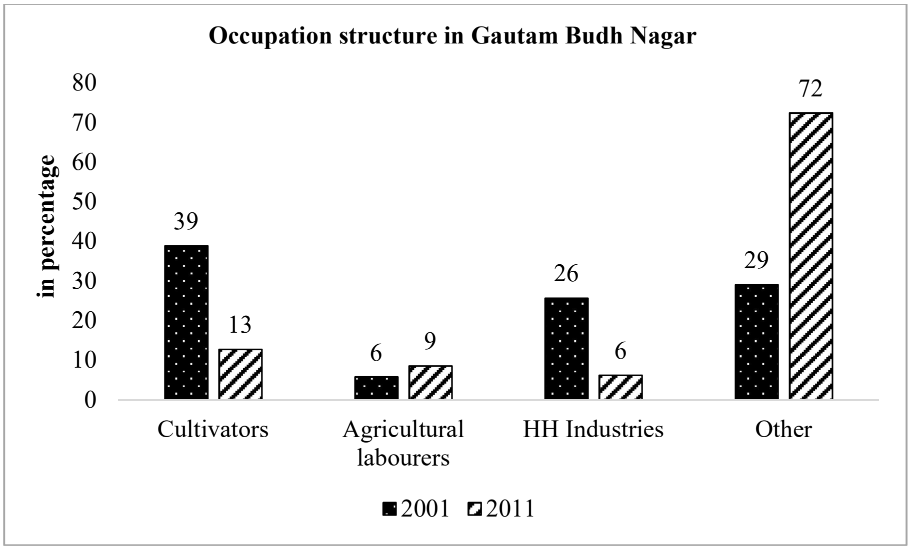
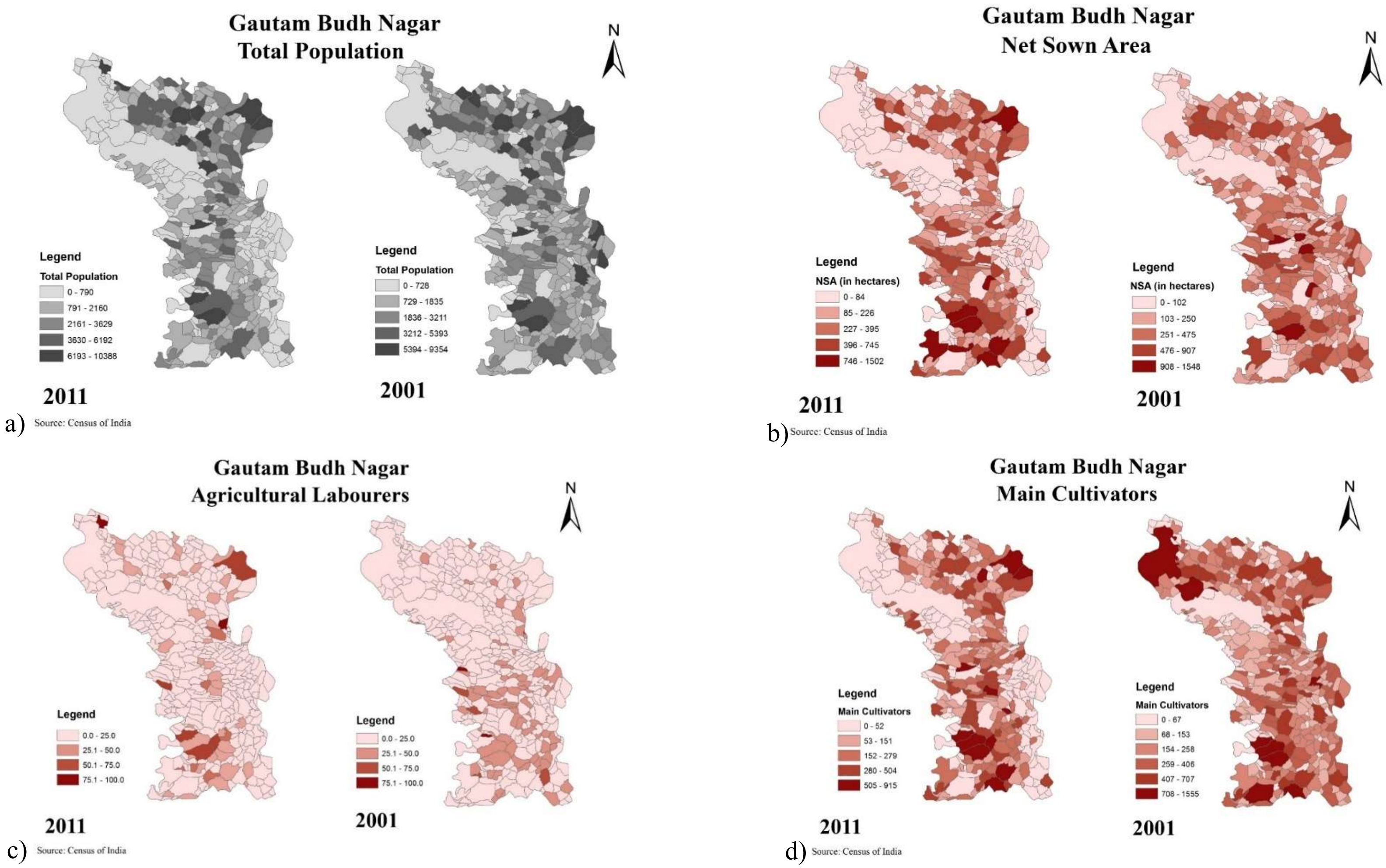


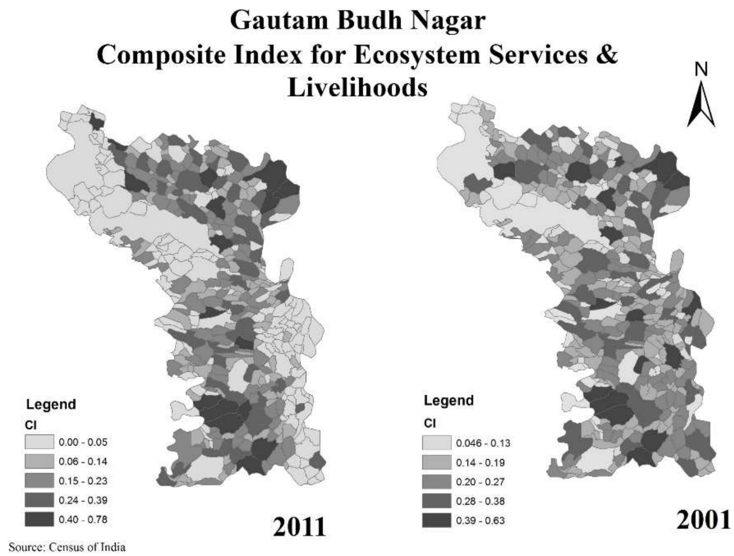
Figure 5.5 Occupation structure in Gautam Budh Nagar

Overall, it can be said that participation of the workers in other sector has increased from 2001 to 2011 which may be a possible influence of NCR urbanisation over this region.

Further, to analyse the dependency on cultivation as a source of livelihood at the village level, a composite index has been computed. It includes proxy variables such as net sown area, workers who engaged in cultivation, agricultural labourers, total population, and total geographical area.



Map 5.1 Comparative village level map of Gautam Budh Nagar for 2001 & 2011 a) Total population; b) Net Sown Area; c) Agricultural labourers; d) Main Cultivators



Map 5.2 Composite Index for Ecosystem Services & Livelihoods in Gautam Budh Nagar (2001 & 2011)

The composite index for the people dependent upon ecosystem services (crop production) for their livelihood in this region reveals that due to industrialisation and urbanisation in this region, land under cultivation become less and further cultivators are now indulging in other occupation along with cultivation. Higher values for composite index depicts higher the dependency on primary activities or say depend upon ecosystem services and vice-versa. Composite index in 2001 for total population depended upon agriculture as their source of livelihood shows that there were 17 villages which come under a high level of dependency on primary activities. The composite index for this time period ranges between 0.046 to 0.63. Values which were close to 0.63 considered as the highly dependent population on primary occupation. In this category, some villages were showed high values namely Dhoom Manikpur, Dankaur, Dayantpur etc. Village Bishada was at 15th rank which shows significant dependency on primary activities. Whereas in 2011, the composite index for the same variables varies between 0.05 to 0.78. Fifteen villages were close to higher values of composite index namely Dayatpur, Jarcha, Kalonda, Falaida Bangar, Dankaur etc. In 2011, Bishada shows 13th rank that means the dependency on a primary source of income has increased.

Though agriculture is the main occupation of the people in this district, but due to fast industrialization and urbanisation land size under cultivation is decreasing recently. The availability of land for agriculture is also decreasing due to the acquisition of land by the Yamuna Expressway, Greater Noida Development Authority and Noida Development Authority to land. Even though agriculture occupies a prominent place in the economy in the district that indicates a dependency on agriculture ecosystem services is significant in the region. Wheat, Paddy, Barley, Jawar, Bajra, Corn etc. are the main crops cultivated in the district. The area covered under the various crops is highest in Wheat followed by Rice, Bajra, Barley, Vegetables etc. (*Statistical Abstract, Gautam Budh Nagar, 2011-12*). While it can be noticed that vegetables cultivation nowadays growing rapidly because of the rapid urbanisation , *Horticulture* products show a good demand in Gautam Budh Nagar district. It will help to boost farmers income as well provide gainful employment. Various scheme (National Mission on Micro Irrigation, Agricultural Technology Management Scheme(ATMA), Diversified Support Project (DASP) and National Agriculture Development Scheme for promotion and development of Horticulture activities are operational in the district for horticulture development under which the area under vegetables, fruits & spices is being extended. *Livestock farming* is another important livelihood option next to farming in rural areas. It provides multiple provisioning ecosystem services to the people.This occupation is complementary to agriculture. It not only provides employment opportunities but also it is the source of nutritious food and also provides leather as raw materials to industries. The milk and milk products industries rely on it. Most of the people in Gautam Budh Nagar district are interested and habituated in rearing cattle, pigs, poultry etc.

Singh et. al (2011) study demonstrate that rapid urbanisation in Gautam Budh Nagar district has resulted in the reduction in agriculture land, forest, and shrub since 1995. More than 36% of forest and 22% of the shrubs area were transformed into farmlands and built-up area. The change in hydrological condition affected the river’s flood protection capacity and increasing the flood risks.

5.3.2.2 Faridabad

In the process of urbanisation, the location of any region plays an important role. Faridabad is located 25 kilometers south of Delhi and touched the boundary of National Capital Territory of Delhi on its north, Gurgoan district on the west, and Gautam Budh Nagar district in the east and south. The Yamuna River flows through eastern part of the district adjacent to the western part of the Gautam Budh Nagar district. It is the only city in Haryana to have a functional municipal corporation, governing its 35 wards and to have a million plus inhabitants. It has become as the seventh fastest growing city of the world.

Historically, Faridabad town originated in the Mughal period. It was said to have founded in AD 1607 by Shaikh Farid. Faridabad is a treasure of Jahangir a Mughal Emperor. The town was built up with the objective of protecting the highway which passed through the town. Sheikh Farid built a fort, a tank and a mosque in the town. Later it became headquarter of a pargana which was converted into Jagir of Ballabhgarh ruler. But the site of present Faridabad township was selected by the Government of India for rehabilitating the displaced person migrated from the North west frontier province, on the eve of the partition of India in 1947 (Gazetteer of Haryana, 1965). In the late 1950’s the industrial oriented development began and a number of industrial units came up along the National Highway. The geomorphology of this region also limits the expansion of the city in all directions. As Aravalli hills are present on the western part and Agra canal on the eastern side has been responsible for the linear development of the city. Due to the close proximity to Delhi, it has taken huge advantages to acquire the image of an industrial township which grown into a bustling metropolis.

As earlier in the third chapter, it was discussed that Faridabad falls under the Ring 2 region which is demarcated as Central National Capital Region (CNCR) or Delhi Metropolitan Area (DMA), showed a tremendous change in the land use and land cover pattern, in particular, expansion of urban settlements.

Demographic picture of the city showed that it grew from 1901 with a population of 9,815 persons which has increased to 37,393 in 1951 and reached to 1,798,954 persons in 2011and becoming the first metropolitan city in Delhi Metropolitan Area. Faridabad showed slow population growth rate till 1941 and thereafter rapid increase in growth rate noticed in 1951 by 225.86%. It was mainly attributed to the India-Pakistan partition. A large number of refugees from Pakistan settled down here. Thereafter population growth rate slowed down during 1951-61 which was 57.89%. And then again showed a rapidly increasing trend during 1961-81 by more than 100%. After that during 1981-2011, population growth rate again slowed down by 70.94% (Figure 5.6). However, this signifies that the city has been growing to its full potential and it has the potential capacity for absorbing the in-migrants as it gives a number of opportunities for employment purpose.

Further, urban population constitutes 79.44% in 2011 which increased by 30.87% since 1991. Decadal urban population growth rate shows 70.2% during 1991-2001 and 17.8% during 2001-2011 that means the urban population growth rate has slowed down. However, the concentration of urban population in Faridabad has increased from 0.97 in 1991 to 0.99 in 2001 and further it has reached to 1.27. The concentration of urban population shows that how dense the urban settlement is. That means in near future the densification or concentration of urban population will increase (Table 5.7).

The influence of urbanisation has impacted to the working population. The distribution of the workers in primary sectors has decreased from 2001 to 2011. In 2001, 10.5% of total workers were cultivators which have reduced to around 4.8% in 2011. That means people are shifting from one occupation to other. This can be associated with the contraction of agricultural land to non-agricultural land. On the other hand, total workers in the other sector have increased from 2001 to 2011. It was 20% in 2001 while in 2011 it has increased to 84.6% in others sector (Figure 5.7).

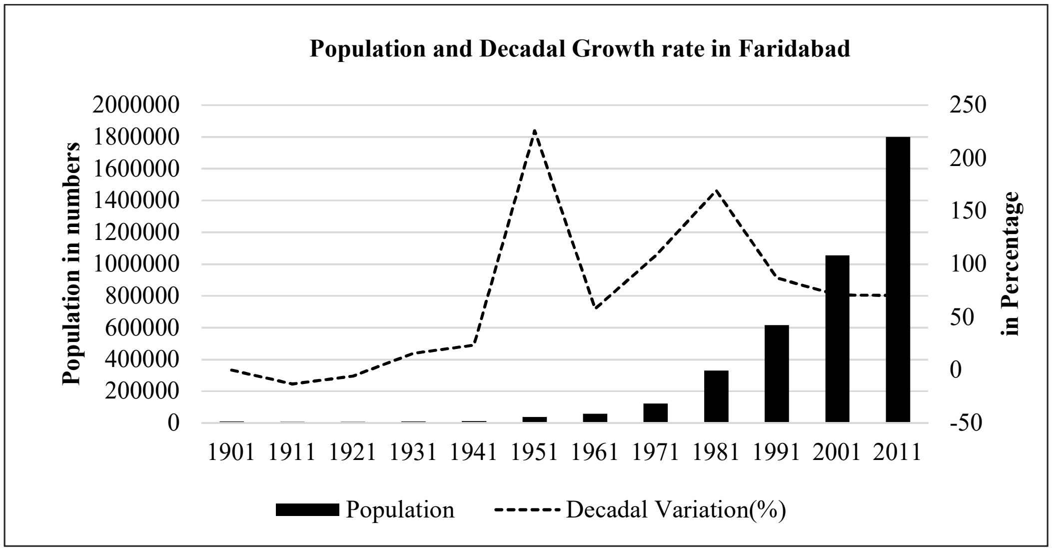


Figure 5.6 Population and decadal growth rate in Faridabad (1901-2011)

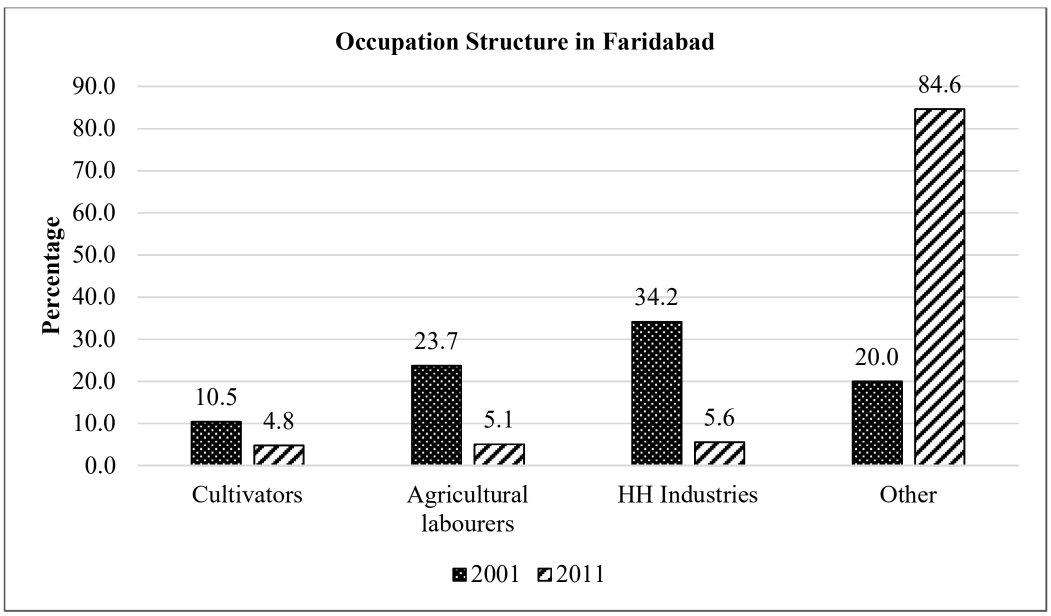


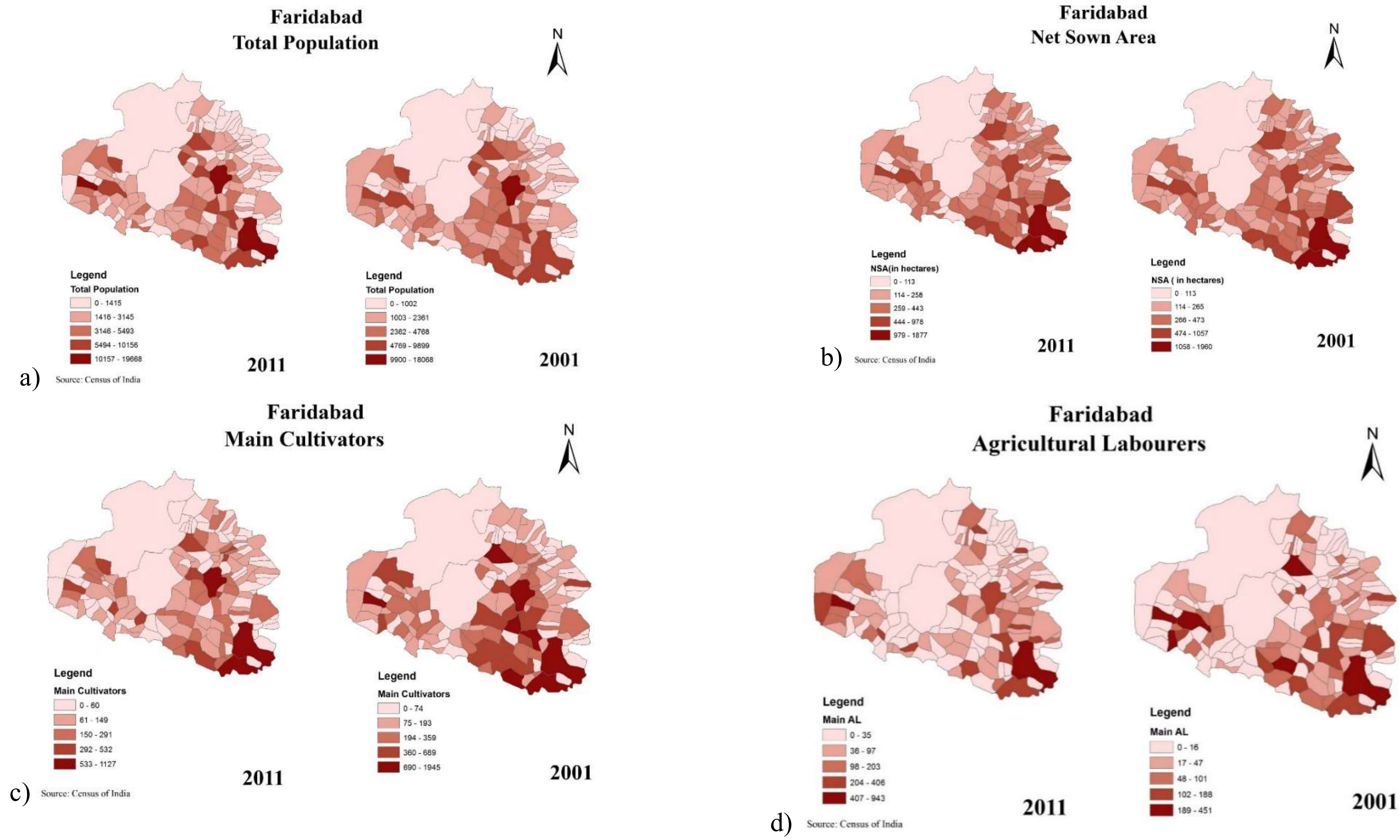
Figure 5.7 Occupation structure in Faridabad

Table 5.8 Distribution of workers as main and marginal and disaggregated in to rural and urban in 2011

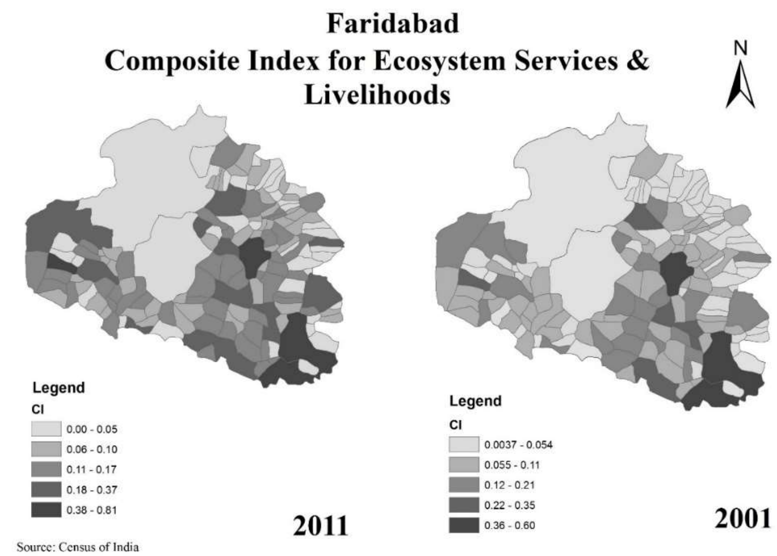
	Main Workers					Marginal Workers					Combined total (Main + Marginal)					Total Workers		
District	**Cultivators**	**Agriculture Labor**	**HH Industries**	**Other Workers**	**Total Main Workers**	**Cultivators**	**Agriculture Labor**	**HH Industries**	**Other Workers**	**Total Marginal workersWorkers**	**Cultivators**	**Agriculture Labor**	**HH Industries**	**Other Workers**	**Total Workforce**	**Rural**	**Urban**	**Total work force**
Faridabad	23654	19382	27869	424411	495316	4051	9906	4417	65539	83913	27705	29288	32286	489950	579229	106758	472471	579229
GBN	60899	27618	26065	343910	458492	11769	21227	9335	68286	110617	72668	48845	35400	412196	569109	216673	352436	569109
NCR	2052233	763868	484507	9933401	13234009	569630	580603	127027	1223660	2500920	2621863	1344471	611534	11157061	15734929	6226491	9508438	15734929

Table 5.9 Total workers among nine categories, census 2001

	1	**2**	**3**		**4**	**5 (Manufacturing, Procesing)**			**6**	**7**	**8**	**9 (Other Services)**		**1 to 9**		
Districts	**Cultivator**	**Agricultural Laborers**	**Livestock, Forestry etc.**	**Rural Industries**	**Mining & Quarrying**	**a)HH Industries**	**b) Other HH than industries**	**c) Electricity, & Gas Power**	**Construction**	**Trade & Commerce**	**Transport, & Storage Communicat ions**	**Financing, Insurance, Real estate & Business**	**Community, & Social Personal**	**Total workers**	**Total Population**	**Participation rate**
								Total Workers								
Faridabad	82175	186403	46513	39924	4476	65918	52788	57172	92582	38370	62321	27201	29113	785762	2194586	35.80
GBN	34338	93015	13884	20839	850	17772	16761	21637	37036	16594	59172	12950	16917	363814	1202030	30.27
NCR	1042122	3114795	593619	1046852	42439	879962	501781	865302	1852217	835849	1315842	532301	540755	12972094	37097239	34.97
								Main Workers								
Faridabad	164734		25824	33334	3891	59911	49091	44210	84524	35777	58619	25711	24037	609663	2194586	27.78
GBN	104669		10033	17665	810	14035	14054	17908	33954	15208	53155	12410	14983	308884	1202030	25.70
NCR	2726436		339775	886977	38098	773216	460199	708680	1734125	794641	1248730	508072	484715	10703664	37097239	28.85
								Marginal Workers								
Faridabad	104650		20689	6590	585	6007	3697	12962	8058	2593	3702	1490	5076	176099	2194586	8.02
GBN	24733		3851	3174	40	3737	2707	3729	3082	1386	6017	540	1934	54930	1202030	4.57
NCR	1447682		257391	145836	4414	106746	41582	156622	118092	41208	67112	24229	56040	2466954	37097239	6.65



Map 5.3 Comparative village level map of Faridabad for 2001 & 2011 a) Total population; b) Net Sown Area; c) Main Cultivators; d) Agricultural Labourers



Map 5.4 Composite Index for Ecosystem Services & Livelihoods in Faridabad (2001 & 2011)

The influence of urbanisation can also be seen in context to the how dependency on primary activities as a source of livelihood gets reduced. For this composite index have been computed by selecting proxy variables that could relate to the people dependency on ecosystem services as their livelihood. The composite index for this region shows that in 2001, there were five villages which come under a high level of dependency on primary activities. The composite index values for this time period varies between 0.003 to 0.6 which reveals that if the index value is higher, higher the dependency and if the index value is lower, then lower will be the dependency on primary activities. In 2001, Kheri Kalan village was at 5th rank which shows high dependency whereas in 2011 its rank gets increased to a 7th position which indicating decreasing the dependency on primary activities. The villages that comes under high level of dependency during 2001 were Chhainsa (0.60), Tigaon (0.5), Mohna (0.4) etc whereas in 2011, again Chhainsa (0.8), Tigaon (0.68), Mohna (0.56) etc shows high level of dependency but the index value has been increased from 2001 to 2011 for these villages that may be indirectly indicating for the increment in the agricultural labourers but decreasing the number of main cultivators.

In summing up this section, it can be said that urbanisation can lead to the change in the land use and land cover pattern of the region, which further impacted to the other aspects such as demographic profile of the region, occupation structure of the region, inversely impacted to provisioning ecosystem services such as crop production, livestock services, water services etc.

Further, in the next section, it would be interesting to understand the socio-economic characteristics of the region which is selected from both districts Faridabad and Gautam Budh Nagar. The main idea to study socio-economic profile of the region is to understand how peri-urban villages have influenced by urbanisation and how are the conditions of villagers in social and economic terms.

SECTION-B

5.4 Spatial unit of study

The spatial units of study have been selected from two districts of NCR i.e., Faridabad and Gautam Budh Nagar. The unit selected from Faridabad district was Kheri Kalan and from Gautam Budh Nagar district was Bishada on the basis of dependency on primary source of livelihood which were discussed earlier in this chapter 1. The dependency on primary source for livelihood was computed through the composite index of socio-economic indicators from census data of 2001 and 2011. Here we are looking at the socio-economic characteristics of the households in both selected villages and also examine the levels of socio-economic vulnerability in context to occupation adopted for the livelihood. Further, the research tried to identity the marginalized communities with their occupation and socio-economic levels.

5.5 Socio-Economic Characteristics of Kheri Kalan and Bishada village

5.5.1 Demographic characteristics of Households

Demographic characteristics of any region play a very important role in context to regional development. It includes the composition of the population, gender, age etc. which are determining a factor for the regional development and growth. According to the census 2011, the total number of households in Kheri Kalan was 1103 while 1167 households in Bishada which accommodate 6,664 and 6,669 populations in Kheri Kalan and Bishada respectively. However, according to the available SECC data, a total number of households and population is varying in both villages due to the supply of limited data. Therefore, on the basis of available 90% data, analysis has been done.

Table 5.10 Total population of Kheri Kalan and Bishada Village (2011)

Name of village	As per Census 2011		As per SECC 2011	
	No. HH	Population	No. of HH	Population
Kheri Kalan (Faridabad)	1103	6664	900	5676
Bishada (GT B Nagar)	1167	6669	972	6009

(Source: Census of India, 2011 & SECC 2011)

According to the analysed results of SECC data, 52.5% population are males and 47.5% population are females in Kheri Kalan village in Faridabad district whereas 54.2% are males and 45.4% are females in Bishada village of Gautam Budh Nagar district. The population of scheduled caste is 17.3% in Kheri Kalan while it is 5.1% in Bishada. Kheri Kalan is dominated by the Jats whereas Bishada is dominated by Rajput caste communities.

5.5.2 Social characteristics of Households

5.5.2.1 Education Level & Gender

The level of education is a very important indicator for human development. If we peep into the level of education across gender and social groups, one picture that is observed, Kheri Kalan has not only a low level of education but the count in SC literacy is also very low. Moreover, the situation of Bishada may be better as compared to Kheri Kalan but here also it’s not a sign of balanced and inclusive development as we can see the gap in the social group and gender**.**

Table 5.11 Cross tabulation between education level and gender

Education Level	Kheri Kalan			Bishada		
	Male	Female	Total	Male	Female	Total
Illiterate	13.7	20.4	34.1	7.9	9.8	17.7
Literate but below primary	6.5	6.1	12.6	8.2	7.2	15.3
Primary	8.3	6.7	15.0	10.0	9.0	19.0
Middle	6.3	5.2	11.6	11.7	9.2	20.9
Secondary	7.5	4.1	11.6	9.2	5.7	14.9
Higher secondary	6.0	3.1	9.1	4.2	2.7	7.0
Graduate or higher	3.3	1.7	5.0	3.3	1.7	5.1
Other (Specify)	0.7	0.2	0.9	0.1	0.0	0.1
Total	52.5	47.5	100.0	54.6	45.4	100.0

(computed from Socio Economic caste census survey, 2011)

Education level in Kheri Kalan village shows that literate population is 65.9% while in Bishada it is 82.3%. But if we look at the gender wise literacy, it is found that 27.1% females are literates out of 47.5% female population in Kheri Kalan whereas in Bishada female literacy is 35.5% out of 45.4% of female population. The illiterate population is higher in Kheri Kalan than Bishada (Figure 5.8).

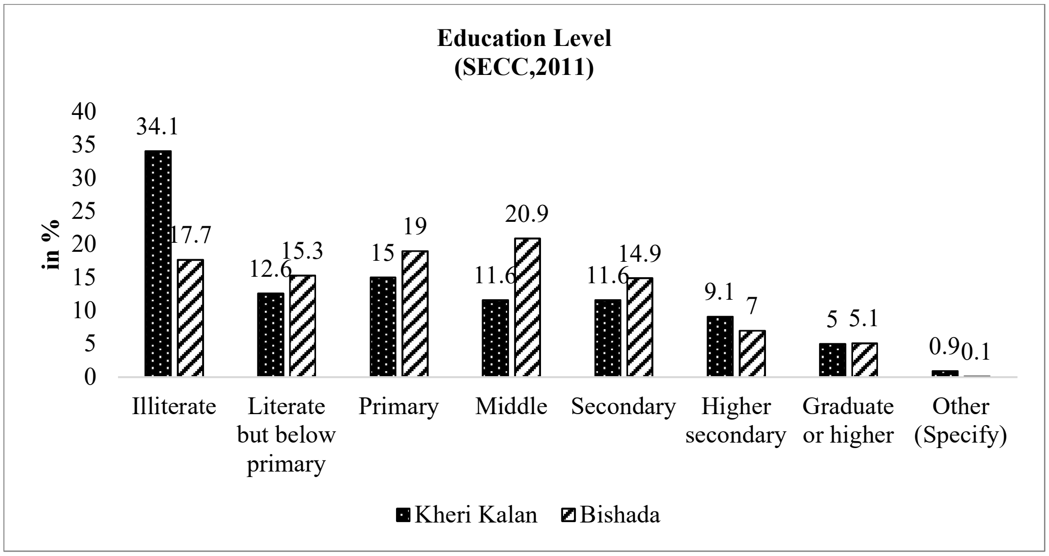


Figure 5.8 Education level in Kheri Kalan and Bishada village (SECC, 2011)

5.5.2.2 Education level and Social Group

When we look at education level among social groups, it is found that 7.7% of SC population is illiterate out of 17.4% SC population in Kheri Kalan. Bishada shows 0.5% illiterate population out of 5.1% total SC population. Further, ST population is not found in both villages but other category shows 56.1% literate people in Kheri Kalan while 77.7% population is literate in Bishada. Almost 5% of the population in both villages in other category shows graduate or higher level of education.

Table 5.12 Cross tabulation between education level and caste

Education	Kheri Kalan			Bishada		
	SC	Others	Total	SC	Others	Total
Illiterate	7.7	26.5	34.1	0.5	17.2	17.7
Literate but below primary	2.7	9.9	12.6	2.9	12.4	15.3
Primary	3.5	11.5	15.0	0.8	18.2	19.0
Middle	1.9	9.7	11.6	0.4	20.5	20.9
Secondary	0.9	10.7	11.6	0.2	14.8	14.9
Higher secondary	0.5	8.6	9.1	0.2	6.8	7.0
Graduate or higher	0.1	4.9	5.0	0.1	5.0	5.1
Other (Specify)	0.0	0.9	0.9	0.0	0.1	0.1
Total	17.4	82.6	100.0	5.1	94.9	100.0

(computed from Socio Economic caste census survey, 2011)

5.5.3 Economic Characteristics of Households

5.5.3.1 Housing condition

Housing is a major element of people's material living standards. It is essential to meet basic needs, such as for shelter from weather conditions, and to offer a sense of personal security, privacy, and personal space. Good housing conditions are also essential for people's health and affect childhood development (OECD, 2011).

Table 5.13 Predominant material of wall of the Dwelling Rooms

Code No.	Predominant material of wall	Kheri Kalan		Bishada	
		No. of Households	% of Households	No. of Households	% of Households
1	Grass/thatch/bamboo etc.	3	0.33	3	0.31
2	Plastic/polythene	Nil	Nil	Nil	Nil
3	Mud/unburnt brick	5	0.56	1	0.10
4	Wood	Nil	Nil	1	0.10
5	Stone not packed with mortar	Nil	Nil	Nil	Nil
6	Stone packed with mortar	Nil	Nil	3	0.31
7	G.I./metal/asbestos sheets	Nil	Nil	2	0.21
8	Burnt brick	884	98.22	945	97.22
9	Concrete	7	0.78	16	1.65
0	Any other	1	0.11	1	0.10
	Total number of households	900	100	972	100

*computed from Socio Economic caste census survey, 2011

There are 900 households in the Kheri Kalan and 972 households in Bishada. Out of which majority of 98.22% and 97.22% household have burnt brick houses which characterise a good level of housing condition in the villages. Further, there is nearly

0.78% and 1.65% household living in a concrete as the predominant material of the wall which again manifests a good level of housing condition. However, there is nearly 0.33% household which is not in good condition and their predominant material of the wall is either of grass or plastic and wooden.

5.5.3.2 Income and Employment Characteristics

Income is considered to be one of the most important attributes for the economic status of household and income generated from different sources decides the standard of living condition of a household.

Table 5.14 Income and Employment characteristics

Code no.	Income & Employment characteristics	Kheri Kalan		Bishada	
		No. of Households	% of Households	No. of Households	% of Households
I.	**Salaried Job**				
1	Yes	331	36.8	362	37.2
	Govt.	106	11.8	54	5.6
	Private Sector	213	23.7	303	31.2
	Public Sector	12	1.3	8	0.8
2	No	569	63.2	610	62.4
II.	**Pay income tax or professional tax**				
1	Yes	114	12.7	42	4.3
2	No	786	87.3	930	95.7
III.	**Own/operate an enterprise**				
1	Yes	22	2.4	174	17.9
2	No	878	97.6	798	17.9
IV.	**Monthly Income**				
1	Less than Rs. 5,000,	405	44.9	532	54.7
2	Between Rs. 5,000 and Rs 10,000	257	28.6	331	34.1
3	Rs. 10,000 or more	238	26.5	109	11.2
V.	**Main Source of Income**				
1	Cultivation	218	24.2	589	60.6
2	Manual casual labour	313	34.7	175	18
3	Part-time or full-time domestic service	52	5.8	123	12.7
4	Foraging, rag picking	Nil	Nil	1	0.1
5	Non-agricultural Own Account Enterprise	29	3.2	9	0.9
6	Begging/ Charity/ Alms collection	Nil	Nil	Nil	Nil
7	Others	288	32.0	75	7.7
	Total number of households	**900**	**100**	**972**	**100**

*computed from Socio Economic caste census survey, 2011

If we compare at the income and employment structure across these two villages, it shows Kheri Kalan is in better off situation than in Bishada. Data on salaried job shows more or less similar results in both villages. 36.8% of households have a salaried job in Kheri Kalan while 37.2% households have a salaried job in Bishada. But further differences can be seen in the classification of salaried job sources. Salaried job from private sources accounted highest among both villages. It is 23.7% in Kheri Kalan and 31.2% in Bishada. The reason for adopting private jobs in Bishada often attributed to the establishment of NTPC (National Thermal Power Corporation) power plant around the village periphery during 1983. It gives ample opportunities to Bishada villagers for working as a private job. While in Kheri Kalan, it can be associated with the close proximity to the Faridabad city so people can get various private jobs. However, the concern is for those households who are not getting a salaried job. The ratio of these households is much more than getting a salaried job. It is 63.2% in Kheri Kalan and 62.4% in Bishada. This can be relating to those households who do not have a permanent source of income and in this category, the majority of the households are marginal cultivators. Another employment characteristic are paying income tax or professional tax or not, 12.7% household pay income tax in Kheri Kalan whereas only 4.3% households in Bishada pay income tax that means there is a wide gap between rich and poor in both villages. Further in Kheri Kalan, there is 2.4% household which has a registered enterprise or organisation with their name while it is more in Bishada by 17.9%. Any registered enterprise or organisation has a role to play in development process like schools as the registered enterprise gives education and generate skills and create employment opportunities.

Apart from the employment characteristics and indirect growth and development of household, the direct income of the household is the most important manifestation of the level of development. Under the category of less than Rs. 5,000 monthly incomes there is 44.9% household in Kheri Kalan whereas in Bishada it is 54.7%. In the category Rs. 5,000 to Rs. 10,000 there are 28.6% of household in Kheri Kalan whereas in Bishada it is 34%. And the third category of income group is more than Rs. 10,000 monthly incomes, shows 26.5% households in Kheri Kalan whereas in Bishada it is only 11.2%. Further in the context of main source of income, there are mainly cultivators that accounts 60.6% in Bishada whereas in Kheri Kalan cultivators are just 24.2% but one thing to notice here is there is 34.7% person in the category of manual casual labourers in Kheri Kalan which attributed to the low status of households and further low development of village.

5.5.3.3 Assets owned

Assets of a household symbolises economic status as well as wealth of physical capital in a household. It sometimes correlates with the status of livelihood strategies in terms of availability of physical assets in a household.

Table 5.15 Household assets owned

Household assets owned		Refrigerator		Telephone/Mobile Phone				Motorized Two/Three/Four Wheelers or Motorized Fishing Boat				
		Yes	No	Landline only	Mobile only	Both	No	Two Wheeler	Three Wheeler	Four Wheeler	Motorized Fishing Boat	No
Kheri Kalan	No. of Households	481	419	8	695	7	190	562	6	152	1	179
	% of Households	53.5	46.5	0.9	77.3	0.8	21	62.4	1	16.9	0.1	20
Bishada	No. of Households	417	555	175	616	12	169	331	33	35	148	425
	No. of Households	42.9	57.1	18	63.4	1.2	17.4	34.1	3	3.6	15.2	44

*computed from Socio Economic caste census survey, 2011

In all the assets Bishada village is at a lower level and Kheri Kalan village from Faridabad is at a higher level. Percentage of households who own refrigerator is 53.5% in Kheri Kalan which is higher than Bishada (42.9%). Percentage of household who owned a mobile is nearly 77.3% in Kheri Kalan whereas in Bishada it is nearly 63.4%. Percentage of household who owns motorized wheels is high again in Kheri Kalan than that of Bishada. Percentage of households who own motorized fishing Boat is 15.2% in Bishada whereas it is very low in Kheri Kalan. Overall, it can say that Kheri Kalan village has a high level of physical capital than Bishada village which again manifests the level of economic development of a village in a way.

5.5.3.4 Other Assets owned

Other assets in a household include agricultural equipment's, mechanized agricultural vehicles, Kisan Credit Card (KCC) etc.

Table 5.16 Other household assets owned

Household other assets owned		Mechanized 3/4 Wheeler Agricultural equipment		Irrigation equipment		KCC with limit Rs 50,000 or above	
		Yes	No	Yes	No	Yes	No
Kheri Kalan	No. of Households	83	817	156	744	2	898
	% of Households	9.2	90.8	17.4	82.6	0.2	99.8
Bishada	No. of Households	23	949	19	953	99	873
	No. of Households	2.4	97.6	2.0	98.0	10.2	89.8

*computed from Socio Economic caste census survey, 2011

There are 90.8% of household in Kheri Kalan and 97.6% household in Bishada not having owned mechanized ¾ wheeler agricultural equipment. As per the irrigation equipment percentage of household is very low (2.0%) in Bishada but at least 17.4% households own irrigation equipment in Kheri Kalan. A number of households having KCC with limits Rs 50,000 or above are very low (0.2%) in Kheri Kalan whereas 10.2% households have KCC in Bishada. Overall, it represents the economic condition of the cultivators that how much economically well are the farmers in both villages. It shows from Bishada village farmers are taking facility of Kisan Credit Card which enables them to financially supported by loans for agricultural production.

5.5.3.5 Land Ownership

Land ownership status symbolises as a wealth of household. There is only 43.8% household in Kheri Kalan who owned land whereas 56.2% of households are landless. Similarly, in Bishada only 27.4% of the households have land and other remaining households around 72.6% are landless. We can say that percentage of land less household in Bishada is high which represents the presence of economically backward households are more in terms of land ownership. It is known consensus that owning land is a symbol of economic wealth in a household so less number of household with land ownership shows the possible low level of economic development.

Table 5.17 Land Ownership status

Land Owned	Kheri Kalan		Bishada	
	No. of Households	% of Households	No. of Households	% of Households
Land Owned	394	43.8	266	27.4
Landless	506	56.2	706	72.6
Total	899	100	972	100

*computed from Socio Economic caste census survey, 2011

5.5.3.6 Farmers categorization based on Land owning status

Based on Agricultural Census of India, land holding categories of farmers are divided into five classes. These are marginal (below 1.0 hectare), small (1.0 to 2.0 hectare), semi-medium (2.0 to 4.0 hectare), medium (4.0 to 10 hectare), and Large (10.0 hectare & above).

Table 5.18 Farmers categorization based on Land owning status

Code No.	Farmers categorise based on land owning status	Kheri Kalan		Bishada	
		No. of Households	% of Households	No. of Households	% of Households
1	Landless or no land	507	56.2	706	72.6
2	Marginal	235	26.14	214	22.02
3	Small	71	7.90	32	3.29
4	Semi-medium	59	6.56	12	1.23
5	Medium	17	1.89	7	0.72
6	Large	12	1.33	0	0.00
	Total	900	100	972	100

*computed from Socio Economic caste census survey, 2011

As per socio-economic caste census data, both villages are showing a high number of marginal farmers with compare to other categories of land holding size. But landless households are more than land owned households in both villages. There are 26.14% of marginal farmers in Kheri Kalan whereas in Bishada there is only 22.02% of farmers are marginal. Farmers with small land holding size are 7.90% in Kheri Kalan whereas only 3.29% of small land holding size farmers are found in Bishada. The percentage of the semi-medium farmer is 6.56% in Kheri Kalan and 1.23% in

Bishada. Further, fourth category, medium land holding size of farmers shows very less number of both villages. It is 1.89% in Kheri Kalan and only 0.72% in Bishada. The fifth and last category of large land holding size of farmers are negligible in Bishada whereas, in Kheri Kalan, the number of large farmers is 12 which accounts 1.33% out of total households of the village. In nutshell, it can say that land holdings with farmers are high in Kheri Kalan than Bishada but more marginal farmers are found in both villages.

5.5.3.7 Occupation Structure

Occupation structure of any region is a manifestation of economic development. The participation of people in different sectors of economy decides the backwardness and forwardness of a region. It also depends on the available resources, facilities, location reason such as near to city or far away city etc. to indulging population in particular occupation. It is evident that rural areas are normally based on primary activities with involving in other small household industries. However, changing scenario of land use and land cover and other factors are possibly leading to change in the occupation structure in rural areas too. This occupational diversification can also be seen in studied villages.

Table 5.19 Number of Workers and Non-workers

Category	Kheri Kalan		Bishada	
	Numbers	Percentage	Numbers	Percentage
Workers	979	17.25	950	15.81
Non-Workers	4697	82.75	5059	84.19
Total Population	5676	100	6009	100

*computed from Socio Economic caste census survey, 2011

Before going into the classification of occupation structure of village, it is important to understand the working and non-working population scenario. There are 17.25% people who are actually working in Kheri Kalan and 82.75% people considered as non-workers. Similarly, in Bishada only 15.81% people are actual workers and remaining 84.19% are non-workers, and this is according to the national classification of occupation. Further, to know about in which activities these workers are engaged, NCO (National Classification of Occupation) classification has been adopted and occupation classification was seen at one digit, two-digit level and a further important portion will be explored at three-digit level.

5.5.3.7.1 Occupation classification according to NCO in Kheri Kalan Village

According to the NCO classification, Kheri Kalan's occupational structure shows that out of 5,676 persons, only 979 persons are workers and within this worker's category, further they are classified into nine categories of occupation at one-digit level. The highest number of persons are involved in elementary occupations (6.8%) followed by skilled agricultural and fisheries workers (6.3%), service workers and shop and markets sales workers (1.4%), plant and machine operators and assemblers (0.9%), professionals (0.7%), associate professionals (0.7%), craft and related trade workers (0.4%), clerks (0.1%) and legislators, senior officials & managers (0.04%).

At two-digit level, Elementary Occupation further classified into three categories. These are sales and service elementary occupations, agricultural, fishery and related labourers, and labourers in mining, construction, manufacturing, and transport. Among these 6.38% persons are labourers in construction, mining, transport, followed by sale and service elementary occupation (0.26%), and agricultural, fishery & related labourers (0.14%) In another category, skilled agricultural and fishery workers are further classified into two categories. It shows 5.25%-person involvement in market oriented skilled agricultural workers and 1.01% involvement in subsistence agriculture and fishery workers.

At three-digit level, again Elementary Occupation further classified into seven categories in which under sale and service elementary occupation, garbage collectors & related labourers are highest (0.09%) followed by messengers, porters, door keepers and related workers (0.09%), domestic helpers, cleaners (0.05%), and street vendors (0.04%). Under labourers in mining, construction, manufacturing & transport, mining & construction labourers are 6.29% and transport labourers are 0.09%. In the second category of skilled agricultural workers at three-digit level of classification, shows three further categories in which market gardeners and crop growers are highest (5.05%), followed by subsistence agriculture & fishery workers (1.01%), and market-oriented animal producers & related workers (0.2%) in Kheri Kalan village

Table 5.20 OCCUPATION CLASSIFICATION ACCORDING TO NCO AT 3-DIGIT LEVEL (KHERI KALAN)

Code No.	NCO 1 digit Code (KHERI KALAN)	No. of persons (%)	NCO 2 digit Code	No. of persons (%)	NCO 3 digit Code	No. of persons (%)
	WORKERS	**979 (17.25%)**				
1	Legislators, Senior Officials, and Managers	2 (0.04%)				
2	Professionals	38 (0.7%)				
3	Associate Professionals	38 (0.7%)				
4	Clerks	5 (0.1%)				
5	Service Workers and Shop & Market Sales Workers	82 (1.4%)				
6	Skilled Agricultural and Fishery Workers	**355 (6.3%)**	**61.** Market oriented skilled agricultural & fishery worker **62.**Subsistence agriculture & fishery workers	298 (5.25%) 57 (1.01%)	**611**.Market gardeners & crop growers **612**.Market-oriented animal producers & related workers **620**.Subsistence agriculture & fishery workers	287 (5.05%) 11 (0.2%) 57 (1.01%)
7	Craft and Related Trades Workers	24 (0.4%)				
8	Plant and Machine Operators and Assemblers	50 (0.9%)				
9	Elementary Occupations	**385 (6. 8%)**	**91**.Sale &Service EO	15 (0.26%)	**911**.Street vendors **913**.Domestic & related helpers, cleaners &launderers **915**.Messengers, porters, door keeper & related workers **916**.Garbage collectors & related labourers	2 (0.04%) 3 (0.05%) 5 (0.09%) 5 (0.09%)
			92.Agricultural, fishery & related labourers	8 (0.14%)	**920.**Agricultural,fishery & related labourers	8 (0.14%)
			93.Labourers in mining, construction, manufacturing & transport	**362 (6.38%)**	**931**.Mining &construction **933.**Transport labourers	**357(6.29%)** 5 (0.09%)
	NON WORKERS	**4697 (82.75%)**				
X	Workers not Classified by Occupations	2341 (41.2%)				
555	House work	1510 (26.6%)				
777	Dependent	801 (14.1%)				
999	Pensioner	45 (0.8%)				
	Total Population	5676 (100%)				

Table 5.21 OCCUPATION CLASSIFICATION ACCORDING TO NCO (BISHADA)

Code No.	NCO 1 digit Code (BISHADA)	No. of Persons (%)	NCO 2 digit Code	No. of Persons (%)	NCO 3 digit Code	No. of Persons (%)
	WORKERS	**950 (15.81%)**				
1	Legislators, Senior Officials, and Managers	1 (0.02%)				
2	Professionals	41 (0.7%)				
3	Associate Professionals	8 (0.1%)				
4	Clerks	4 (0.1%)				
5	Service Workers and Shop & Market Sales Workers	42 (0.7%)				
6	Skilled Agricultural and Fishery Workers	**305 (5.1%)**	**61.** Market oriented skilled agricultural & fishery worker	305 (5.08%)	**611**.Market gardeners & crop growers **612**.Market-oriented animal producers & related workers	302 (5.03%) 3 (0.05%)
7	Craft and Related Trades Workers	51 (0.8%)				
8	Plant and Machine Operators and Assemblers	18 (0.3%)				
9	Elementary Occupations	**480 (8%)**	**91**.Sale &Service EO	11 (0.18%)	**911.**Street vendors **913.**Domestic & related helpers, cleaners &launderers **915.**Messengers, porters, door keeper & related workers **916**.Garbage collectors & related labourers	1 (0.02%) 8 (0.13%) 1 (0.02%) 1 (0.02%)
			92.Agricultural, fishery & related labourers	**318 (5.29%)**	**920.**Agricultural,fishery & related labourers	**318 (5.29%)**
			93.Labourers in mining, construction, manufacturing & transport	151 (2.51%)	**931**.Mining &construction	151 (2.51%)
	NON WORKERS	**5059 (84.19%)**				
X	Workers not Classified by Occupations	1974 (32.9%)				
555	House work	752 (12.5%)				
777	Dependent	2313 (38.5%)				
999	Pensioner	20 (0.3%)				
	Total Population	6009 (100%)				

5.5.3.7.2 Occupation classification according to NCO in Bishada Village

According to the NCO classification, Bishada occupational structure shows that out of 6,009 persons, only 950 persons are workers and within this worker's category, further they are classified into nine categories of occupation at one-digit level. In Bishada also highest number of persons are involved in elementary occupations (8%) followed by skilled agricultural and fisheries workers (5.1%), craft and related trade workers (0.8%), service workers and shop and markets sales workers (0.7%), professionals (0.7%), plant and machine operators and assemblers (0.3%) associate professionals (0.1%), clerks (0.1%) and legislators, senior officials and managers (0.02%).

At two-digit level, Elementary Occupation further classified into three categories. These are sales & service elementary occupations, agricultural, fishery & related labourers, and labourers in mining, construction, manufacturing, and transport. Among these, 5.29% persons are agricultural labourers followed by labourers in construction, mining, transport by 2.51% person's involvement, and 0.18% workers are engaged in sale and service elementary occupations in Bishada village. In another category, Skilled Agricultural and Fishery workers are further classified. It shows 5.08%-person involvement in market oriented skilled agricultural workers.

At three-digit level, again Elementary Occupation further classified into six categories in which under sale and service elementary occupation, domestic helpers, and related workers are 0.13% followed by street vendors (0.02%), messengers, porters, door keepers (0.02%), and garbage collectors and related labourers (0.02%). Under labourers in mining, construction and related labourers, mining and casual construction labourers are 2.51%. In the second category of skilled agricultural workers, at three-digit classification, it shows 5.03% persons are market gardeners and crop growers and 0.05% persons are market-oriented animal producers and related workers.

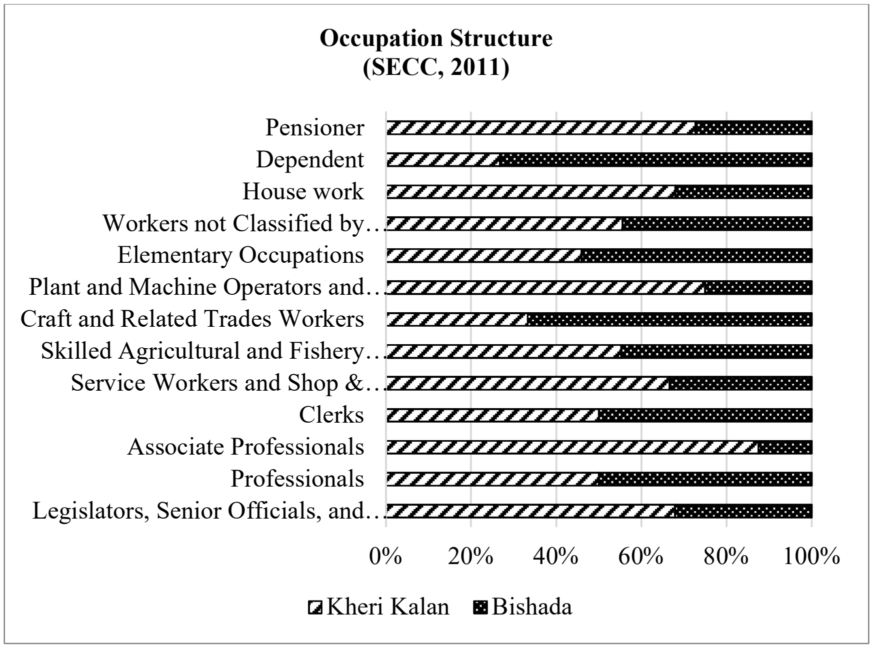


Figure 5.9 Occupation structure (SECC, 2011)

Overall, it can be said that work force is an important part of the economy and it is only the work force that gives impetus to the economy. Since work force is engaged in production it is a crucial element of economic development. People are engaged in what kind of work is mainly determined by the skill profile and available opportunities which are a function of the level of economic development. While comparing these two villages, occupation classification at one-digit level shows clear picture regarding the development gap in both villages which is attributed to the clustering of elementary occupations in both villages. But within that share, Bishada is highest under elementary occupation. Further, if we compare skilled agricultural workers in both areas, Kheri Kalan shows more workers than Bishada. It can also be attributed to the presence of a high number of landless people in Bishada. The dependent population is higher in Bishada than Kheri Kalan. It shows the population under age group between 1 to 15 and 60 and above are high in Bishada. Non workers are also found highest in Bishada. Therefore, it can say that there is a wide gap in the economic development of Bishada village.

5.6 Assessment of Socio-Economic Vulnerabilities

To understand the concept of socio-economic vulnerabilities and their linkages with poverty, is important to study for the welfare of society. Vulnerability refers to the 'propensity to suffer some degree of loss from a hazardous event' (Berkes, 2007). The International Strategy for Disaster Reduction (UN/ISDR, 2004) defines vulnerability as 'the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards' whereas in contrary the United National Development Programme (UNDP) defines vulnerability as 'a human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given stressor (UNDP,2004). In general, vulnerability means, risk exposure or potential for loss, but this potential for loss varies as per our socio-economic situation and geographical space. Whilst vulnerability has often been closely linked with poverty, it has seen as a dynamic concept which identifies and captures change, however, poverty has been seen as being static (Moser, 1998). Poverty is an important aspect of vulnerability because of its direct association with access to resources which affects both baseline vulnerability and coping with the impacts of extreme events.

Poverty refers to the lack of access to resources and income opportunities, it is also seen as different forms of deprivation that can be expressed in different forms like basic needs, income human capabilities etc. Poor households often identify vulnerability as a condition that takes into accounts both exposures to serious risks and defencelessness against deprivation. Defencelessness, in turn, is often viewed as a function of social marginalization that ultimately results in economic marginalization. Since understanding the linkages between poverty and vulnerability, this section basically deals with the identification of socio-economic marginalised communities in the peri-urban environment with context to the poverty aspect.

In India, numerous initiative has been taken for the identification of poor such as in late 1970's Planning Commission appointed a task force on 'Projections of minimum needs and effective consumption demand' that defined rural poverty as per capita consumption expenditure level based on minimum calorie intake, in 1993 Lakdawala Committee introduced poverty line based on per capita consumption expenditure, another one in 2005, Tendulkar Committee reviewed the methodology for identification of poor, and on the other hand in 1992 Ministry of rural development introduce a system of uniform identification of BPL (Below Poverty Line) households in rural areas based on income criteria, and then in 1997, to improve 1992 methodology for identification of poor census used expenditure and multiple criteria. Further in 2002 census used scored based ranking for each household on the basis of 13 criteria approach for identification of poor but after criticism of these all approaches, in 2009 N.C Saxena Committee proposed an improved method for identification of BPL households in rural areas. It was based upon the automatically exclusion, automatically inclusion and deprivation indicators. Similarly, Socio-Economic Caste Census 2011 adopted same criteria of exclusion and inclusion but with the modifications in questions and using a set of simplified scoring criteria.

The analysis of this section is divided into three parts: first, would be deals with the identification of rural poor on the basis of SECC 2011 Committee Criteria, second, would be focus on Saxena Committee criteria and to compare both criteria's in relation to identification of poor and gaps in the both methodologies, further in third part, based on rural occupation structure deprived section of society would be identified among adopting different livelihood strategies on the basis of deprivation indicators and scoring index. Score index varies between 0 and 7. A high score indicates a high level of socio-economic vulnerability and vice-versa.

5.6.1 SECC Committee criteria for identification of rural poor

The SECC Committee criteria includes three stages: First stage (Automatic Exclusion), Second stage (Automatic Inclusion), and Third stage (Scoring with equal weights)

i) First stage (Automatic Exclusion)

1. Motorised two/three/four wheeler/fishing boat
2. Mechanised three/four wheeler agriculture equipment
3. Kisan credit card (KCC) with credit limit of Rs 50,000 and above
4. Household with any member as a government employee
5. Households with non-agricultural enterprises registered with the government
6. Any member of the family earning more than Rs 10,000 per month
7. Paying income tax or professional tax

8. Three or more rooms with all rooms having pucca walls and roof
9. Own a refrigerator and landline phone
10. Own 2.5 acres or more of irrigated land with at least one piece of irrigation equipment
11. 5 acres or more of irrigated land for two or more crops season
12. Owning at least 7.5 acres of land or more with at least one piece of irrigation equipment

ii) Second stage (Automatic Inclusion)

1. Households without shelter
2. Destitute/living on alms
3. Manual scavengers
4. Primitive tribal groups
5. Legally released bonded labourers

iii) Third stage (Scoring with equal weights) Deprivation indicators

1. Household with only one room, kucha walls, and kucha roof
2. No adult member between the age of 16 and 59
3. Female headed households with no adult male member between 16 to 59
4. Household with a disabled member and no able-bodied adult member
5. Scheduled caste / Scheduled tribe households
6. Households with no literate adult above 25 years
7. Landless households deriving a major part of their income from manual casual labour

According to SECC, households with highest deprivation score will have the highest priority for inclusion in the list of BPL (Below Poverty Line) households but in this chapter same criteria has been used for the identification of socio-economically vulnerable households. High scores denote to high vulnerability and vice –versa.

5.6.1.1 Automatic Excluded Households

Table 5.22 Automatic Excluded Households (SECC Committee Criteria)

Code No.	**Indicators**	**Kheri Kalan**		**Bishada**	
		Number Of Households	%	Number Of Households	%
AE1	Vehicles	720	80.08	545	56.06
AE2	Agricultural Equipment	9	1	4	0.41
AE3	KCC with limit Rs 50,000 or above	Nil	Nil	20	2.05
AE4	Govt. Employee	16	1.77	29	2.98
AE5	Registered non-agricultural enterprise	3	0.33	118	12.13
AE6	Earning more than 10,000/month	4	0.44	11	1.13
AE7	Income tax payee	Nil	Nil	1	0.10
AE8	Professional tax payee	Nil	Nil	Nil	Nil
AE9	3 or more rooms with pucca wall and roofs	52	5.78	69	7.09
AE10	Own a refrigerator	30	3.33	23	2.36
AE11	Own a landline phone	2	0.22	Nil	Nil
AE12	Own 2.5 acres/more of irrigation land with at least one irrigation equipment	1	0.11	Nil	Nil
AE13	5 acres/more irrigated land for 2/more crop season	Nil	Nil	2	0.20
AE14	Owning at least 7.5 acres of land or more with at least one irrigation equipment	Nil	Nil	Nil	Nil
	Total	837	93.10	822	84.56
	Total number of Households	899	100	972	100

*computed from Socio Economic caste census survey, 2011

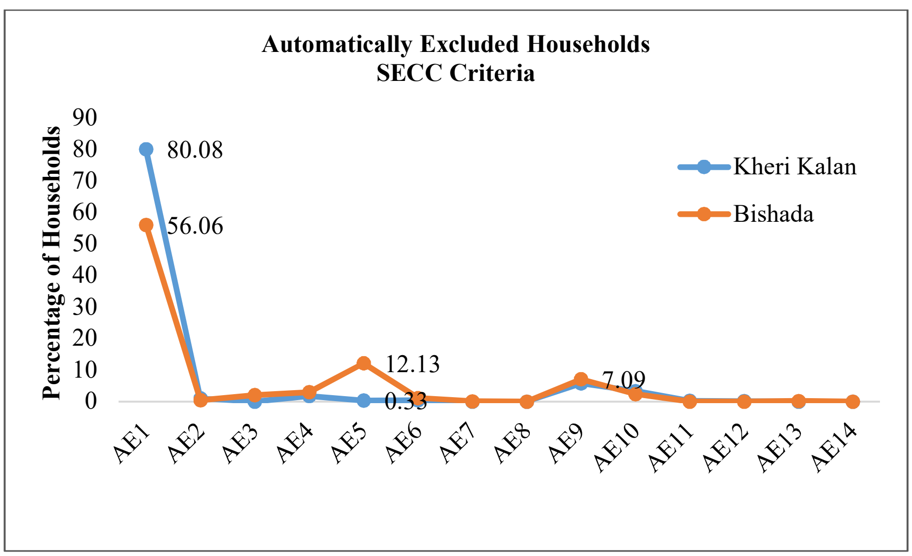


Figure 5.10 Automatic excluded households (SECC Committee)

The above table and graph (Table 5.22 and Figure 5.10) depicts the proportion of excluded households on the basis of having any one of the assets like Agricultural Equipment, Refrigerator, Landline Phone, and Vehicle etc. or possesses Land ownership with Pucca houses. Around 80% of the households possess 2/3/4-wheeler motorized vehicle in village Kheri Kalan followed whereas it the proportion of vehicle in Bishada is only 56.0%. Maximum automatically excluded households are from village Kheri Kalan 93.10% while in Bishada, automatically excluded households are 84.56%. According to SECC Committee criteria, automatically excluded households are economically well off and visibly noon poor households.

5.6.1.2 Automatically Included Households

Table 5.23 Automatically Included Households (SECC Committee Criteria)

Code No.	Indicators	Kheri Kalan	Bishada
		Number Of Households	Number Of Households
A11	Household without shelter	Nil	Nil
A12	Destitute/living on alms	Nil	Nil
A13	Manual scavengers	Nil	Nil
A14	Primitive tribal groups	Nil	Nil
A15	Legally released bonded labourers	Nil	Nil
	Total households	Nil	Nil

*computed from Socio Economic caste census survey, 2011

Automatically included households inferred that these are socio-economically disadvantaged groups who are transparently poorest of the poor like manual scavengers, primitive tribal groups, destitute/living in Alms, legally released bonded labourers etc. From the above Table 5.23, it is clear that there is no single household included in automatically inclusion criteria from both villages which further shows the non-existence of pooper of the poor in these villages according to SECC criteria.

Further, after identification of automatic exclusion and inclusion household, SECC committee has introduced deprivation indicators for those households who are deprived on the basis of deprived selected indicators. Deprivation indicators fill the gap for identification of rural poor.

5.6.1.3 Deprivation Indicators

Table 5.24 Deprivation indicators according to SECC Committee Criteria

Code No.	**Indicators**	**Kheri Kalan**		**Bishada**	
		Number Of Households	%	Number Of Households	%
D11	One room with kucha walls and roofs	7	0.77	3	0.30
D12	No adult member between age 16 and 59	4	0.44	14	1.44
D13	Female headed household with no adult male member between age 16 and 59	12	1.33	17	1.74
D14	Household with disabled member and no able bodied adult	6	0.66	3	0.30
D15	SC/ST	173	19.24	52	5.34
D16	No literate above 25 years of age	87	9.67	58	5.96
D17	Landless household deriving income through manual casual labour	281	31.25	132	13.58
	Total households	570	63.40	279	28.61

*computed from Socio Economic caste census survey, 2011

This table (Table 5.24) depicts that a maximum number of deprived households were present in village Kheri Kalan (63.40%) followed by Bishada (28.61%). Almost 9.67% households of Kheri Kalan have no literate member above 25 years of age whereas in Bishada it is 5.96% which infers the low level of education in Bishada. Landless households deriving income through manual casual labour found higher in Kheri Kalan (31.25%) whereas in Bishada it is 13.58%. Households whose livelihood depends upon manual casual labour has a temporary source of income, which makes their economic condition even worse. Scheduled caste household found higher in Kheri Kalan (19.24%) whereas in Bishada they are 5.34% of total population.

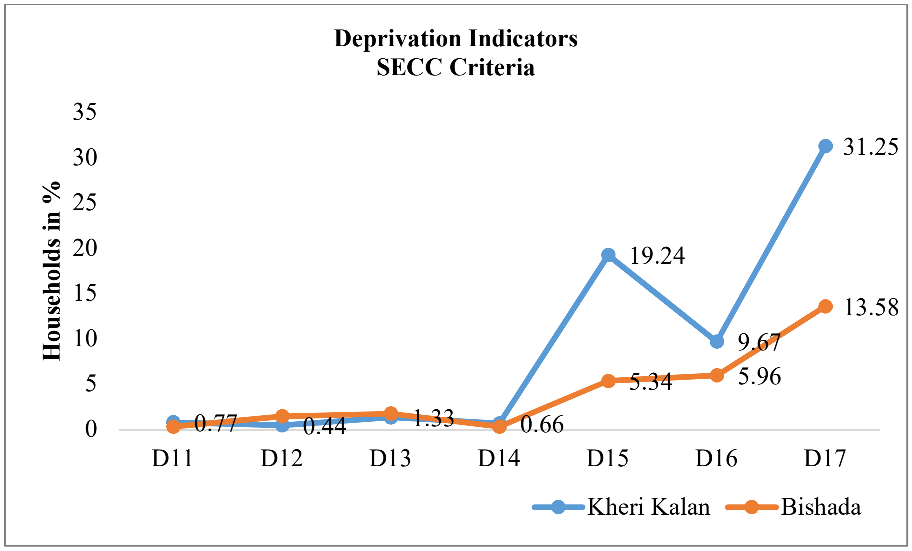


Figure 5.11 Deprivation Indicators (SECC Committee)

5.6.1.4 Scoring Index of Deprivation Indicators

After identification of deprived households on the basis of deprivation indicators, then scores for each deprived households were allotted on the basis of submission of these indicators. If the household gets the highest score, then that household will get priority to inclusion under BPL category and then real beneficiaries will be identified.

Table 5.25 Scoring Index of Deprivation Indicators

S.No.	Indicators	Kheri Kalan		Bishada	
		Number Of Households	Percentage	Number Of Households	Percentage
1	Households with score 5	Nil	Nil	Nil	Nil
2	Households with score 4	2	0.22	Nil	Nil
3	Households with score 3	32	3.55	1	0.10
4	Households with score 2	130	14.46	33	3.39
5	Households with score 1	206	22.91	210	21.60
	Total Households	370	41.15	244	25.10

*computed from Socio Economic caste census survey, 2011

Scoring Index of the deprivation indicators depicts that higher percentage of the households comes under the score 1 category that shows 41.15% of households in Kheri Kalan and 21.60% of household in Bishada. There is a wide gap between both villages in terms of deprivation indicators. Households with score 4 found in Kheri Kalan village are only with 0.22%. The score 3 found a maximum number of households again from Kheri Kalan village. Overall, it is clear that in terms of the scoring index of deprivation indicators, most of the deprived or marginalised households were at a maximum in Kheri Kalan with compare to Bishada village.

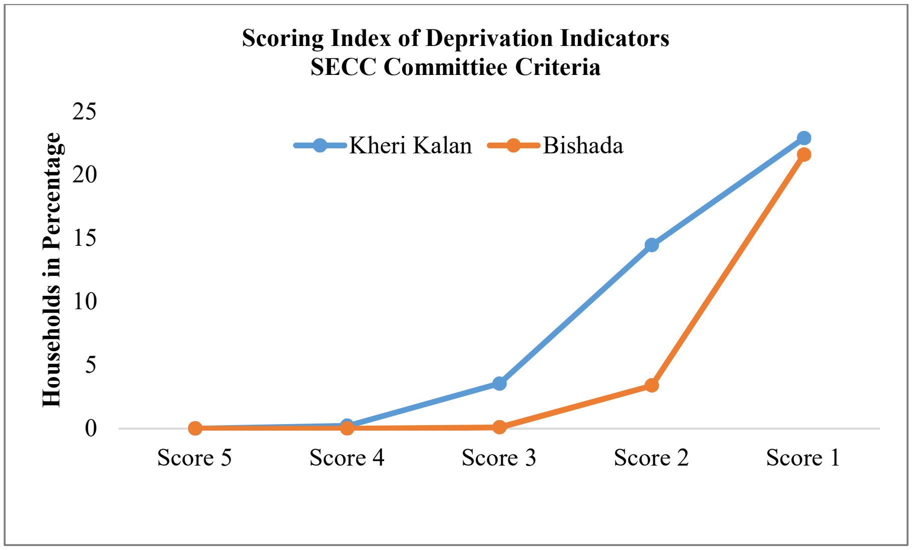


Figure 5.12 Scoring Index of deprivation indicators (SECC Committee)

5.6.2 SAXENA Committee Criteria for identification of rural poor

N.C Saxena Committee was constituted in 2009, for the identification of rural poor and presented the critical review of the 2002 BPL methodology. SECC Committee followed the Saxena Committee criteria for identification of rural poor with some modifications in the selection of indicators in automatic exclusion and inclusion. Saxena Committee recommended a three stage process-automatic exclusion that includes five indicators whereas in SECC Committee criteria there were 14 indicators; automatic inclusion that includes eight indicators whereas in SECC Committee criteria there were only five indicators, and at final third stage, on the basis of selected five deprivation indicators rest households were identified and then scores have been given by submission of weights given to the households.

5.6.2.1 Automatically Excluded Households

Table 5.26 Automatically Excluded Households (Saxena Committee)

Code No.	Indicators	Kheri Kalan		Bishada	
		Number Of Households	Percentage	Number Of Households	Percentage
AE1	Households having double the district average of agricultural land per agricultural household if partially or wholly irrigated	61	6.78	17	1.74
AE2	Households having 3-4 wheeler	112	12.45	30	3.08
AE3	Households having mechanised farm equipment like tractor, power tiller, thresher	36	4.00	13	1.33
AE4	Households earning 10,000 or more from a private organization or in govt. job	74	8.23	93	9.56
AE5	Income tax payers	5	0.55	1	0.10
	Total households	288	32.03	154	15.84

*computed from Socio Economic caste census survey, 2011

According to Saxena Committee, automatically excluded households are those who have agriculture equipment, 3-4 wheeler vehicle, 10,000 and above income from private or government job, agricultural land, and pay income tax. Based on this criteria, automatically excluded households were found the maximum in Kheri Kalan (32.03%) whereas excluded households in Bishada shows 15.84% only. maximum households, who possess land was found in Kheri Kalan village (6.78%) whereas households with higher earning 10,000 and above income from private and government job were in Bishada village (9.56%). Overall, it is depicted from below figure 5.13 that a maximum number of deprived communities is found in Bishada village as the number of excluded household was less in Bishada.

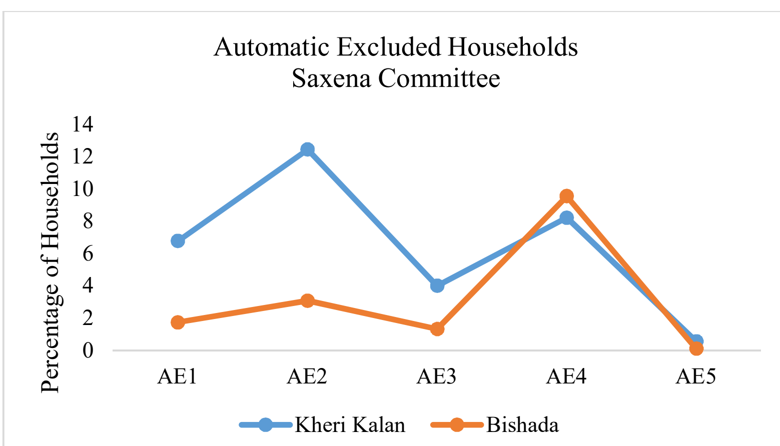


Figure 5.13 Automatic excluded households (Saxena Committee)

5.6.2.2 Automatically Included Households

Table 5.27 Automatically Included Households (Saxena Committee)

Code No.	Indicators	Kheri Kalan		Bishada	
		Number Of Households	Percentage	Number Of Households	Percentage
AI 1	Primitive tribal groups	Nil	Nil	Nil	Nil
AI 2	Maha Dalit groups	Nil	Nil	Nil	Nil
AI 3	Households headed by single women	104	11.56	69	7.09
AI 4	Households with a disabled person as bread earner	9	1.00	8	0.82
AI 5	Households headed by a minor	Nil	Nil	10	1.02
AI 6	Destitute households dependent on alms for survival	Nil	Nil	Nil	Nil
AI 7	Homeless households	Nil	Nil	Nil	Nil
AI 8	Households with bonded labour	Nil	Nil	Nil	Nil
	Total households	113	12.56	87	8.95

*computed from Socio Economic caste census survey, 2011

With the assessment of automatically included households in the process of identification of rural poor, it is found that a maximum number of the household were included in this criteria from the Kheri Kalan. As shown in above table 5.27, households headed by single women found the maximum in Kheri Kalan (11.56%) whereas in Bishada it is just 7.09%. Further, if we see another indicator of inclusion i.e., household with a disabled person as bread earner, it states almost equal involvement of both villages in this category around 0.9%. A maximum number of households headed by minors found higher in Bishada village (almost 10 households) whereas in Kheri Kalan village no household is headed by a minor.

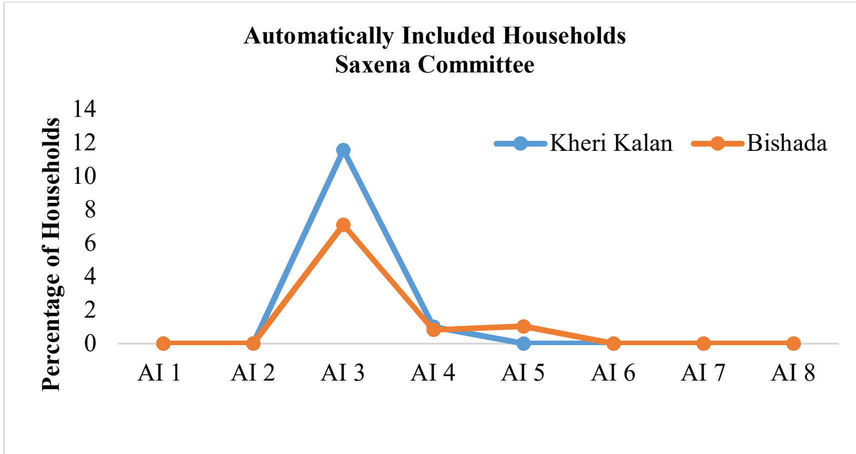


Figure 5.14 Automatic included household (Saxena Committee)

5.6.2.3 Deprivation Indicator

Table 5.28 Deprivation indicator (Saxena Committee)

Code No.	Indicators	Kheri Kalan		Bishada	
		Number Of Households	Percentage	Number Of Households	Percentage
DI 1	Households with SC/ST, Denotified tribes and designated, Muslim/OBC	173	19.24	52	5.34
DI 2	Households with landless agricultural worker, agricultural labourer, casual worker, self-employed artisans, self-employed fisher folk	180	20.02	214	22.01
DI 3	Household with no adult member studied up to class 5	87	9.67	58	5.96
DI 4	Households with any member having Tb, leprosy, disability, mental illness, HIV-AIDS	22	2.44	12	1.23
DI 5	Households headed by an old person of age 60 and above	194	21.57	201	20.67
	Total households	656	72.96	537	55.24

*computed from Socio Economic caste census survey, 2011

After exclusion and inclusion criteria of Saxena committee, on the basis of deprivation indicators, other remaining households were identified as poor. These deprivation indicators include households with SC/ST, denotified tribes, Muslim/OBC, households with landless agricultural worker, agricultural labourer, casual worker, household with no adult member studied up to class 5, households with any member having TB, disability, mental illness etc., and household headed by an old person of age 60 and above. On the basis of deprivation index, Kheri Kalan shows maximum number of households which included under the deprivation criteria. It is 72.96% in Kheri Kalan and 55.24% in Bishada. Among these indicators SC were higher in Kheri Kalan (19.24%) whereas landless agricultural workers were highest in Bishada (22.01%).

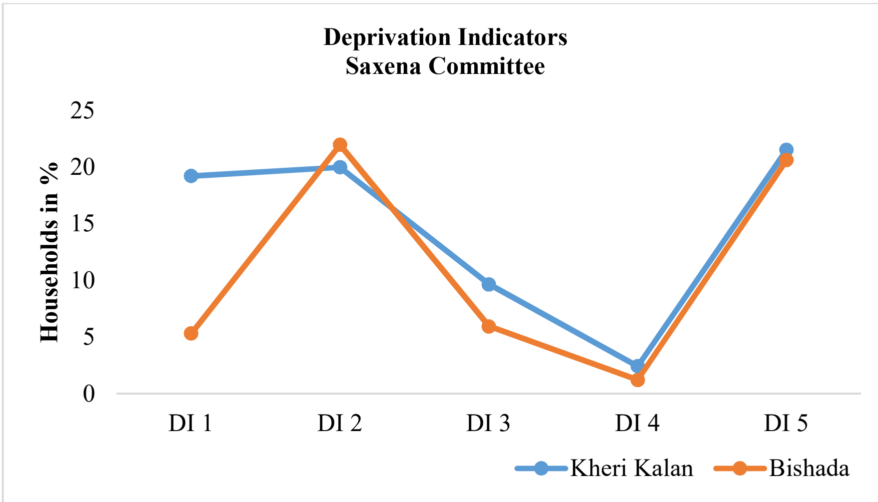


Figure 5.15 Deprivation Indicators (Saxena Committee)

5.6.2.4 Scoring Index

Table 5.29 Scoring Index (Saxena Committee)

S. No.	Indicators	Kheri Kalan		Bishada	
		Number Of Households	Percentage	Number Of Households	Percentage
1	Households with score 7 and above	5	0.55	Nil	Nil
2	Households with score 6	27	3.00	4	0.4
3	Households with score 5	51	5.67	23	2.36
4	Households with score 4	33	3.67	9	0.92
5	Households with score 3	92	10.23	61	6.27
6	Households with score 2	79	8.78	155	15.94
7	Households with score 1	174	19.35	191	19.65
	Total Households	461	51.27	443	45.57

*computed from Socio Economic caste census survey, 2011

According to Saxena Committee, scoring index of deprivation indicators shows that 0.55% of households of Kheri Kalan covered under score 7, whereas in Bishada 0.4% households reached score 6. A maximum number of households found in the category of score 1 in both villages with the almost same percentage of households. Overall, it can say that Kheri Kalan has highest score under the deprivation indicators which further indicating the higher presence of rural poor or marginalised communities in Kheri Kalan village.

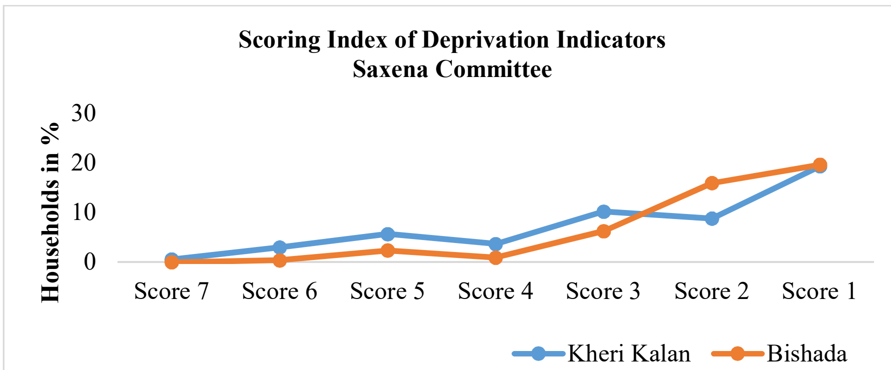


Figure 5.16 Scoring Index of deprivation indicators (Saxena Committee)

5.6.3 Comparison between SECC Committee criteria (2011) and Saxena Committee criteria (2009)

The purpose of comparing SECC Committee criteria with Saxena Committee criteria is to see the difference in the process of identification of rural poor and see the gaps between them.

Table 5.30 Comparison between SECC Committee Criteria (2011) and Saxena Committee Criteria (2009)

Comparison Indicators	Kheri Kalan		Bishada	
	SECC (2011)	Saxena Committee (2009)	SECC (2011)	Saxena Committee (2009)
Automatically Excluded Households	93.1	32.03	84.56	15.84
Automatically Included Households	Nil	12.56	Nil	8.95
Households under Deprivation	63.4	72.96	28.61	55.24

*computed from Socio Economic caste census survey, 2011

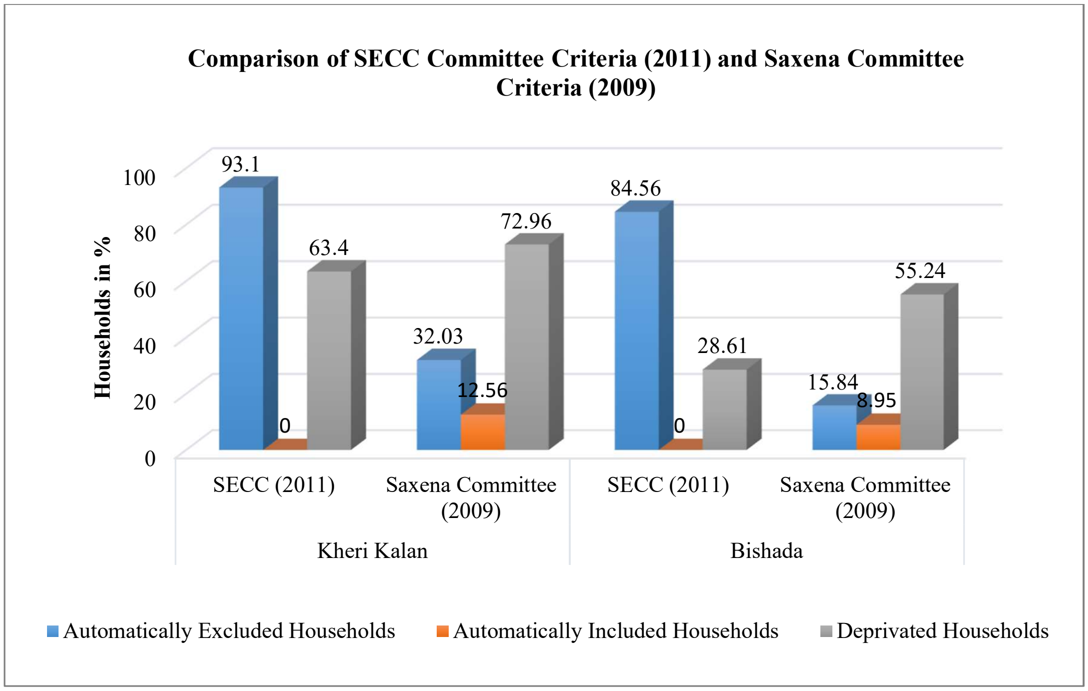


Figure 5.17 Comparison of SECC Committee criteria (2011) and Saxena Committee criteria (2009)

The above table and figure show the comparison of SECC Committee Criteria (2011) with Saxena Committee Criteria (2009). It is clearly evident from the figure 5.17 that in both villages, households excluded automatically are higher under SECC Criteria. Inversely, the households included in the automatically were found higher in Saxena Committee criteria for both villages. It is because female headed households were included in the automatic inclusion with Saxena Committee criteria whereas in SECC criteria it was not included. Further, deprived households found more with the assessment of Saxena Committee criteria. Therefore, it can say that apparently small differences in both criteria make large gaps in identifying the poorer section of society.

In the next section, socio-economic vulnerability has been evaluated across the main source of income groups. These main sources of income groups are classified into three major groups: a) Income generated from farming activities, b) Income generated from elementary occupations, and c) Income generated from non-farming and others activities. The main purpose to see socio-economic vulnerability across these groups is to find out the deprived section of groups based on occupational diversity. It will not only tell the socio-economic vulnerability to specific adopted occupation, it will also have identified the poorest of the poor across all groups.

5.6.4 Socio-economic vulnerabilities based on the main source of income

The assessment of socio-economic vulnerability based upon the main source of income groups is adopted from the Saxena (2009) and SECC Committee (2011) criteria by using selected socio-economic indicators. But before calculating socio-economic vulnerabilities, households were classified into broad three categories based on the main source of income such as farming, elementary occupation, and non-farming & others. Then, socio-economic deprivation indicators have been selected from both committee criteria's (Saxena & SECC). These indicators are– numbers of household's heads illiterate, a number of females headed households, the number of scheduled caste (SC)/scheduled tribe (ST), a household with no literate adult, a household with disable member, household's monthly income below Rs.5000, and landless households. Because all these indicators are negative which depicts that if in the case of any natural calamity or economic stress or shock, then this section of society is more likely to get affected and less likely to recover soon. Therefore, they are considered socio-economically more vulnerable.

Table 5.31 Classification of households based on main source of Income

Village	Farming		Elementary Occupation		Non-Farming & Others		Total	
	No of Households	%	No of Households	%	No of Households	%	No of Households	%
Kheri Kalan	218	24.24	313	**34.77**	369	41.0	900	100
Bishada	589	**60.59**	176	18.11	207	21.30	972	100

*computed from Socio Economic caste census survey, 2011

The above table (Table no. 5.31) show classification of rural households on the basis of the main source of income. In the category of farming as the main source of income, Bishada shows a higher percentage of households (60.59%) than Kheri Kalan (24.24%) which infers that people in Bishada are more dependent upon farming activity as the main source of income. But if we see the category of elementary occupation as the main source of income, it reveals that people in Kheri Kalan are higher in percentage (34.77%) with compare to Bishada (18.11%). Further, in the third category of income generated through non-farming or others activities represents that 41% of households in Kheri Kalan are involved in non-farming while it is only 21.3% of households involved in Bishada. Overall, it can infer from the graph that the chances of diversification of income sources are higher in the Kheri Kalan village.

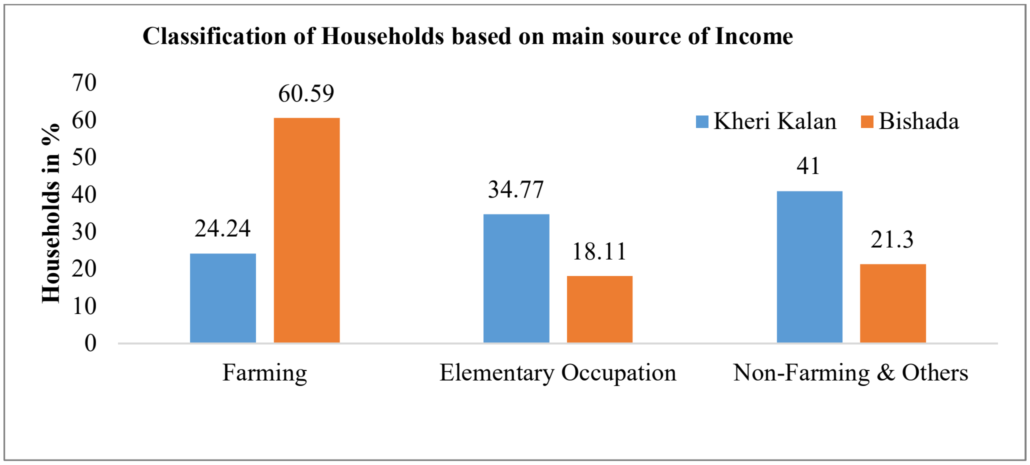


Figure 5.18 Classification of households based on main source of Income

5.6.4.1 Deprivation Index for households engaged in Farming activity, Elementary Occupation and Non-farming & others in Kheri Kalan Village, Faridabad

For the identification of deprived households in context to socio-economically vulnerable across the main source of income category, deprivation index has been analysed on the basis of selected SECC and Saxena Committee criteria.

Table 5.32 Deprivation Index in Kheri Kalan (based on Livelihood Strategies)

Code No.	Indicators (**Kheri Kalan**)	**Farming, THH=218**		**Elementary Occupation, THH=313**		**Non-Farming & Others, THH=369**	
		No. of HH	Percent	No. of HH	Percent	No. of HH	Percent
D11	No. of HHs Head Illiterate	52	23.9	121	38.7	82	22.2
D12	No. of Female HH household	17	7.8	32	10.2	56	15.2
D13	No. of SC/ST Households	3	1.4	125	39.9	46	12.5
D14	Household with no literate adult	6	2.8	35	11.2	18	4.9
D15	Household with disable member	2	0.9	15	4.8	6	1.6
D16	Household income below 5000/month	52	23.9	251	80.2	102	27.6
D17	Landless household	21	9.6	282	90.1	112	30.4

*computed from Socio Economic caste census survey, 2011

In the farming category, a total number of households is 218 which is 24.24% of total households of the village. Within this category, socio-economic vulnerability was higher with those households whose head of the households are illiterate, belongs to SC, headed by females, household monthly income is less than Rs.5000 and landlessness. Among all these indicators, 23.9% of the households are headed by illiterates, 23.9% households have monthly income below Rs.5000, 9.6% households are landless even though they are engaged in a farming activity, 7.8% of the households are headed by females, and 1.4% households belong to a socially marginalised category. That means within the farming category, there is a minor section of this group are socio-economically vulnerable.

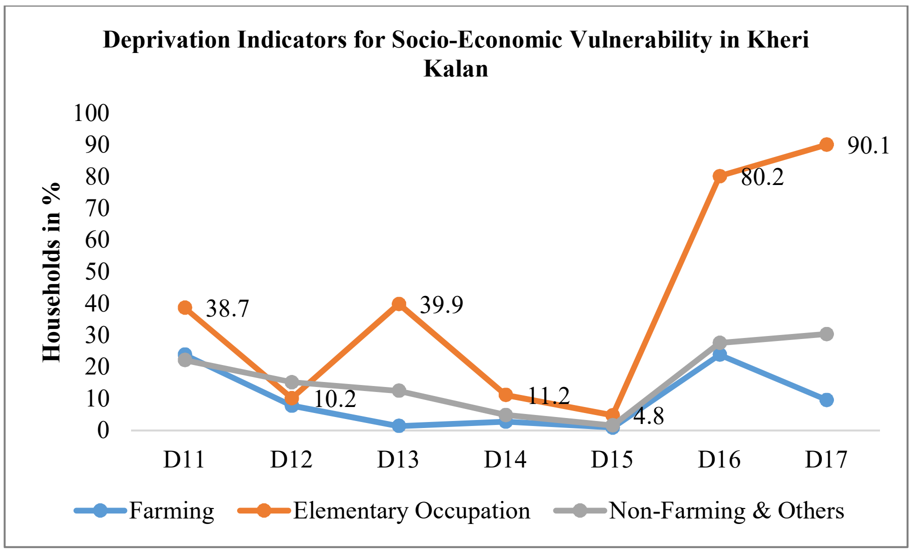


Figure 5.19 Deprivation indicators for Socio-Economic vulnerability in Kheri Kalan

Elementary occupation category represents 34.7% households to total households of the Kheri Kalan village which is higher than the farming category. Within this category, there are 38.7% of the households whose head of the households are illiterate, 90% of households are landless, 80% household's monthly income is below Rs 5000, 39% of the households belong to SC category, 10% are headed by females, and almost 11.2% households are with no literate adult in the family. All these socio-economically deprivation indicators reveal the reality of the elementary occupation category that this chunk group of people in a village are a most marginalised community.

In context to non-farming & others category, 41% of the households to total households of the village are depending upon non-farming &others activities for the main source of income. Within this group of households, 30% of the households are landless, 27% household's monthly income is below Rs. 5000, 22% household's heads are illiterate, 15% of the households are headed by females, 12% of the households belonging to the SC, 1.6% household with disable member, and 4.9% of the households are with no literate adult. It infers that within this category, a marginal number of households is socially and economically deprived.

To assess the most socially or economically deprived community across the main source of income group, deprivation score (in this context it represents socio-economic vulnerability score) has been allotted to the households by submission of all deprivation indicators. It varies between 0 and 7. Higher the score, higher will be the socio-economic vulnerability and vice versa within that category.

5.6.4.2 Socio-Economic vulnerability score in Kheri Kalan

Table 5.33 Socio-economic vulnerability score in Kheri Kalan

S. No.	Vulnerability Score Kheri Kalan	Farming		Elementary Occupation		Non-Farming & Others		Total	
		No. of HH	Percent	No. of HH	Percent	No. of HH	Percent	No. of HH	Percent
1	Households with score 7	0	0	0	0.00	1	0.11	1	0.1
2	Households with score 6	0	0	6	0.67	1	0.11	7	0.8
3	Households with score 5	0	0	27	3.00	9.00	1.00	36	4.0
4	Households with score 4	1	0.11	43	4.78	20	2.22	64	7.1
5	Households with score 3	8	0.89	94	10.44	33	3.67	135	15.0
6	Households with score 2	25	2.78	95	10.56	62	6.89	182	20.2
7	Households with score 1	74	8.22	35	3.89	60	6.67	169	18.8
8	Households with score 0	110	12.22	13	1.44	183	20.33	306	34.0
	Total	**218**	24.22	**313**	34.78	**369**	41.00	**900**	100.0

*computed from Socio Economic caste census survey, 2011

Households with score 7 represent very high socio-economic vulnerable households, which are found under non-farming and others category by 0.1% which represents only one household from the whole village. Households with score 6 are found maximum under elementary occupation category with 0.6% followed by non-farming and another category. Households with score 5 are found maximum again in elementary occupation category. Farming category shows no households under score 7, 6, and 5. Households with score 4 represents the medium level of socio-economic vulnerability which is found higher in elementary occupation (4.78%) followed by non-farming & others (2.2%). Households with score 3 & 2 found higher among elementary occupation category whereas households with score 1 found higher among farming category and non-farming category. Over all, it infers most socio-economically marginalised are those who are involved in elementary occupation in Kheri Kalan village.

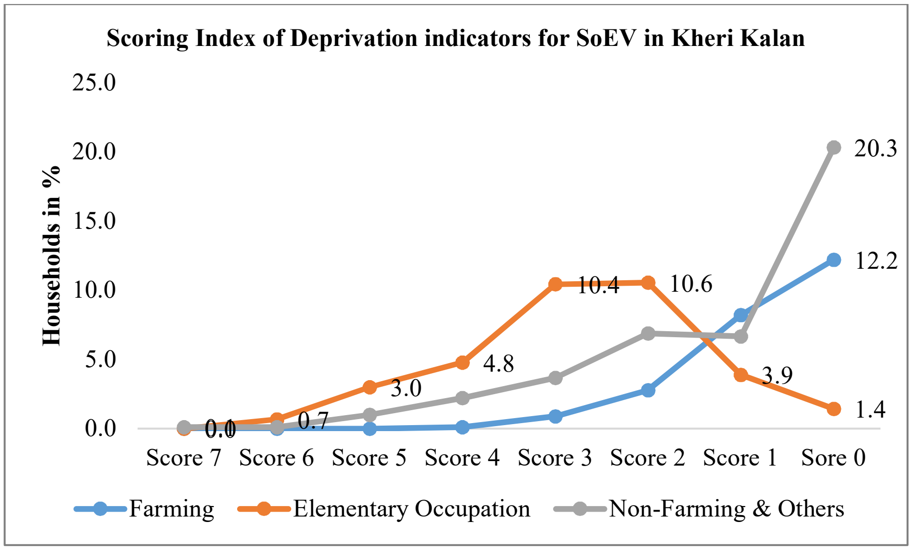


Figure 5.20 Scoring index of deprivation indicators for SoEV in Kheri kalan

5.6.4.3 Deprivation Index for households engaged in Farming activity, Elementary Occupation, and Non-farming & others in Bishada, Gautam Budh Nagar

Table 5.34 Deprivation indicators for Socio-Economic vulnerability (SoEV) in Bishada

Code No.	Indicators (**Bishada**)	**Farming, THH=589**		**Elementary Occupation, THH=176**		**Non-Farming & Others, THH=207**	
		No. of HH	Percent	No. of HH	Percent	No. of HH	Percent
D11	No. of HH Head Illiterate	52	8.8	41	23.3	32	15.5
D12	No. of Female HH household	41	7.0	15	8.5	13	6.3
D13	No. of SC/ST Households	46	7.8	4	2.3	2	1.0
D14	Household with no literate adult	3	0.5	0	0.0	2	1.0
D15	Household with disable member	5	0.8	2	1.1	3	1.4
D16	Household income below 5000/month	338	57.4	138	78.4	56	27.1
D17	Landless household	454	77.1	133	75.6	120	58.0

*computed from Socio Economic caste census survey, 2011

Deprivation Index for households in Bishada village shows, farming category who represents 60% households to the total households of the village that within this category 8.8% of the households are deprived of context to their household's heads are illiterate and important deprived criteria which shows landless households are maximum within this category by 77.1%. Another important notable criterion that household's monthly income is less than Rs.5000 is found 57.4% within the farming activity. Around 7% of the households are headed by females. The situation of farmers in Bishada is not well as compare to Kheri Kalan village as most of the farmers are landless or have marginal landholdings.

Elementary occupation category represents 18.2% of households to total households in a Bishada village. In this category most of the people are deprived of context to landless households (75.6%) household income below Rs.5000 per month (78.4%), household heads are illiterate (23.3%), and female headed household (8.5%). But when we see a composite of these indicators we have found the real picture of socio-economic vulnerability of this category. Now it would be appropriate to say that within 18.2% of households the ratio of socio-economic vulnerable households would be more (or say around 75% of households) in terms of vulnerability scores.

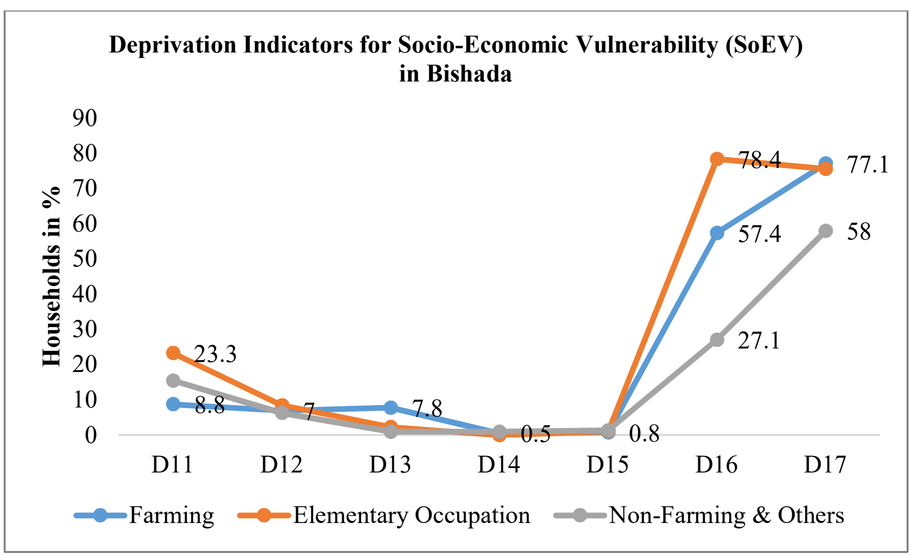


Figure 5.21 Deprivation indicators for Socio-Economic vulnerability (SoEV) in Bishada

In context to non-farming & others category, 21.3% of the households to total households of the village are depending upon non-farming &others activities for the main source of income. Within this group of households, 58% of the households are landless, 27% household's monthly income is below Rs. 5000, 15% household's heads are illiterate, 6.3% of the households are headed by females, one percent of the households belonging to the SC, 1.4% household with disable member, and 1.0% of the households are with no literate adult. That means under the non-farming category, a small section of the population is deprived according to the SECC & Saxena Committee criteria.

5.6.4.4 Socio-Economic vulnerability score in Bishada

Table 5.35 Scoring index of deprivation indicators for SoEV in Bishada

S. No.	Vulnerability Score Bishada	Farming		Elementary Occupation		Non-Farming & Others		Total	
		No. of HH	%	No. of HH	%	No. of HH	%	No. of HH	%
1	Households with score 7	0	0.00	0	0.00	0	0.00	0	0.0
2	Households with score 6	0	0.00	0	0.00	0	0.00	0	0.0
3	Households with score 5	0	0.00	1	0.10	1	0.10	2	0.2
4	Households with score 4	7	0.72	8	0.82	3	0.31	18	1.9
5	Households with score 3	71	7.30	27	2.78	10	1.03	108	11.1
6	Households with score 2	242	24.90	85	8.74	52	5.35	379	39.0
7	Households with score 1	213	21.91	45	4.63	77	7.92	335	34.5
8	Households with score 0	56	5.76	10	1.03	64	6.58	130	13.4
	Total	**589**	**60.60**	**176.00**	**18.11**	**207.00**	**21.30**	**972.00**	**100**

*computed from Socio Economic caste census survey, 2011

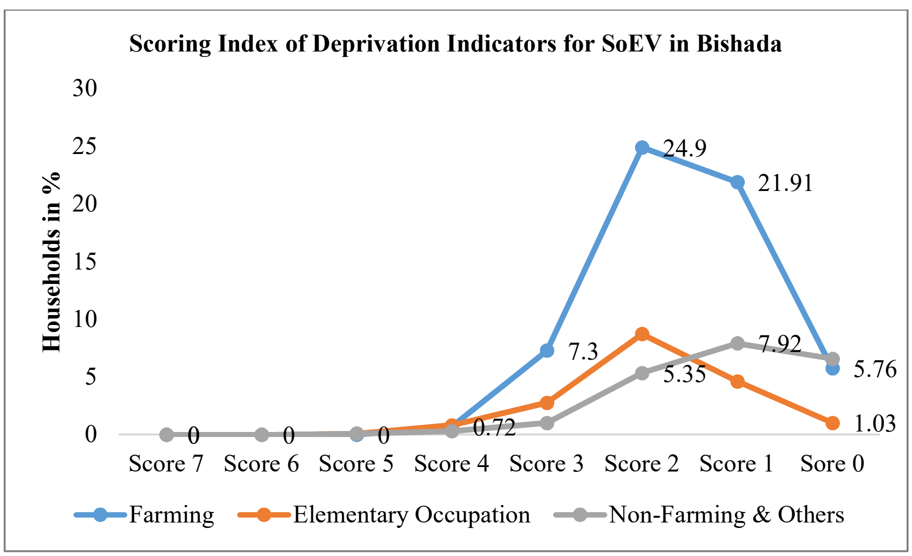


Figure 5.22 Scoring index of deprivation indicators for SoEV in Bishada

After analysing the deprivation indicators, socio-economic vulnerability score has been computed in Bishada village. It shows that maximum score reached to score 5 in the village. Households that represents score 5 are comes under elementary occupation category and non-farming & others category. Households with score 4 are again higher in elementary occupation category maximum number of households are coming under score 2 & 1 in all three categories. That means socio-economic vulnerability is not only present over one kind of occupation activity it prevails in all categories but with some degree of difference. Overall, it can be said that higher vulnerability is found among elementary occupation category in Bishada village as well.

This chapter was dealt with the assessment of socio-economic characteristics and vulnerabilities of Kheri Kalan and Bishada village from the available household level socio-economic caste census data 2011. It reveals that socio-economic vulnerabilities have high in the elementary occupation group of households from the both villages whereas the class of cultivators were high in Bishada but with having small or marginal land holding size or most of the cultivators were landless which further revealing vulnerabilities among farming occupation. Whereas in Kheri Kalan number of cultivators with having medium to small or marginal landholdings were high but most of the cultivators not totally dependent upon farming as their livelihood option. They were diversified in other occupations. This ratio was high in Kheri Kalan with compared to Bishada village.

With linking to next chapter this study was significant as it has constructed the base for the next chapter. So next chapter will be focused upon the primary field survey on Kheri Kalan and Bishada villages from Faridabad and Gautam Budh Nagar district respectively. It will assess the ground realities of the village in context to impact of ecosystem services on livelihoods of the people.

Chapter-6

PRIMARY SURVEY TO STUDY ECOSYSTEM SERVICES AND LIVELIHOODS

(Kheri Kalan and Bishada village in peri-urban)

6.1 Introduction

Ecosystem services are playing a vital role in providing livelihood to the rural communities. As documented by The Millennium Ecosystem Assessment shows a strong relation of poorer member of society towards dependence on Ecosystem Services to sustain their livelihoods (MA, 2003; TEEB, 2008). This dependency is linked to reliance on accessible natural resources, limited adaptive capacity, and vulnerability to natural hazards (Willemen et al., 2013). Over worldwide, the unsustainable use and degradation of ecosystem and their services are now threatening the livelihoods of many poor people. They are providing direct benefits to mainly those who are depending on it and generate monetary benefits when they are paid for (Swalow et al., 2009; Kinzing et al., 2011). Humans have rapidly changed ecosystems since the last 50 years which in turn is leading to a global biodiversity loss and ecosystem services extensively (MA, 2005) and further influencing the livelihood of the people.

The *Ministry of Environment and Forests*, Government of India formally initiated the TEEB study in 2011, and stated the commitment to developing a framework for green national accounts by 2015 for doing an ecosystem based economic valuation.

While consisting of 2.4% of worlds landed area only, India has been reported for having 7% to 8% of the plant and animal species of the world. It also falls among the 18 mega-diverse countries and comprises of three biodiversity hotspots under global scale. India shows greater degree of endemism, for what conserving its biodiversity become essential for future. Being a developing country, India depends on natural capital more than the higher-income countries do. In the global level, forests account for a third of the total land area and near about 80% occupied in the terrestrial biodiversity. Close to 1.6 billion people are dependent for their livelihoods on forest as it provides multiple supporting, regulating, provisioning and cultural services as well to human well-being. As the studies examined by TEEB, the forest as well as agro ecosystems along with other ecosystems has significant contribution to the economic livelihoods of the poor rural folks. Not only have that, forest sector also highly contributed to the national GDP in many tropical countries. The health and state of forests, particularly tropical one, is thus, crucial for the economic growth and livelihoods of ever-increasing populations in the countries of the tropics.

This chapter, hence, focus on the identification and assess the provisioning of the ecosystem services along with the drivers of change of these services and the finally the impacts of those changes in the services on people's livelihoods, with the help of a case study of the Kheri Kalan village from district Faridabad, Haryana which comes under the sub-region of NCR and Bishada from Gautam Budh Nagar district of U.P sub-region of NCR. It deals with the primary field survey's quantitative and qualitative data analysis. The main aspect of this chapter is to know about how rural people are dependent on ecosystem services for their livelihood source and with the expansion of urban areas to its fringes, how these ecosystem services are degraded, thus to see shift in their livelihood pattern.

6.2 Selection of Study area

The study areas were selected based on the working population engaged in the primary activities such as they are main cultivators, agricultural labourers whose primary source of livelihood is generated from ecosystem services and also the demarcation is done within the 5 km periphery from the urban areas to see the urban effects on its fringe areas with respect to loss in the ecosystem services and urban expansion leading to the deterioration in the ecosystem services. Thus, selected study area is Kheri Kalan village in Faridabad Tehsil of Faridabad and Bishada Village in Dadri Tehsil of Gautam Budh Nagar district of National Capital Region. Following flow diagram (Figure 6.1) shows the selection of study areas:

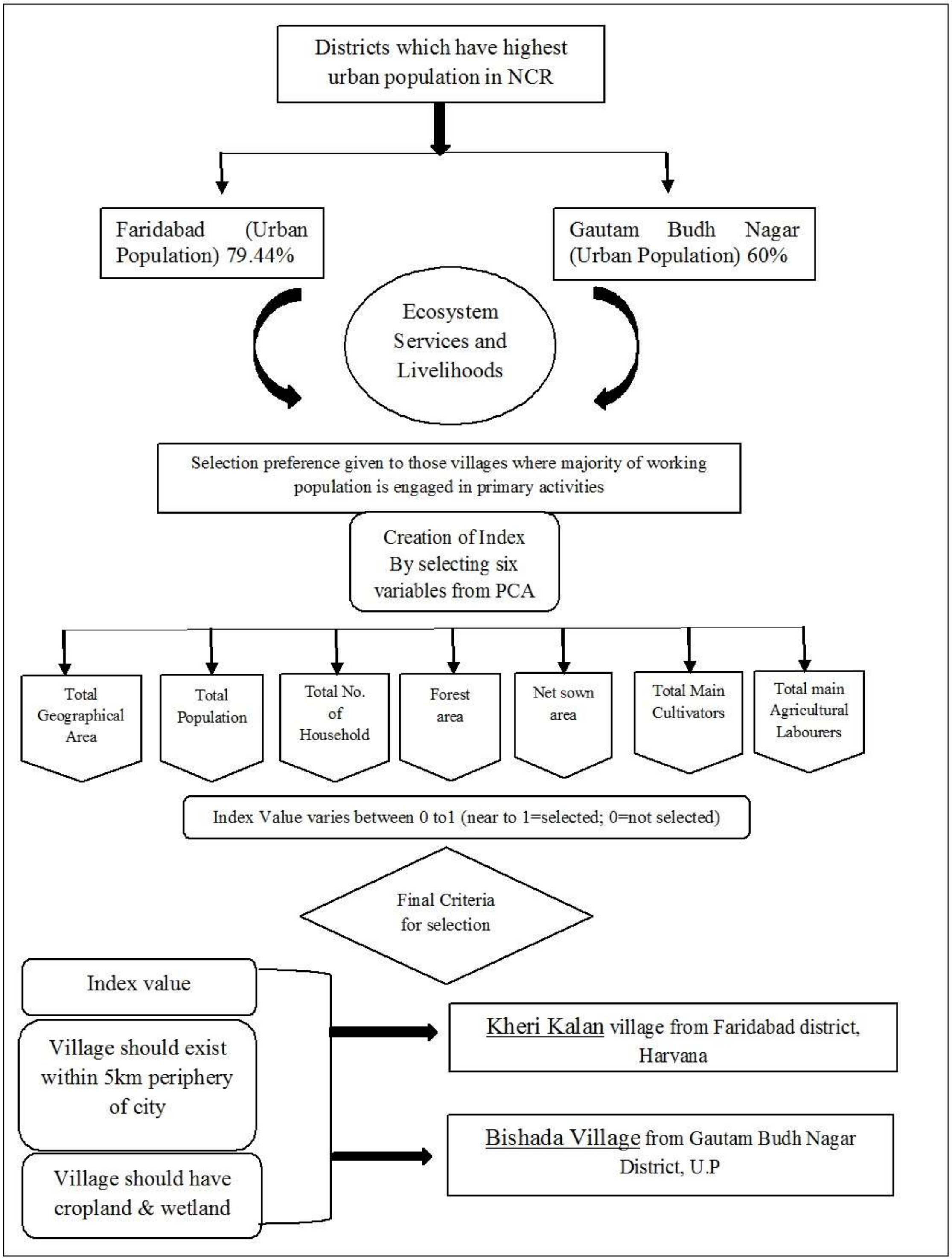


Figure 6.1 Flow chart for selection of study area

6.3 Selection of sample size

Based on the total population and number of household in a village, 10 % of samples have been collected from the study regions with cluster random sampling method. A household survey has been done in selected villages with a sample design depicted in Figure 6.2 and Table 6.1:

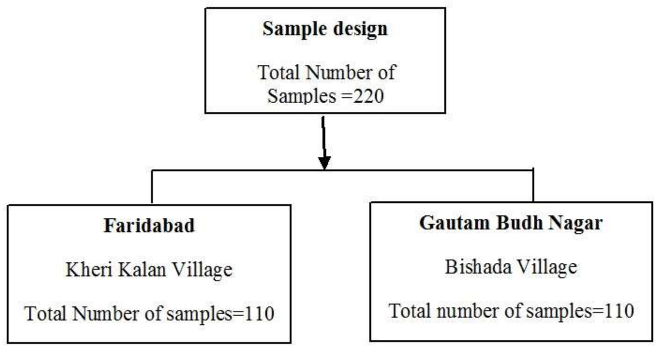


Figure 6.2 Selection of sample size

Table 6.1 Selection of sample size

Name of village	As per Census 2011		Sample Size	
	No. HH	Population	No. of HH	Population
Kheri Kalan (Faridabad)	1103	6664	110	683 (10.2%)
Bishada (GT B Nagar)	1167	6669	110	694 (10.4%)

(Source: Census 2011 & Primary survey, 2016-17)

6.4 Methods of Data Collection

6.4.1 Primary Data Collection

Primary data were obtained through household survey; in-depth personal interviews were conducted using structured questions to keep the interview relatively focused. However, flexibility during interviews was been exercised to allow interviewees the opportunity to share their own perception freely. Data has been collected in a coding manner, where codes have been provided for each answer, which means questions are not open ended. Questions focused on the socio-economic characteristics of household, ecosystem services used as for example crop production, livestock services, water services, common property resources; and people’s habituation on them along with drivers of change as well as impact of that on their livelihoods. Then collected coded information has been inserted into SPSS environment for further analysis. The questionnaire is shown in Appendix. Focused group discussion (FGD) was organized at the community level from the both villages taking 5-6 participants on an average. Ecosystem services and dependency on them for livelihood were also thoroughly discussed among though FGD.

6.4.2 Secondary Data Collection

Secondary data was collected from village directory of Faridabad and Gautam Budh Nagar from Census of India, 2001 and 2011. Specific data related to crop production, land use categorisation and village cadastral maps have been obtained from the regional Tehsil office (Revenue department) from both villages.

6.5 Methods of Data analysis

For Land use and land cover: mapping of village has been done through the base cadastral map of village and then with the help of google earth images of 2006 and 2016, digitization of differential land use classes has been done. The identified land use classes are agricultural land, settlement or abadi area, ponds, apartments, Brick kiln fields, Drain or nala, roads railway line and barren land or wasteland. Area of particular classes then measured through ArcGIS. For the assessment of socio-economic status of household, data analysis has been done through frequency analysis, cross tabulation and correlation. Excel has been used to make graphs and charts.

For assessment of present situation regarding condition in the aforesaid villages, sustainable livelihood framework is adopted from DFID (1991). For this, data was gathered on the different types of livelihood assets like natural capital, physical capital, human capital, social capital, financial capital and ecosystem services (Table no 6.2). The collected data was then analyzed where the original individual indicators has been used and had been indexed for converting it to a composite index towards each capital. Finally, composite livelihood assets index has been calculated from all composite capitals. Here it's important to note that the composite index was invented for each single asset as it's a mean of the all index values. The values were merged into four prime livelihood categories like agriculture; agriculture and others; elementary occupation; and non-agriculture. The values were converted into a composite index for differential capitals and thus livelihood polygons were prepared as visualized by DFID.

The asset pentagon thus, shows the differential capitals for the various livelihood strategies.

Table 6.2 Rationale for constructing the Livelihood Capital Index

Livelihood Capital	Indicators	Implication
Human Capital (HC)	Education Level	The education level of the village residents is assigned as graduate and higher (1), higher secondary (0.75). Secondary (0.50), middle (0.30), primary (0.20), literate but below primary (0.10), or illiterate (0). Here it's important to note that the values of education level of the village people are summed and finally got standardized as well.
	Working age population	Working age population shows human resource availability in household which is above 21years and below 55 years.
Natural Capital (NC)	Land holding per capita	Quantum of land own per capita and standardized.
	Household own & access to water resources	If the household have and own water resources at home then the value for given household is 1 and not own is 0.
Physical Capital (PC)	Household assets	Submission of basic household assets and then standardized. It includes TV, Motorcycle, Four wheeler, Refrigerator, Tractor, Tube well, Electricity, Toilet Facility, LPG, and Air conditioner (AC)
	Livestock	Livestock is one of the most important physical capital, found in the study area. The primary types of livestock include goat and cattle, weighted as 0.5 and 1, respectively. The livestock capital as a part of physical capital of one family is thus calculated as the sum of individual livestock number multiplied by its weight then finally standardized.
Social Capital (SC)	Membership	Ration card membership, if yes=1 and No=0 values given and then standardized.
	Mandi facility	Household availing mandi facility valued 1 for yes and 0 for no.
Financial Capital (FC)	KCC (Kisan credit card)	Values for having KCC is 1 and 0 for no.
	Occupation diversification	Occupational diversification in household shows next income source other than primary source. It enhances the economic condition of a household. Values were assigned as Yes=1 and No=0, and then standardized.
Ecosystem Services (ES)	Crop Production	Values for each household for crop production for rabi and kharif season, assigned as single crop (0.5), more than one crop (0.75), horticulture and agroforestry (1), and no crop production (0).The crop production values of each household were summed and standardized.
	Livestock Services	The benefits that gained from livestock are milk, meat etc. Values were assigned on the basis of benefits. For example, self-consumption= 0.5, self-consumption and sold=1, and no livestock services=0. Then values were summed up and standardize.
	Fisheries	Fish production, yes=1, and No=0.
	Water services	Water habituated for irrigation and drinking purpose, on the basis of dependency on water i.e. public source=1, public source and private source=0.5, and have own private source=0.25. then values were summed up and standardize.
	Use of firewood & fuel for cooking	Households which uses firewood and fuel for cooking assigned value =1, and no use=0.
Total Livelihood Capital Index	LCI=HC+NC+PC+SC+FC+ES	

The Pearson's correlation coefficients were calculated for indices of the five types of livelihood capital to verify the applicability of the model and find out the relationship between several capitals as independent variables with the livelihood strategy (e.g. on-farm income and off-farm income) as dependent variable. Livelihood strategy consists of on-farm income (income from agriculture and livestock produce) and off-farm income (income generated from wages earned, from petty and small businesses to large businesses, other income generated activities).

The multiple linear regression has been used to ascertain the correlates for livelihoods strategies (On-farm based and Off-farm based) with livelihood capitals and also to find out the effects of the independent variable (e.g., livelihood capital) on the dependent variables (e.g., livelihood strategies). Coefficient of multiple determinations was used to find out total variation explained by the independent variable on the dependent variable in the regression model.

A positive regression coefficient indicates a positive relationship between livelihood capital and livelihood strategies (on-farm, off-farm and both), however a negative regression coefficient indicates adverse relationship between livelihood capital and livelihood strategies. The odds ratio, an important indicator quantifying the degree of influence that an independent variable has on a dependent, can be measured as a specific value between the incident frequency of occurrence and not occurrence, with the result that the probability of livelihood strategies increases or decreases by expected times as the livelihood capital increases or decreases by one unit (Maharajan et al., 2011; Fang et al., 2014; and Wang et al., 2015).

6.6 Results and Discussion

6.6.1 Introduction to village Kheri Kalan and Bishada

I. Kheri Kalan Village, Faridabad

Kheri Kalan is situated at a distance of 8 km from main Faridabad city and in the east direction beyond Agra canal. The total geographical area of village is 973 hectares. According to the Census 2011, Kheri Kalan has a total population of 6,664 peoples. This village consists of 1,103 houses. Faridabad, urban hub, located in its proximity. As told by the Sarpanch and some respondents from the village, this is an old historical village founded by Anangpal Tanwar[1] descends. This village came into existence after war fought against Aurangzeb with Jats around 1669. After the war, Panchayat came into existence in which 'Narvat' title (which means a warrior) was awarded to that group of peoples who fought against the Aurangzeb. So later on the title has been converted in to the Narwat Gotra of Jats. Moreover, the people of this village took part in India's freedom movement through Azad Hind Fauj. Before 1947 when India was ruled under Britishers, 50 percent population of this village were Muslims but after independence there were less number of Muslim population and presently there are only 10 to 15 households remained. This is the largest village of Jats. Although all the communities like Pandit, Harijan, Balmiki, Dhobi, Kumahar, Naee & some muslims residing here.

Since the ground water is the major source of irrigation for the Kheri Kalan villagers, so the problem for the depletion of groundwater in this region is under great pressure caused by increasing demand in irrigation as well as household needs. The frequent cases of well failure of tube well were reported in village. Greater portion of the arable land is occupied by the real estate developers resulting into the loss of agricultural lands.

a)

[1] Anangpal Tomar or Bilan Dev Tomar (731-736 A.D.) was a Chandravanshi Puruvanshi Kshatriya, descendant of Samrat Parikshit of Mahabharat fame. He was the first ruler to make ancient Indraprastha, modern day - Delhi his capital.

b)

Plate 6.1 a) &b) Land conversion from agricultural to non-agricultural purpose in and around Kheri Kalan village, Faridabad

II. Bishada Village, Dadri, Gautam Budh Nagar

Geographically this village is situated between the Dadri (NPP) and Patadi (Census Town) in Gautam Budh Nagar district, Uttar Pradesh. Bishada is one of the large village situated in Dadri Tehsil of Gautam Buddha Nagar with 1167 resident families. It has a population of 6669 out of which 3052 are females while 3617 are males as per Census of India, 2011.

The child population between 0-6 age group is 975 contributing to 14.62 % of total population of that village. Here average Sex Ratio has been recorded as 844 which is lower than state average of Uttar Pradesh i.e. 912 while child Sex Ratio has been found as 776, lower than Uttar Pradesh average i.e.902 again. 2011 Census shows comparatively higher literacy rate has been recorded in Bishada i.e. 77.22% than Uttar Pradesh i.e. 67.68%. But the scenario is not totally convincing because female literacy rate with 65.99% lags behind Male literacy rate which stands at 86.83 %.

According to the Sarpanch Hari Om, the total geographical area of this village is 714.430 hectares and net sown area is 463.45 hectares. The main source of livelihood is agriculture. 80% of population are engaged in primary activities but most of the agricultural land owners are Thakurs and Brahmins. Other castes and Muslims does not have any land. They are mainly casual and agricultural labourers.

The interface of rural and urban area, Bishada too have faces the loss in the arable land for construction purposes. This is situated near the Dadri town and with expansion in its boundary towards the rural urban continuum Bishada village is not been untouched. An incumbent government plans and policies resulted in the change in the landscape pattern of this village. The southern part of this village comes under the plan for making Highways that would lead it to the loss of its fertile land for the construction of roads. This would relate to one side with the development process of the village but on the other side it leading to not only loss of ecosystem services but also effecting the livelihood of the people. The farmers who had land in the southern portion of village had to sold their land to the government but in return they got compensation for short term but for long term they have lost their lands and would have to search for other livelihood options.

6.6.2 Land use and land cover changes and identification of Ecosystem Services

Land use and land cover in both villages shows that there was a loss in the agricultural land but the conversion of arable land to non-arable land was seen highest in the Kheri Kalan village with compare to Bishada. In Kheri Kalan, hoardings on the prime Kheri road that connected to the village near Sector 89, Faridabad declares 'affordable mall' for the first time in the NCR (National Capital Region) and 'luxurious homes that can still be owned only if you hurry' (Ghosh, 2011). The intended mall anticipates office ambience, shopping nirvana, food fantasia, entertainment bonanza, etc. with beauty of full bloom mustard fields in the background which shows the oddments of sprawling arable landscape. With developing real estate occupancy and private educational institutions as well, the fertile agrarian land has resulted in the shortage of work opportunities.

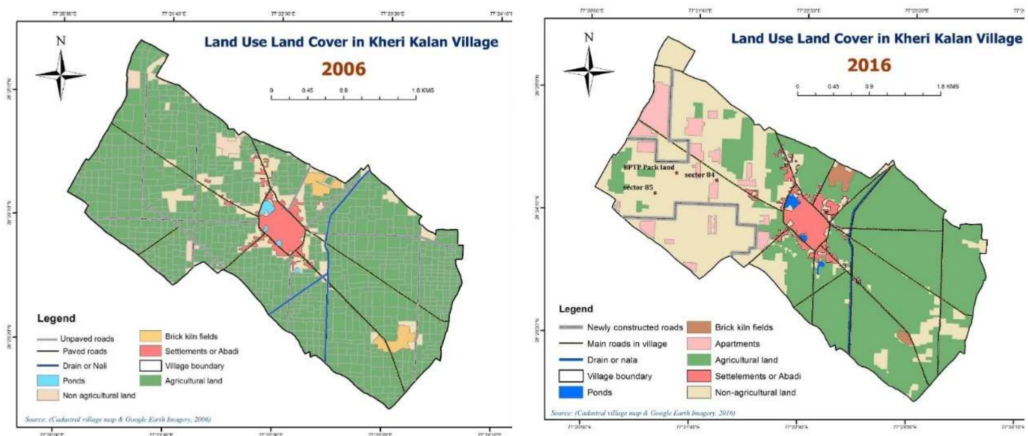
The data for land use classification for current year (2016-2017) were collected from the Tehsil revenue office, Faridabad and Gautam Budh Nagar. They record facts regarding land use classification in village, crop grown in Rabi and Kharif seasons, soil classification, area under crops, wells and other means of irrigation in the village and cultivation & capacity of the cultivators. All this village information is recorded in Lal Qitab (village note book) and Kharsa Girdawari. It is a register of harvest inspection. The patwari (a government accountant) a field to field harvest inspection in every six months i.e. in the month of October and March).

According to Khasra Girdawari, land use classification of village (2016-17)

Table 6.3 Land use classification of village (2016-17)

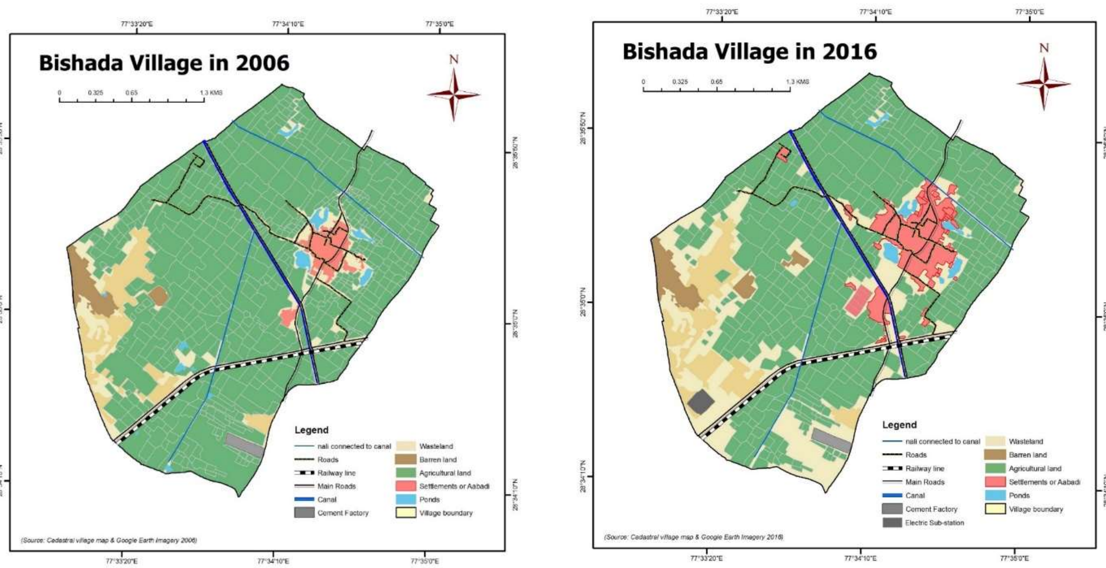
S.No.	Land use classification	Kheri Kalan(Area in ha)	Bishada (Area in ha)
1	Agricultural Land	845.4	461.7
2	Non Agricultural Land	125.85	222.91
3	Irrigated Land	843.19	461.7
4	Canal Area	1.21	2.17
5	Current fallow	2.21	3.27
6	Barren Land	0.80	24.38
7	Total area	973.26	714.43

(Source: Khasra Girdawari-a village note boo, 2016)



Map 6.1 A) LULC in Kheri Kalan in 2006; B) LULC in Kheri Kalan in 2016

Due to the peripheral location of this village to Faridabad urban area, a greater section of the agrarian land has been developed by real estate for the built-up purpose. The pattern of land use and land cover in this village from 2006 to 2016 has been changed (shown in Map 6.1 A& B). Most of the agricultural land which is situated at the western part of the village were gone into the sector 85, 84 and to the real estate's developers. As told by one of respondent 'Land has been started to be acquired from 2004-06. It was around 1000 acre of agricultural land. All the western part has been acquired by private developers not by the government. The land initially started for selling from Rs.20 lakhs and went up to the Rs.2.5 crore in the village.



Map 6.2 A) LULC in 2006 ; B) LULC in 2016 Bishada

Agricultural land is the prominent land use class in the Bishada village but as we can see from the above depicting maps (Map 6.2 A & B) that from 2006 to 2016 agricultural land got converted into built-up area and fallow or barren land too. Water bodies include ponds, canal and sub-canal or nali. In 2006 there were eleven ponds but in 2016 it has reduced to six ponds only. The major changes have been found in arable land. As this was also seen during field visit that agricultural land are now being converted into the plots.

Plate 6.2 Conversion of agricultural land into plots in Bishada village of Gautam Budh Nagar

6.6.3 Socio-economic profile of villages

Socio-economic status of any region is representing how develop the area is in terms of literacy, social structure, population diversity, household income and occupation. Some basic socio-economic characteristics of Kheri Kalan and Bishada villages are presented in Table 6.4:

Table 6.4 Socio-economic characteristics of village

Socio-Economic Characteristics	Kheri Kalan (Faridabad)	Bishada (GT B Nagar)
Number of surveyed households	110	110
Population	683	694
Male	55.1%	55.2%
Female	44.9%	44.8%
Household Heads (%)		
Male	96.4	95.5
Female	3.6	4.5
Caste (%)		
SC	11.85	8.6
Others	88.14	91.35
Education Level (%)		
Illiterate	25.5	18.7
Literate but below primary	13.0	9.4
Primary	15.5	18.0
Middle	11.9	18.0
Secondary	14.1	13.5
Higher secondary	13.9	12.5
Graduate or higher	4.8	8.8
Income of household (%)		
Less than Rs. 5,000	44.9	54.7
Between Rs. 5,000 to Rs 10,000	28.6	34.1
Rs. 10,000 or more	26.5	11.2
Land Ownership (%)		
Land Owned	68.9	70.0
Landless	30.1	30.0

(Source: Primary Survey, 2016-2017)

Both villages were similar in many of the socio-economic characteristics. The total sample size for both villages were 110 households each. Among the households interviewed in both villages more or less 55 percent were male population and 45 percent were female population but when we look at the household head scenario of both villages, it shows that in Kheri Kalan there were only 3.6 percent households were female headed and rest were male headed. Similarly, in Bishada female headed households were 4.5 percent and rest 95.5 percent were male headed households.

Caste structure in both villages shows different proportion for different castes. As Jats are highest in the Kheri Kalan whereas Rajputs are highest in population in Bishada village. We can see the caste structure in more detail in given below pie diagrams for both villages (Figure 6.3).

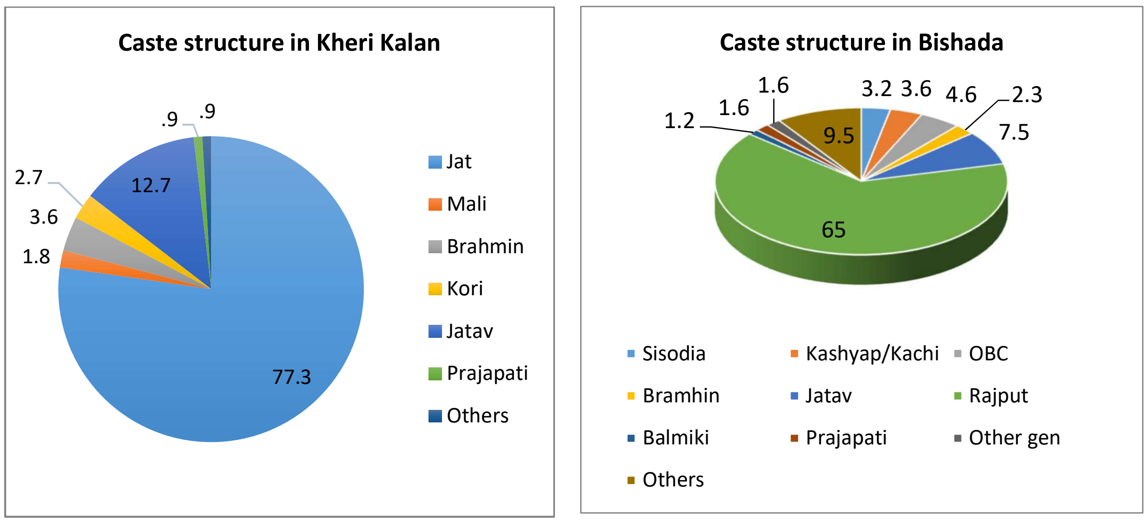


Figure 6.3 Caste structure in Kheri Kalan and Bishada village

(Source: Primary Survey, 2016-17)

Other than major caste population, 12.7 percent are Jatavs in Kheri Kalan whereas they are 7.5 percent in Bishada. Other castes in Kheri Kalan are Brahmins (3.6%), Kori (2.7%), Mali (1.8%), Prajapati and others (0.9%). Similarly, in Bishada other castes are Sisodia, Kashyaps, other backward castes, Brahmins, Balmiki, Prajapati and others general castes. Caste structure in our Indian society has plays a significant role in ascertaining the factor for socio-economic prosperity in a region. If the lower castes do better in terms of education, income, occupation then it depicts the socio-economic growth and development of that region.

Education level of surveyed households in Kheri Kalan reveals that one-fourth of the population is illiterate. Population which is literate but below primary is 13 percent only. The composite of primary, middle and secondary level shows 41.5 percent. Graduate and higher population are only 4.8 percent only. However, in Bishada the percentage of illiterate population is less than Kheri Kalan. It is 18.7 percent that means literacy in Bishada is higher than Kheri Kalan. Literate but below primary population shows 9.4 percent and the composite of primary, middle and secondary shows 49.5

percent which is half of the population. Graduate or higher education shows 8.8 percent. Overall, literacy rate is higher in Bishada i.e. 80 percent. Kheri Kalan has 73.2 percent people literate only.

But if we see education level in both villages with male and female composition, it shows that females are the more illiterate than males and the number of literate's females are less. In Kheri Kalan the literacy among females shows 30 percent whereas in Bishada it is 34 percent.

Table 6.5 Cross tabulation of level of education and Gender in Kheri Kalan and Bishada

Level of Education * Gender Cross tabulation (in numbers)						
Level of Education	**Kheri Kalan**		Total	**Bishada**		Total
	Male	Female		Male	Female	
Illiterate	75	99	174	57	73	130
literate but below Primary	45	44	89	30	35	65
primary	55	51	106	70	55	125
middle	53	28	81	67	58	125
secondary	59	37	96	59	35	94
higher secondary	61	34	95	54	33	87
graduate or higher	21	12	33	42	19	61
others	7	0	7	0	0	0
Total	376	305	681	379	308	687

(Source: Primary Survey, 2016-2017)

Additionally, if we see the cross-tabulation of gender and social groups, it shows that in Kheri Kalan, Jats are more educated than other caste groups. Similarly, in Bishada Rajputs are more literate than other caste groups as seen in Appendix Table no. 1 & 2.

Income shows the level of economic condition of a household. It plays an important role in deciding how poor or rich is the household. As depicted in the Table 6.4, more than 50 percent of household in Bishada and almost 50 percent in Kheri Kalan are below Rs.5000 of income. Between Rs.5000 to 10,000 income, most of the households are farmers and engaged in other occupation. It is 28.6 percent in Kheri Kalan and 34.1 percent in Bishada. Households which comes in the category of earning more than Rs 10,000 income are majority under government jobs or have own business or enterprise. One-fourth of the households found in this category in Kheri Kalan whereas only 11.2 percent found in Bishada. That means in terms of economic status of village Kheri Kalan is in better off condition but when we talk about the status of ecosystem services in both villages, it is found that Kheri Kalan is more vulnerable than Bishada as 50 percent of its agricultural land has been lost.

Land ownership also depicting the economic status and condition of a household. It is considering that owning land is an asset for sustainable livelihood because it acts as a backup for any household when the household comes under any pressure or shock by any reason. It not only provides better livelihood in rural areas but also helps in strengthens the situation of living condition. As shown in Table 6.4, almost in both villages 70 percent of households have land ownership and others 30 percent are landless.

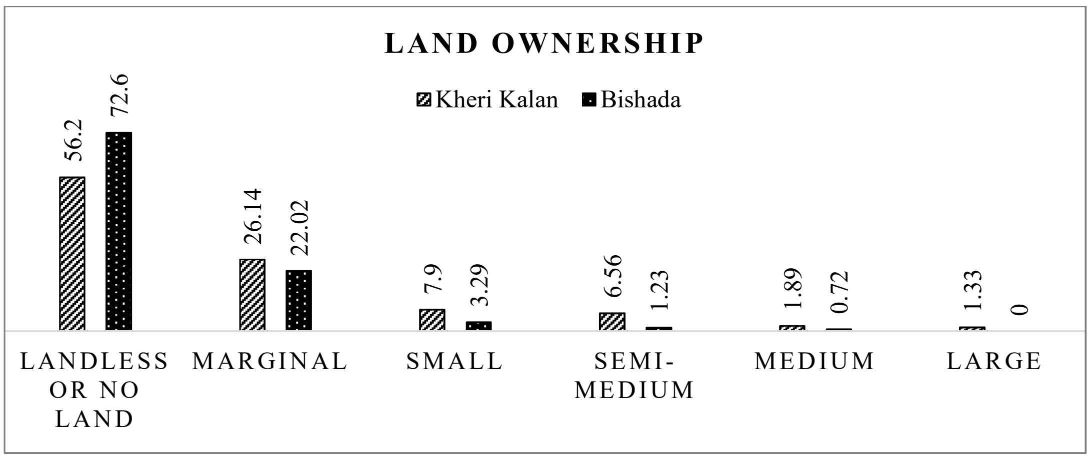


Figure 6.4 Land Ownership in Bishada and Kheri Kalan

(Source: Socio-Economic Caste Census, 2011)

But if we look at the whole scenario of village in terms of land ownership from the socio-economic caste census data analysis, it shows that 56.2 percent and 72.6 percent households are landless in Kheri Kalan and Bishada respectively. However, from the primary survey it is found that only 30 percent household are landless. This difference is possibly attributed to the selection of samples as it is only 10 percent of households from the total households of the village. But further, if we see landownership classification of households in these villages it is found that most of the farmers are marginal farmers (1 hectare or less). Percentage of large farmers (more than 10 hectares) are negligible in Bishada but found 1.3 percent of large farmers in Kheri Kalan.

6.6.4 Occupation structure and shift in occupation

Against the background of a similar resource base, Kheri Kalan and Bishada broadly display a comparable pattern of occupational structure, with a fairly eminent level of diversification. The prime occupation of the villagers is cultivation. According to primary survey results, though agriculture was the primary source of livelihood in both villages for almost all the households, the bulk of them were supplementing their agricultural livelihood through diversifying into various non-farm occupations and employment (Table 6.6).

In Kheri Kalan, 81.8 percent respondents were farmers by occupation, though only 10 percent were agricultural labourers and 9 percent engaged in other activity. As told by villagers that earlier all caste groups from the village basically dependent on agriculture for their source of livelihood but now they have been shifted to other occupational opportunities because of loss in the agricultural land. And another reason for quitting agriculture practice was that most of the farmers thinks that they could not fulfill the demands of their family just depending upon agriculture for livelihood so diversification of occupation is possible in the village. People are going to other sectors for earning more income and betterment of their lifestyles. Many of the villagers engaged in the private jobs in Faridabad city as a constructional labourers, domestic workers and few of them have government job.

Similarly, in Bishada 77.3 percent household respondents were farmers by occupation and 22.7 percent were engaged in other activities. But within farmers, there were some respondents who were engaged in both agriculture and other activities.

Table 6.6 Major Source of Livelihood of the Sample Households

Livelihood Sources	Kheri Kalan		Bishada	
	Number	Prop (%)	Number	Prop (%)
Cultivation	90	81.8	85	77.3
Livestock	55	50.0	79	71.8
Fishing	0	0	2	1.8
Agricultural Labour	11	10.0	8	7.3
Casual Labour	16	14.5	17	15.5
Gov. Service	11	10.0	8	7.3
Other	39	35.5	19	17.3

Source*:* Sample Survey of 110 households conducted in Kheri Kalan and Bishada, Dec-Feb 2016-17

Notes: Because of the multiple occupations pursued by the households, there is an overlap in the number of households under different sources of livelihood.

Since land is the major asset owned by all households, agriculture is the primary occupation of the households. In Kheri Kalan, as in Bishada, besides agriculture, the households supplement their livelihood through other means. About 50-70 percent households engaged in livestock with cultivation and about 15 to 35 percent households pursue various non-farm occupations both inside and outside the village, like artisians, contractor, business, government and private jobs.

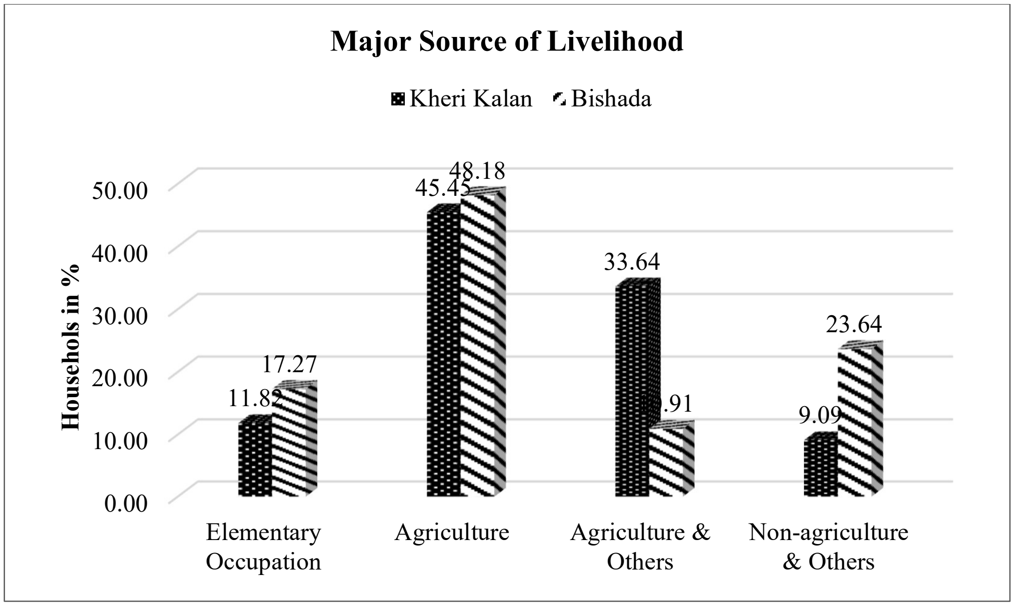


Figure 6.5 Major Source of Livelihood in Kheri Kalan and Bishada

6.6.4.1 Shift in Livelihood

The respondents from both villages revealed that there is diversification of livelihood largely due to distress conditions, arising out of degradation and decline of local ecosystem services crucial for livelihood of the households. The declining capacity of the local ecosystems, primarily consisting of land and water, coupled with increasing population pressure, has compelled households to look for external avenues to supplements their livelihoods. With the degradation or loss of agricultural land, the households have been deprived of another vital source of livelihood.

6.6.5 Provisioning Ecosystem Services

Food, water, wood, and other goods are some of the direct benefits people obtain from the ecosystem called **'provisioning services'**. These services have an economic value for the marketing purpose. However, in many regions, rural households also directly depend on provisioning services for their livelihoods. Kheri Kalan and Bishada, both villages are a case study of such example. Detailed analysis of these services in these two villages are discussed in this section.

6.6.5.1 Crop Production

A variety of crops are grown across the surveyed villages in Faridabad and Gautam Budh Nagar, either for home consumption, for sale or both. Before going into the results of primary survey, secondary village level data have been analysed in this section. Data that has been collected from the land revenue office of both villages for both districts (Faridabad and Gautam Budh Nagar) have shown the classification of agricultural land use with different crops grown which is given below in Table 6.7 and Table 6.8. This data has recorded by the village land record officer (Patwari) and recorded in Rabi and Kharif Girdawari (a government document that have records of the agricultural area under different crops in each season).

Kheri Kalan village shows that in Rabi season, main crop is wheat followed by vegetables, fodder crop, flowers and nursery. And in Kharif season, main crop is fodder followed by rice, vegetables, pulses, flowers, Bajra and Bagh.

Table 6.7 Season wise crops in Kheri Kalan, Faridabad, 2016

Rabi Crops	Area (ha)	Kharif Crops	Area (ha)
Wheat	421	Rice	29
Barsam	2	Fodder	271
Vegetables	5	Vegetables	27
Flowers	2	Arhar Dal	16
Nursery	1	Flowers	12
Bagh (Garden)	1	Bajra	6
		Bagh (Garden)	1

Source: Rabi and Kharif Girdawari (Gov.document) of Kheri kalan Village, 2016

Similarly, according to Rabi and Kharif Girdawari (2016), Bishada village shows that in Rabi season main crop is wheat followed by Jai (fodder crop), Barsam, vegetables and flowers. And in Kharif season, main crop is rice followed by vegetables, Jowar, Arhar and flowers.

Table 6.8 Season wise crops in Bishada, GT B Nagar, 2016

Rabi Crops	Area (ha)	Kharif Crops	Area (ha)
Wheat	302.68	Rice	313.46
Barsam	3.37	Jowar	18.46
Jai (fodder crop)	14.03	Arhar	10.31
Vegetables	2.48	Vegetables	27
Flowers	1.27	Flowers	3

Source: Rabi and Kharif Girdawari (Gov. document) of Bishada village, 2016

Overall, data on crops grown in both villages shows that area under cereal crops are highest in both villages in both seasons (Rabi and Kharif) but in Kheri Kalan the area under wheat production is more than Bishada village. Whereas area under rice production is more in Bishada village with compare to Kheri Kalan. However, according to the land record officer (Patwari) of both villages said that cropping pattern has been changed since past 10 years. Earlier farmers were used to grow sugarcane, maize but due to animal interferences they stopped growing these crops. Now they are shifted to growing more vegetables due to urban demand.

To know more about the cropping pattern and production of different crops in both villages the primary survey results are discussed below.

6.6.5.1.1 Cropping Pattern

Cropping pattern refers to the percentage of area under versatile crops at a given point of time. In countries like India, the cropping pattern adopts two distinct seasons i.e. Kharif from July to October and Rabi season from October to March. The crops growing between the period March to June comes under Zaid season. The crops are generally grown in three style i.e. single or mixed (in case of mixed-cropping) or in a certain sequence (in case of rotational cropping). Thus, the land may be engaged by single crop during one particular season or by two or more crops during that season (in case of double-cropping) which may be grown following a sequence in a year.

In surveyed villages of Faridabad and Gautam Budh Nagar, cropping pattern in rabi season shows that only wheat is produced by 38.2 percent farmers in Bishada and 29.1 percent farmers in Kheri Kalan which is main crop in this season and region. Wheat and Barsam are grown by 22.7 percent farmers in Bishada and 31.8 percent farmers in Kheri Kalan. Three crops grown mainly wheat, barsam and vegetables are grown by 3.6 and 5.5 percent farmers in Bishada and Kheri Kalan. The combination of more than three crops in rabi season are with wheat, barsam, vegetables and oil seeds. It shows only 5.5 percent grown by Bishada farmers and 10 percent grown by Kheri Kalan farmers. More than three crops grown by basically medium to large landholding size farmers in both villages. (see Table 6.9)

Table 6.9 Cropping pattern in Rabi Season

Crops	Bishada		Kheri Kalan	
	N	%	N	%
no crop	1	0.9	0	0
wheat	42	38.2	32	29.1
wheat and jowar	3	2.7	0	0
wheat and barsam	25	22.7	35	31.8
wheat and oil seed	2	1.8	1	0.9
wheat, barsam, veg	4	3.6	6	5.5
wheat, veg and oil seed	2	1.8	3	2.7
wheat, oil seed and barsam	2	1.8	1	0.9
wheat, barsam, veg and oil seed	6	5.5	11	10.0
not applicable/noland	23	20.9	21	19.1
Total	110	100	110	100

(Source: Primary Survey, 2016-2017)

In Kharif season main crops grown in both villages are rice, bajra, fodder crop, pulses, vegetables and jowar. Rice (16.8%) cultivation is highest in Bishada whereas bajra (15.5%) grown more in Kheri Kalan with compare to Bishada as single crop. More than one crop grown by mainly small or medium farmers. These crops are basically combination of creal crop and fodder crop. Fodder crop generally grown by those farmers who also do livestock farming. Sometimes fodder crops are sold to those cultivators who do not capable to grown fodder crop and have livestock at their home and then they have to buy fodder for them. In Kheri Kalan fodder crop and bajra combination is grown by 25.5 percent of farmers whereas in Bishada it is grown by 10.9 percent of farmers only. Rice, bajra, fodder, vegetables and pulses is grown by 1.8 percent of farmers in Bishada and 3.6 percent of farmers in Kheri Kalan (see Table 6.10).

Overall, kharif season in both villages, crop diversification is seen in both villages but more is seen Kheri Kalan village. It may be because the influence of peri-urban effect on this village is more with compare to Bishada. Therefore, the demand for the vegetables and other crops is more in Kheri Kalan.

Table 6.10 Cropping pattern in Kharif Season

Crops	Bishada		Kheri Kalan	
	N	%	N	%
no crop	1	0.9	3	2.7
rice	18	16.8	3	2.7
fodder crop	12	10.9	6	5.5
bajra	6	5.5	17	15.5
vegetables	1	0.9	1	0.9
Pulses	0	0	2	1.8
fodder crop and bajra	12	10.9	28	25.5
bajra and veg	3	2.7	2	1.8
fodder crop and pulses	0	0	1	0.9
fodder crop, bajra and veg	0	0	4	3.6
rice and jowar	12	10.9	0	0
rice and fodder crop	10	9.1	3	2.7
rice and bajra	1	0.9	7	6.4
rice and pulses	2	1.8	0	0
rice, fodder crop, bajra, veg	2	1.8	7	6.4
rice, fodder crop, veg, pulses	1	0.9	1	0.9
rice, fodder crop, pulses	3	2.7	0	0
rice, fodder crop, bajra, veg, pulses	2	1.8	4	3.6
rice, fodder crop, bajra, pulses	1	0.9	0	0
not applicable/no land	23	20.9	21	19.1
Total	110	100	110	100

(Source: Primary Survey, 2016-2017)

In Zaid season or mainly in summer, basically vegetables and some fruits are grown. These are mainly watermelon, muskmelon, cucumber and vegetables. 71 percent of farmers do not grow any crop in this season in both villages. Watermelon is grown by 2.7 percent and 3.6 percent of farmers in Bishada and Kheri Kalan respectively. 2.5 percent of farmers grow vegetables. (see Table 6.11).

Table 6.11 Cropping Pattern in Zaid Season

Crops	Bishada		Kheri Kalan	
	N	%	N	%
no crop	78	70.9	79	71.8
vegetables	2	1.8	3	2.7
watermelon	3	2.7	4	3.6
veg and watermelon	1	0.9	0	0
watermelon and cucumber	2	1.8	2	1.8
watermelon and vegetables	1	0.9	0	0
not applicable	23	20.9	22	20
Total	110	100	110	100

(Source: Primary Survey, 2016-2017)

In above table 6.11, not applicable means those households who do not have land and not practice agriculture.

The below table 6.12 shows crop that has been grown in past 10 years. Farmers are now stopped growing these crops. These crops mainly were maize and sugarcane. Few of respondents said that they have also stopped growing moong dal, peas, arhar, gram and flowers.

Table 6.12 Crop that has been grown in past 10 years

Crops	Bishada		Kheri Kalan	
	N	%	N	%
maize	6	5.5	4	3.6
moong	1	0.9	0	0
sugarcane	10	9.1	24	21.8
maize and sugarcane	1	0.9	0	0
spinach, floriculture	1	0.9	1	0.9
sugarcane and maize	1	0.9	8	7.2
Sugarcane, maize and peas	1	0.9	3	2.7
maize, peas, arhar	1	0.9	0	0
peas, maize and sugarcane	1	0.9	0	0
sugarcane, peas,pulses,gram	1	0.9	3	2.7
sugarcane, peas, cotton	1	0.9	2	1.8
matar, arhar, masor, gram	1	0.9	0	0
no crop	61	55.5	44	40
not applicable	23	20.9	21	19.1
Total	110	100	110	100

(Source: Primary Survey, 2016-2017)

6.6.5.1.2 Reason behind changing in crop preference

From the primary field survey, maximum respondents have told that due to animal interferences they have left the crop which they used to grown earlier. These cases among farmers are 17 from Kheri Kalan while 30 from Bishada village. Some respondents specially those who were small farmers said, they did not change the cropping pattern in their fields. 2 and 9 cases from the Kheri Kalan and Bishada village told that low productivity was also the issue for changing in their cropping pattern. Almost 6 percent farmers from both villages said that due to decline in output value of crop production they have shifted to grow those crops which generates more income in short duration such as these days' practice of horticulture is common in both villages.

Plate 6.3 Horticulture practicing over study area a) Kheri Kalan b) Bishada

6.6.5.1.3 Agriculture inputs

Farmers basically require land, labour and capital to carry out their farming activities. In this section, agricultural inputs and technologies employed by farmers in Kheri Kalan and Bishada are presented for crop producers. Some of the results are presented in Table 6.13.

Table 6.13 Agriculture Inputs Used

Inputs used	**Bishada (%)**	**Kheri Kalan (%)**
Proportion of crop cultivators	N=85	N=90
Use of fertilizer	99	95
Use of pesticides	99	87.7
Agricultural tools (possession)		
owned	11.5	19.1
Rented	85.3	77.8
Irrigation (water)		
Tube well	56.5	96.6
Canal	1.1	0.9
Both	43.5	2.4

(Source: Primary field survey, 2016-17)

Agriculture inputs required for crop production includes the use of variety of seeds, fertilizers, pesticides, use of manure, water for irrigation from different sources, use of labours, use of agricultural tools (tractor, tube well, thresher etc). Seeds which are used for cropping in both villages are generally high yield variety of seeds (HYV) followed by desi or traditional seeds. 90 percent of farmers used HYV seeds for both cereals crops and other crops such as vegetables, oil seeds, pulses etc. According to respondent cultivators, one acre of land requires 60 kg of wheat seeds and it costs Rs.1000 to 1200. Seed for rice cultivation require 5 to 6 kg of seed in one acre of land and it costs Rs.150-200. Farmers buy it from the either government shop or private shops.

Use of fertilizers enhances the production of crop output. With continuous cropping on the same land, the amount of nutrient available in the soil gradually decreases and it fails to sustain the crop growth. Fertilizer is one of the important external sources, generally used to maintain nutrients in the soil. It provides the essential nutrients, primarily nitrogen, phosphate and potash, needed by plants. Nowadays, almost all farmers used chemical fertilizers that includes mostly Urea and DAP. The consumption of these fertilizers has grown rapidly. Earlier farmers have used organic manures in their farms but today they consume more chemical fertilizers. According to some respondents from both villages, farmers said that they used 50 kg of DAP and 50 kg of Urea in 1 acre of land for wheat crop but for rice crop they have used double of it. From the Table 6.13 reveals that 99 percent cultivators in Bishada and 95 percent cultivators in Kheri Kalan used fertilizers.

In order to achieve the target related to crop production, protection of plants from diseases and pests is important. Plants diseases are caused by micro-organisms including fungi, bacteria, virus and micro-plasmas. Not only that, environmental causes like excess or lack of soil moisture, high or low temperatures, excess or deficiency of plant nutrients, poor aeration, soil alkalinity or acidity also are responsible for plant diseases. By applying various pesticides plant diseases can be contained to a certain extent. The choice of fungicidal compounds depends on the nature of the disease and on the susceptibility of the crop. In Kheri Kalan and Bishada village, respondents told that they have used 100 to 150 gram of pesticides in 1 acre of land for wheat crop which costs them Rs.200. For other crops they have used pesticides according to the crop requirement. Major source of fertilizer and pesticide is purchasing directly from the market (60%) and government shop (40%), whereas purchasing manure is relatively less common. Many cultivators in Bishada and Kheri Kalan use crop residues and /or animal refuses (if they have animals) for manuring, and some collect animal wastes from surrounding livestock keepers who do not actually cultivate crops.

Agricultural tools that required for cultivation are tractors for pulling or pushing agricultural machinery or trailers, for ploughing, tilling, disking, harrowing and planting, thresher for separating the seeds from the stalks and husks, fodder cutter, tube well for irrigation purpose and wage labour. Possession of own agricultural tools are less in numbers in both villages. It is 11.5 percent and 19.1 percent in Bishada and Kheri Kalan respectively. Generally, marginal and small farmers use agricultural equipment's on rent. It shows 85.3 percent in Bishada and 77.8 percent in Kheri Kalan.

For irrigation purpose, cultivators used tube wells, canal and both. In Bishada, a short part of linked ganga nahar or canal namely '*Mainkalda*' going through the village which have water in all seasons. Therefore, the use of canal for irrigation purpose is common in Bishada specially for those farmers whose farmland are nearby the canal areas. A number of small sub-stream or say 'nali' are connected to the main canal and goes to the fields which provides water for the distant farmlands. But the use of tube wells for irrigation is highest. It is 56.5 percent in Bishada. 43.5 percent of farmers have used both (tube well and canal) for irrigation purpose. However, in Kheri Kalan the use of tube wells is more frequent than canal because canal water is not regular in this village. It only receives water during the rainy season and remain dry almost all the year. The percentage of tube well for irrigation is 96.6 and the use of canal is just 0.9 percent. Overall, the increasing demand of vegetables to urban areas, farmers have now diversified their cropping pattern.

6.6.5.2 Livestock Services

Livestock farming is considered to be one of the very important sector especially for the socio-economic influence on rural areas and delivery of important ecosystem services of public interest as well. The domestic animals provide rural people with food in the shape of meat and milk. The animal wealth of our country had an intimate bearing on its agricultural development, health and economic prosperity of the nation. Livestock plays a major role in augmenting the family income and generating employment for the weaker section of the society. This sector provides ample opportunities of employment, especially for small and marginal farmers and act as a potential tool in alleviating rural poverty. Their waste products are also used as fuel and manures (GOI, 2014).

Table 6.14 Livestock and their Services

Livestock	**Bishada (N=110)**	**Kheri Kalan (N=110)**
Own livestock		
Yes	78 (70.9)	86 (78.2)
No	32 (29.1)	24 (21.81)
Cattle/Buffaloes	78 (70.9)	86 (78.2)
Goat	2 (1.8)	1 (0.9)
Poultry	1 (0.9)	0 (0.0)
Livestock services (proportion with own livestock households)		
Food	78 (100)	85 (98.8)
Fuel	75 (96.2)	81 (94.2)
Manure	75 (96.2)	81 (94.2)
Use of benefits (proportion with own livestock households)		
For domestic use only	66 (84.6)	76 (88.4)
For income generation	14 (17.9)	19 (22.1)
For both	7 (9.0)	8 (9.3)

(Source: Primary field survey, 2016-17)

As presented in Table 6.14 above, the study found that in Bishada mostly livestock were used for domestic use and in Kheri Kalan livestock used for dairy purpose along with self-consumption. 70.9 percent and 78.2 percent of households have livestock in Bishada and Kheri Kalan respectively. Among them more than 90 percent of household own cattles/Buffaloes at their home. Two cases found in Bishada which have goat in their home and one case found who do poultry farming. Livestock services are supplement to the household income as well as provide basic needs for daily requirement such as food, fuel and manure.

Plate 6.4 Livestock farming in surveyed villages

The use of benefits from livestock are supplement for the household income in both villages. Benefits from the livestock are milk, meat, wool, eggs, fuel, manure etc. Majority of the household uses its benefits for household consumption only because they do not get the surplus output from the benefits which they get. It accounts 84.6 percent in Bishada village and 88.4 percent in Kheri Kalan village. The domestic use of these services in both villages is high which means they depend upon on livestock services for livelihood. Around 20 percent household from surveyed villages shows that they used benefits from the livestock for income generation. Few of respondents who practice livestock farming said that when the benefits are consumed by family members and after that if it became surplus then they sell that products for making income and that resulted in the making household more secure in terms of making few savings from ecosystem services. That means dependency of ecosystem services in the rural communities are persistence with the increasing population, diversifying income sources, occupation etc. the importance of these services are still prevails in the villages.

But the problems regarding keeping livestock at villages is that these days they do not have the pasture lands or grazing lands in the villages as it all has been converted into the other land use purposes. Therefore, farmers have to grow fodder for them, buying supplements etc. and the ratio of keeping livestock in a household are now decreasing. If we see the scenario of keeping livestock and farmers landholding size and social groups, it reveals that in Bishada mostly Rajputs and Thakurs have livestock and from the Kheri Kalan, Jats have the majority of livestock.

6.6.5.3 Water Services

Ecosystem play a vital role in providing the flow and storage of fresh water. It is essential for all the living beings such as plants, animals and human beings. Crops are heavily dependent on fresh water as almost 60 percent of freshwater withdrawals go towards irrigation use.

In Bishada village two respondents used to practice fishing as their livelihood option. Apart from this they sometimes used to do water crop cultivation such as cultivation of water chestnut herb (Trapa bispinosa) in ponds. Its local name is '*Singara*' cultivation.

Box 6.1

Engagement with water ecosystem services and livelihoods: A case study of Satpal's family

The household of Satpal (about 56 years of age) in Bishada village is a typical case of how engagement with water ecosystem services can be survival strategy for one faced with a big family and not having any land to support the livelihood. Satpal's household consists of 12 members. His family do not have any land except residential land. He belongs to the Kashyap clan or also known as Dimar caste which is most backward caste within OBC (Other Backward Caste) and considered low in status in Uttar Pradesh. He used to practice fishing from past 20 years. And he said this is the only occupation on which his family surviving. Apart from fishing he sometimes cultivate water crops such as chestnuts or *singhara*. He is illiterate and he wants to give a good education to their children but due to the family burden and other pressures he was not able to give further education after higher secondary. Now his four sons who are working as labourers in agricultural fields also helping him in practicing fishing.

He mentioned that he got quite good amount of money when the production of fish is well. Satpal further mentioned that he has to take the permission for this contract from the Panchayat. For this he has to give some fixed amount on quarterly basis in a year. His family's main income source is dependent upon fishing activity only.

Plate 6.5 People involved in fishing practices at Bishada village

Apart from the direct services of the water ecosystem to human use such as for drinking purpose, sanitation, food production etc, it also helps in maintaining the disaster risk reduction, nutrient cycling, recreation and to fisheries. But as told by the villagers, decrease in the ground water level and quality nowadays become a problem. Earlier, in Bishada, they get the ground water at 50-60 feet but now it goes down to 120 feet but the area which is near the canal have water at 60-70 feet. Similarly, in Kheri Kalan, ground water level has gone down by 120 feet. Earlier it was 30-40 feet.

Similar findings have been found from both villages regarding ponds. The situation of ponds has been degraded except those ponds on which fishing is practising. Villagers said that ponds are now being degraded. All the village waste is going into it. There is no proper waste management system. Earlier ponds were also used by cattle's but now they are not of any use except polluting surrounding area.

a) b)

Plate 6.6 a) Domestic waste water & solids drained into the ponds ; b) Problem of eutrophication in ponds

Eutrophication is another problem in ponds which is increased by human activities. Eutrophication, is the enrichment of a water body with nutrients, usually with an excess amounts of nutrients. This process includes growth of plants and algae and dye to the biomass load, may result in oxygen depletion of the water body. It is induced by the discharge of phosphate-containing detergents, or sewage, into an aquatic system. It not only destroys aquatic living organisms it also impacted to livestock and human health.

Plate 6.7 Use of Public hand pump and tubewell

6.6.5.4 Agroforestry or agro-Sylviculture and Horticulture

Agro-Sylviculture is a usual practice in rural areas. It enhances the income source of farmers. From the surveyed villages it has been found that semi-medium to large farmer are engaged in agroforestry (Figure 6.6).

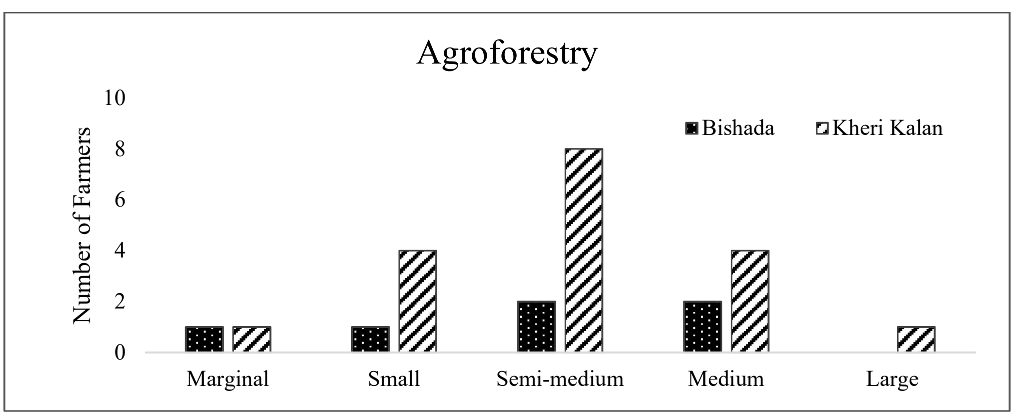


Figure 6.6 Practice of agro-forestry with land holding size of farmers

Villagers from Kheri Kalan are more engaged in agroforestry than Bishada. Mostly semi-medium to medium farmers are practicing agroforestry. It is around 16.4 percent in Kheri Kalan and 5.5 percent in Bishada.

Plate 6.8 Plantation of Eucalyptus trees for income generation in farms at Bishada village

Respondent from Kheri Kalan said that mostly semi-medium, large farmers and 'Mali'(Gardener) community are practicing horticulture and agroforestry. Large and medium farmers give their land on lease to a fixed price for one or two years or seasonally to these Malis for cultivating the crops. Because this community do not have land in the village as they are migrants from the Uttar Pradesh particularly from Bareily and Bulandshar. They cultivate almost all crops including cereals (wheat, rice, bajra), vegetables, flowers etc.

Plate 6.9 Planted Guava trees along with vegetable crops in Bishada Village

6.6.5.5 Common Property Resources (CPR)

CPR are categories as natural resources but its ownership rights and managing rights area hardly hold by individuals rather collectively dealt by a society or community. In the surveyed villages, identified common property resources are canal, ponds, and panchayat land. Panchayat land is used in the different forms such as for agricultural purpose, recreational purpose etc. In Bishada, respondents said that they are using CPR mostly for recreational purposes such as panchayat land for marriage purpose, celebrating festivals and other village engagements and public events. Similarly, in Kheri Kalan, respondents said that panchayat give land on lease for cultivation to farmers but there is a separate panchayat land for Harijans around 2-4 acres. Same other uses of panchayat land are for social-cultural events.

6.6.6 Impact on Livelihood: Household income and livelihood strategies

In this section, results for the contribution of provisioning ecosystem services, dependences on farming, income variations and distributions among farmer households, and livelihood strategies of peri-urban residents are presented in detail across household groups of different source of income from Kheri Kalan and Bishada village.

6.6.6.1 People dependency on ES's- livelihood strategies of the locals in the village

I. *Contribution of Ecosystem Services for income generation*

People in Bishada and Kheri Kalan make their livelihood strategies from different primary (directly depend on ES) and non-primary based activities. As shown in Figure 6.7 around 93.6 percent of households in Bishada and 80 percent of households in Kheri Kalan are fully to partially depend upon primary activity (crop production, livestock production, or both, agroforestry and fishing) for income generation. Among them around 40 percent are fully dependent on ecosystem services. Around 6.4 and 20 percent of households are fully engaged in non-primary activity.

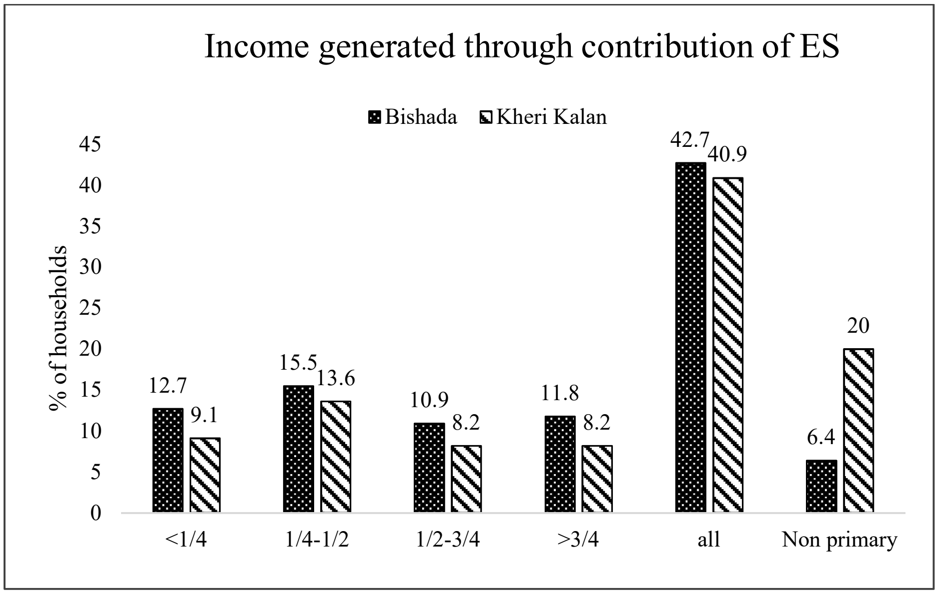


Figure 6.7 Income generated through contribution of ES in Bishada and Kheri Kalan

II. Income Sources of provisioning ES

The largest share of ES was drive from the both crop production and livestock production. It is 73 percent in Kheri Kalan and 68 percent in Bishada. No cultivation denotes to the income generated from non-primary activity. It is 12 percent in Kheri Kalan and 17 percent in Bishada.

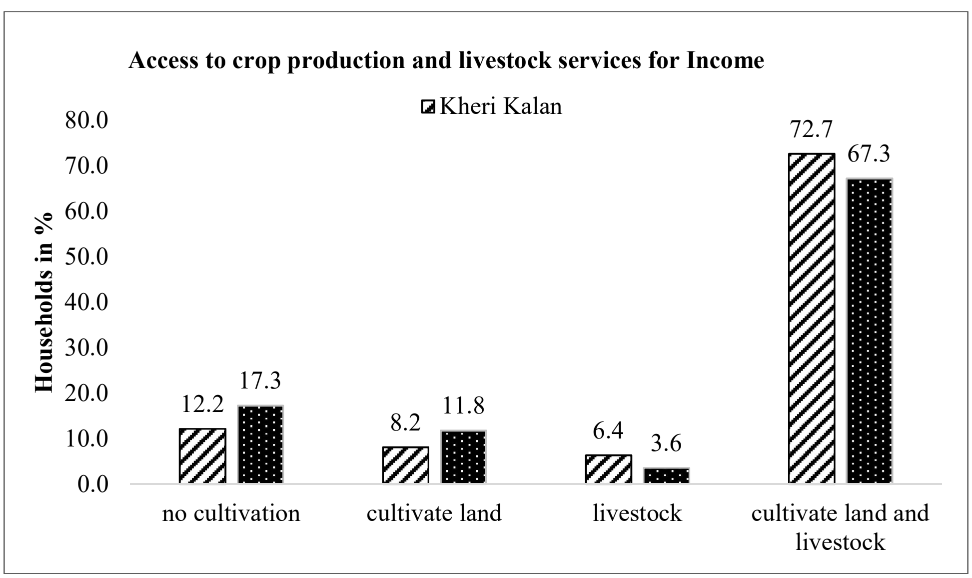


Figure 6.8 Access to crop production and livestock services for Income in Kheri Kalan and Bishada

The share of income generated through production of fishing was very low. It was 1.8 percent in Bishada only.

6.6.7 Sustainable Livelihood Framework

Department for International Development (DFID, 1999) provides sustainable livelihood framework from where the approach to understand the current livelihood base has been adopted. Here livelihood bases deal with the notion through which households pursue a living; also called as capitals. Thus, livelihood bases have been identified as all those human or non-human resources, i.e. financial, physical, natural, etc. through which households generate their livelihood.

Access to livelihood capitals plays a vital role for the households to cope with and adapt to shocks. For example, in the case of the land owning households, when they suffer reduced access to land owning to land acquisition interventions through government and private developers, the monetary compensation that they receive adds to their existing financial capital. Financial capital is easily transformable and may be invested in purchase of any of the other assets and in the process it enables the household to build up a new set of asset portfolio and resultant activity portfolio that may maintain the welfare aspect of the household. Similarly, when invested in human capital, it builds on future prospects of absorption within the high return non-farm economy further strengthening future livelihoods. However, for the tenant cultivators, loss of access to land does not entail any financial compensation. So, for the latter, loss of access to natural capital gets translated into series of deterioration of asset endowments eventually resulting in destabilization of the livelihood system of the tenant households. The latter may rely upon his social capital for assistance which may not be able to ensure a secure livelihood. It is therefore probable that inspite of loss of access to land the land owning households will continue to remain in the trajectories of sustainable livelihoods while the tenant households will suffer deterioration of livelihoods.

6.6.7.1 Livelihood Capital pentagon based on livelihood strategy

The livelihood capital polygon best explains the composition and structure of household livelihood capital. The centre of pentagon represents a 0 value, while the external boundary (vertex) shows a maximum value of some capital. The ideal livelihood capital polygon is regular polygon, namely balanced and coordinated development of various types of livelihood capitals. Figure 6.9 & 6.10 shows the different livelihood capitals with livelihood strategies. The brief discussion of livelihood capital based livelihood strategy is presented given below for both villages i.e. Kheri Kalan in Faridabad and Bishada in Gautam Budh Nagar.

I. Kheri Kalan village

The livelihood capital assessment of Kheri Kalan with livelihood strategy shows that human capital is high in people engaged in both agriculture and other livelihood strategies followed by non-agriculture, agriculture and elementary occupation. That means people who engaged in petty occupations such as casual labourers, agriculture labourers, sweepers, domestic helpers etc. have not access to human capital. In case of natural capital, again people who involve in elementary occupation are deprive of land holding, own water access assets at their home etc. and also they belong to socially deprived communities whereas livelihood strategy with agriculture, and agriculture & others have high natural capital. Households who involved in non-agricultural activities shows that they have somewhat access to natural capital assets. Physical capital found very high in both agriculture and agriculture & other livelihood strategy with compare to non-agriculture and elementary occupation. As found from the field observations in Kheri Kalan village indicates that most of the farmers who have land and have second source of livelihood have almost all the physical assets including livestock. However, social capital found satisfactory in elementary occupation livelihood strategy with compare to non-agriculture strategy. It denotes involvement with the membership of government or non-government schemes or organisations.

Table 6.15 Livelihood assets and Livelihood strategy in Kheri Kalan

Kheri Kalan village	**Livelihood strategies**			
Livelihood Capital	Elementary Occupation	Agriculture	Agriculture & Others	Non-agriculture
Human Capital	0.24	0.30	0.40	0.34
Natural Capital	0.00	0.53	0.58	0.35
Physical Capital	0.16	0.50	0.55	0.40
Social Capital	0.35	0.71	0.50	0.20
Financial Capital	0.00	0.14	0.49	0.10
Ecosystem Services	0.34	0.44	0.42	0.28
Livelihood Capital Index	1.09	2.62	2.94	1.67

(Source: Authors computation)

Financial capital was found nil in elementary occupations that means they do not have access to loan facility and other support from other source of livelihood. Whereas financial capital was found high among agriculture and other livelihood strategy. The important aspect with involvement of different livelihood strategies in relation to ecosystem services represents the highest access by agriculture followed by agriculture & other and elementary occupation. It shows that the benefits that derive from ecosystem services are benefiting most to the farmers of the village this may be attributed to the land and livestock ownership with farmers but in case of elementary occupations, they are getting benefits from the provisioning ecosystem services in the form of fuelwood for cooking, water for drinking and domestic purpose etc. They are fully dependent on these services as they do not own it but access through ecosystem as benefit.

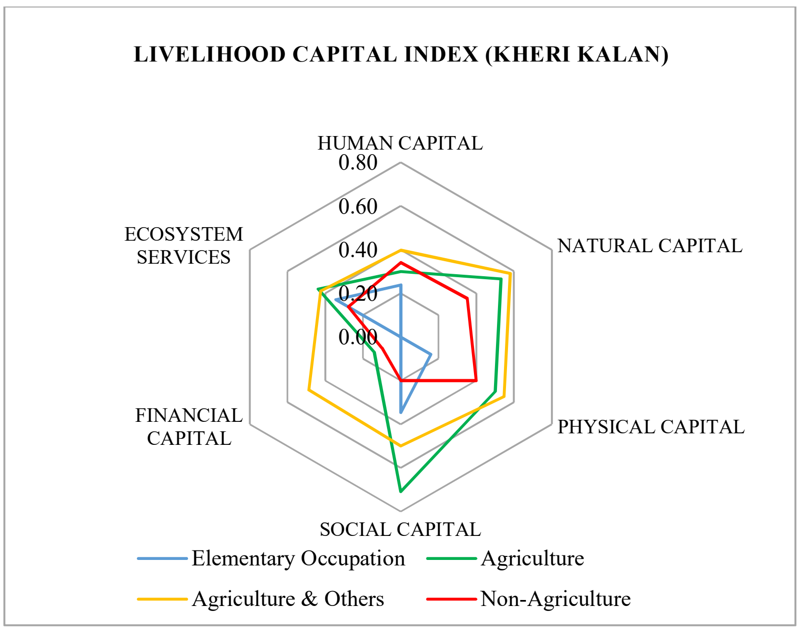


Figure 6.9 Livelihood Capital Index of Kheri Kalan

II. Bishada village

The livelihood assessment of the Bishada village in Gautam Budh Nagar, U.P, shows a very positive sign as all types of capitals were found high in livelihood strategy of agriculture and others with compare to other strategies. The lowest and negative pentagon were found in elementary occupations that signifies lack of all capitals as well access to ecosystem services. Livelihood capital pentagon of agriculture & others strategy shows high social capital assets with compare to others. It means they are in a better off condition with compare to other livelihood strategy when any shock and stress comes.

Table 6.16 Livelihood asset and Livelihood strategy in Bishada

Bishada village	**Livelihood Strategies**			
Livelihood Capitals	Elementary Occupation	Agriculture	Agriculture & Others	Non-agriculture
Human Capital	0.29	0.32	0.36	0.34
Natural Capital	0.24	0.56	0.56	0.55
Physical Capital	0.19	0.44	0.48	0.35
Social Capital	0.50	0.65	0.75	0.54
Financial Capital	0.18	0.30	0.50	0.46
Ecosystem Services	0.33	0.47	0.47	0.34
Livelihood Capital Index	1.74	2.75	3.11	2.59

(Source: Authors computation)

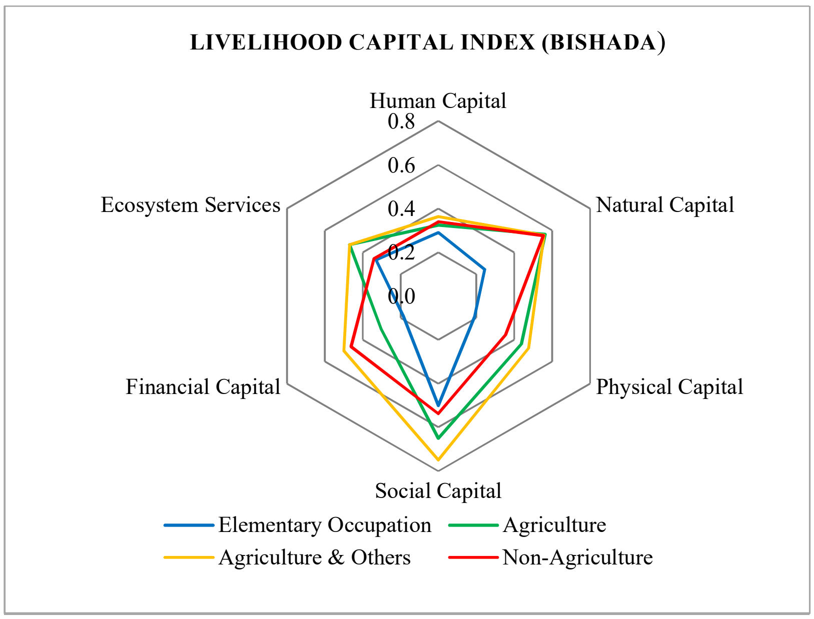


Figure 6.10 Livelihood Capital Index of Bishada

However, in the case of access to ecosystem services, the highest value was received by both agriculture and agriculture &others. It may be associated with the high number of livestock, crop production and water services were found with the farmers. Whereas households who were engaged in elementary occupations were the actual dependent on ecosystem services for getting basic requirements such as fuelwood for cooking, dung cakes as fuel, water for drinking and domestic purpose etc.

6.6.7.2 Livelihood capital index for Kheri Kalan and Bishada

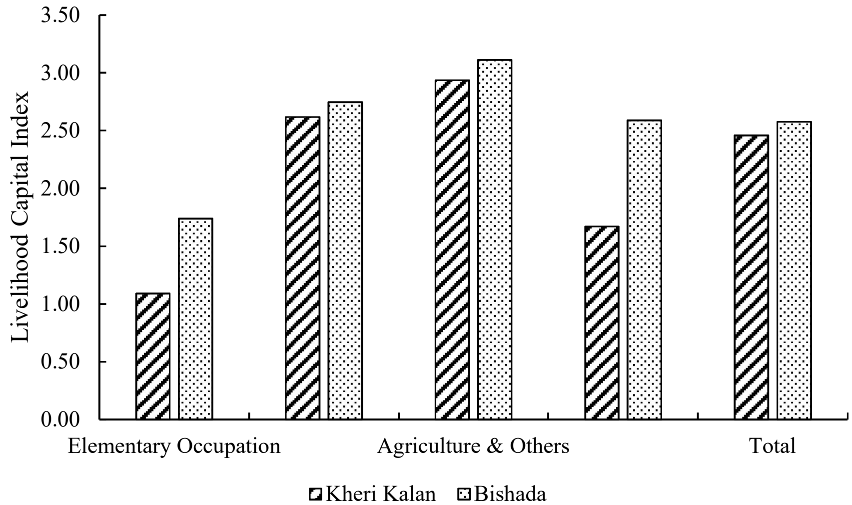


Figure 6.11 Livelihood capital index for Kheri Kalan and Bishada

The livelihood capital index of different livelihood strategies is 2.458 in Kheri Kalan and 2.575 in Bishada (Table 6.15 & 6.16). It's very clear that there is a difference among the livelihood indexes of heterogeneous households in both villages. Agriculture & Others livelihood strategy have greater livelihood capital index i.e. 2.94 value in Kheri Kalan and 3.11 value in Bishada, followed by Agriculture, Non-agriculture and Elementary Occupation in both villages. However, Bishada shows high livelihood capital index in all livelihood strategies with compare to Kheri Kalan. But the marginalised community i.e. engaged in elementary occupation such as wage labourers are showing very low livelihood capital index in both Kheri Kalan and Bishada.

In addition, human capital is low among all livelihood strategies. Natural capital and physical capital is high among those who are working in agriculture and connected activities but Kheri Kalan reported high value than Bishada villages in both capitals. Ecosystem services shows, marginal change on each livelihood categories but it is high in Bishada with compare to Kheri Kalan village.

6.6.7.3 Relationship between Livelihood Strategy and Livelihood Capital

The Pearson correlation coefficients have been used to calculate the indices of the major types of livelihood capital to verify the applicability of the model and analyze relationship among them. Table 6.17 shows significant positive correlation among human capital, natural capital, physical capital and social capital in Kheri Kalan. Negative correlation has found among social capital, human capital and financial capital.

Table 6.17 The correlation coefficients between different livelihood capitals in Kheri Kalan

Kheri Kalan	*Human Capital*	*Natural Capital*	*Physical Capital*	*Social Capital*	*Financial Capital*	*Ecosystem Services*
Human Capital	1					
Natural Capital	0.307**	1				
Physical Capital	0.300**	0.722**	1			
Social Capital	-0.215*	0.258**	0.135	1		
Financial Capital	0.356**	0.220*	0.162	-0.059	1	
Ecosystem Services	0.147	0.061	0.130	0.225*	0.212*	1

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

Table 6.18 The correlation coefficients between different livelihood capitals in Bishada

Bishada	*Human Capital*	*Natural Capital*	*Physical Capital*	*Social Capital*	*Financial Capital*	*Ecosystem Services*
Human Capital	1					
Natural Capital	0.234*	1				
Physical Capital	0.312**	0.729**	1			
Social Capital	0.337**	0.154	0.277**	1		
Financial Capital	0.455**	0.262**	0.264**	-0.010	1	
Ecosystem Services	0.055	0.175	0.532**	0.290**	0.072	1

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

Similarly, in Bishada, significant positive correlation has been found among human capital, physical capital, social capital and financial capital. Negative correlation found between social capital and financial capital.

To understand the determinants of livelihood strategy with livelihood capitals, livelihood strategies were divided into three types i.e. income generated from on-farm, off-farm and both (On-farm and Off-farm). For this multiple linear regression analysis has been done for both villages.

6.6.7.3.1 Regression Analysis

Table 6.19 Regression analysis for On-Farm income (Livelihood strategy: Agriculture)and Livelihood Capitals

VILLAGE	KHERI KALAN, (R. Square .423)					BISHADA, (R. Square value .296)				
	Livelihood Strategy: Agriculture									
LIVELIHOOD CAPITALS	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	-.300	.177		-1.690	.094	-.501	.201		-2.490	.014
Human Capital	-.312	.289	-.095	-1.078	.284	.020	.336	.006	.061	.952
Natural Capital	.602*	.225	.311	2.672	.009	.582*	.318	.240	1.831	.070
Physical Capital	-.150	.239	-.069	-.629	.531	.064	.503	.020	.127	.899
Social Capital	.362**	.127	.245	2.857	.005	-.038	.178	-.020	-.212	.832
Financial Capital	-.856***	.164	-.429	-5.214	.000	-.339**	.150	-.219	-2.257	.026
Ecosystem Services	1.593***	.403	.320	3.952	.000	1.920***	.481	.434	3.992	.000

Dependent Variable: On-farm income; ***significance level: 0.01%; **significance level: 0.05%; significance level: 0.10%

Table 6.20 Regression analysis for Off-Farm income (Livelihood strategy: Non-Agriculture & Others) and Livelihood Capitals

VILLAGE	KHERI KALAN, (R. Square .672)					BISHADA, (R. Square value .421)				
	Livelihood Strategy: Non-Agriculture & Others									
LIVELIHOOD CAPITALS	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	1.326	.109		12.149	.000	1.586	.180		8.822	.000
Human Capital	.311*	.178	.116	1.744	.084	.210	.300	.066	.700	.486
Natural Capital	-.899***	.139	-.569	-6.477	.000	-.339	.284	-.142	-1.194	.235
Physical Capital	.063	.147	.036	.431	.667	-.607*	.449	-.192	-1.353	.179
Social Capital	-.208*	.078	-.172	-2.665	.009	-.173	.159	-.093	-1.085	.280
Financial Capital	-.408***	.101	-.250	-4.029	.000	.149	.134	.098	1.110	.270
Ecosystem Services	-1.517***	.248	-.373	-6.108	.000	-1.902***	.429	-.437	-4.431	.000

Dependent Variable: Off-farm income, ***significance level: 0.01%; **significance level: 0.05%; significance level: 0.10%

Table 6.21 Regression analysis for both On-Farm & Off-Farm income (Livelihood strategy: Agriculture & Others) and Livelihood Capitals

VILLAGE	KHERI KALAN, (R. Square .547)					BISHADA, (R. Square value .101)				
	Livelihood Strategy: Agriculture & Others									
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
LIVELIHOOD CAPITALS	B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	-.027	.149		-.179	.859	-.084	.142		-.592	.555
Human Capital	.001	.243	.000	.004	.997	-.230	.237	-.114	-.972	.333
Natural Capital	.297*	.189	.162	1.567	.120	-.243	.224	-.161	-1.085	.280
Physical Capital	.087	.201	.042	.432	.667	.543	.354	.271	1.532	.129
Social Capital	-.154	.106	-.110	-1.445	.151	.210*	.126	.178	1.674	.097
Financial Capital	1.264***	.138	.668	9.149	.000	.190*	.106	.197	1.796	.076
Ecosystem Services	-.077	.339	-.016	-.226	.822	-.018	.339	-.007	-.054	.957

Dependent Variable: Both (On and Off-farm income), ***significance level: 0.01%; **significance level: 0.05%; significance level: 0.10%

Regression analysis of livelihood capitals effect on livelihood strategies shows that, there is significant positive regression coefficient of natural capital and ecosystem services on On-farm income, which suggests a positive influence of these independent variables on farm-income in Kheri Kalan. Similarly, in Bishada village, there is significant positive regression coefficient of these two independent variables i.e. natural capital and ecosystem services on On-farm income. That means they are the determinants factors of the farm-income. On contrary, farm-income has significant negative regression coefficient with financial capital in both Kheri Kalan and Bishada village which illustrates, financial capital is negatively affected on farm income. This is because occupational diversification, is not found among farmers who totally dependent on farm based income therefore they are negatively regressed.

In second scenario of off-farm income as a dependent variable and livelihood capitals as an independent variable, multiple linear regression shows that, significant negative regression coefficient at 0.01% level significance is found in natural capital, financial capital and ecosystem services in Kheri Kalan whereas only ecosystem services show significant negative regression coefficient in Bishada. That reveals that there is a higher probability of going in off-farm activities in Kheri Kalan than Bishada. On contrary, positive regression coefficient significant at 0.10% level found in human capital and social capital only. It explains that when human and social capital is high then there is higher probability of going in off-farm activities. But this is contradicting with the elementary occupational livelihood scenario, as their human capital is very low (as earlier discussed in livelihood pentagon scenario) so that they were only engaged in working as wage labourers, domestic helpers etc. but it is true that when the human capital is high then people are more likely to go in off-farm livelihood option.

In third scenario, income generated from both livelihood strategy i.e. on-farm and off-farm income as dependent variable and livelihood capitals as independent variables, there is positive regression coefficient at 0.01 % level of significance in financial capital only and 0.10% level of significance found in natural capital in Kheri Kalan village whereas in Bishada, financial and social capital that includes government loans and support, shows positive regression coefficient at 0.10 % level of significance with livelihood strategy.

Overall, results from multiple linear regression shows that natural capital and ecosystem services are significant determinants of on-farm income; human capital is significant determinant of off-farm income; and financial and social capital as well ecosystem services are significant determinants of both on-farm & off-farm income. The analysis of variance (ANOVA) results of all three models for both villages reveal the significance of the fitted models. Further, the R^2 values of 0.423, 0.672, and 0.547 for all three models in Kheri Kalan and R^2 values of 0.296, 0.421and 0.101 for all three models in Bishada reveal that the models are able to explain a fairly effecting factor of livelihood strategy are livelihood capitals.

In nutshell, primary survey results explained the transformation of occupation structure from primary to other occupations. However, still ecosystem services have developed livelihood strategies in rural areas to support the farmers in both villages which includes small scale agriculture, domestic consumption of cash crops in local scale, consumption of milk, agroforestry etc. To make ES sustainable in these regions there is need to incorporate policy intervention at village level to keep ecosystem and livelihood secure.

With this background, the next chapter will be focusing on the study of policy interventions in these areas to fill the gaps into introduced urban development policies and further, highlights the challenges and suggestions for the study.

Chapter-7

POLICY INTERFERENCES

7.1 Introduction

This chapter investigate the complex interaction of formal policies of government, its implications and processes responsible for the transformation in peri-urban areas in two villages of NCR Kheri Kalan of Faridabad and Bishada of Gautam Budh Nagar in relation to ecosystem services and livelihood security. In these villages the population is dependent on the ecosystem services for their basic needs but with the expansion of the urban activities on the fringes there is a shift in livelihood pattern. Due to the rapid urbanisation on the rural fringes there is a split between rural and urban boundaries evolved as one of the major challenge for government that how to sustain the quality of environment in these areas.

As these two selected peripheral villages are a part of NCR regional plans but there is a negligence of peri-urban areas in consideration of the policy implementation and planning. Hence there is a need to incorporate rethinking of city regularities planning with emphases environment and livelihood options.

This study has to better understand peri-urban ecosystem services and relationship with livelihood. This would generate knowledge and could further help to generate more effective regional development plan initiative (rural & urban). It reflects potential to build synergies occurs rural urban continuum and need to bring initiatives that could address the issues of livelihood vulnerabilities with those focusing on the environment as the integral part of urban/regional development planning.

7.2 Rural-Urban Development Policies

India is a welfare state since independence and the primary objective of the government are the welfare of its people. The policies and programs have formulated with the aim of alleviation of poverty, enhance employment opportunities and decrease inequality to providing a better quality of life. Removal of poverty was the foremost objective of the *Sixth Five-Year Plan* (1980-85) by strengthening the infrastructure for both agriculture and industry as well as tackling interrelated problems through a systematic approach.

7.2.1 Jawahar Rozgar Yojana

During *Seventh Five-Year Plan* (1985-90) special program *Jawahar Rozgar Yojana* was launched in April 1989 by merging existing programs with the major objective to reduce unemployment and poverty.

7.2.2 Kisan Credit Card

Kisan Credit Card (KCC) Scheme a flagship scheme launched by the government in 1998 for farmers to provide short term loans and agriculture need during the cropping season. KCC was brought into focus to meet the comprehensive credit requirement of the agricultural sector through financial support to farmers with the participation of institutions like commercial banks, regional rural banks, and co-operative banks.

7.2.3 Jawaharlal Nehru National Urban Renewal Mission (JNNURM)

A key program for urban poor with the name *Jawaharlal Nehru National Urban Renewal Mission* (JNNURM) was launched in 2005; a reform driven program to ensure long term vision for planned development of cities. JNNURM, an integrated infrastructure development program with the major focus of projects for slum free India, water supply, sewage treatment, drainage sectors and transport sectors.

7.2.4 Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)

An ambitious program of government, *Mahatma Gandhi National Rural Employment Guarantee Act* (MGNREGA) launched in 2005 for poverty alleviation by providing guaranteeing 100 days' wage employment with the major aim to enhancing livelihood security for unskilled manual work. This is a right based approach dedicated to rural unemployed with the provision of unemployment compensation wages.

7.2.5 National Horticulture Mission

National Horticulture Mission (2005-06) is a subsumed mission of Integrated Development of Horticulture to promote holistic growth of horticulture sector based on region specific strategies. Other important objectives of the mission are enhancing production, doubling farmer income and strengthening nutritional security by helping to provide farm level productivity, technological support as well as improving water use efficiency.

7.2.6 National Rural Livelihood Mission (NRLM)

National Rural Livelihood Mission (NRLM) (2011) a major initiative for poverty alleviation implemented by Ministry of Rural Development focused on promoting self-help group and organisation of rural poor. The poor households were aimed to be supported by providing self-employment and skilled wage employment opportunities with the involvement of self-help groups to improve their livelihood on sustainable basis especially for women households. One of the major purposes of NRLM is to increase women participation in self-employmentin the community as well as village level.

7.2.7 National Urban Livelihood Mission (NULM)

National Urban Livelihood Mission (NULM) is a major flagship program of government in 12^{th} five-year plan with the focus on organising urban poor as well as creating opportunities for skill development in relation to market based employment by helping to set a self-help venture. NULM also promote the partnership of private sector to provide skill training, employment including shelter to urban homeless who also contribute towards sustaining the cities with their cheap labour.

7.2.8 Urban Infrastructure Development Program

Ministry of Urban Development is implementing a pilot scheme of *Urban Infrastructure Development Program* in satellite towns around seven mega cities with the main objective to reduce the pressure on mega cities by channelizing their future growth.

7.2.9 Swachh Bharat Mission

A key program *Swachh Bharat Mission* launched in October 2014 with the purpose to 100% scientific management of solid liquid waste in rural and urban India. This is not only a program but a campaign for attitudinal change and awareness. Implementation of the program is guided by a participatory approach to create an enabling environment for private and community participation as well with the relevant government departments and entities.

7.2.10 Smart Cities Mission

The *Smart Cities Mission* was launched in 2015 based on the idea of the development of entire urban ecosystem on the principle of complete and integrated planning. The major focus was on sustainable and inclusive development to promote core infrastructure and give a decent quality of life. A major component of core infrastructure includes adequate water supply, solid waste management, efficient urban mobility, public transport, and sustainable environment.

7.2.11 Shyama Prasad Mukherji Rurban Mission (SPMRM)

A large part of rural areas of country stands of the cluster of settlements are relatively proximate to each other illustrate the potential of growth. Once these cluster developed can be classified 'RURBAN', the government of India proposed *Shyama Prasad Mukherji Rurban Mission* (SPMRM) in 2016 with the aim to develop rural areas to provide economic, social and physical infrastructure facilities. SPMRM follows the development of cluster in villages to preserve the life of the rural community with a focus on equity and inclusiveness to stimulate rural cluster development essentially urban in nature creating 'Rurban' villages.

7.2.12 Below Poverty Line (BPL) card scheme

Below Poverty Line (BPL) card scheme was launched to eliminate ghost beneficiary and identification the real beneficiary by local bodies like gram panchayat and gram sabha. BPL card is issued in the name of household, make allow him /her to avail the few necessity items at a subsidised rate from the public distribution shops.

7.3 Significance of the Rural-Urban Policy Initiatives in Relation to SDGs

Poverty eradication is one of the major concern and largest challenge before the world. Most of the Asian and African countries are facing extreme poverty conditions resulted in hunger, malnourishment, illiteracy, health problems etc. A large part of the population is still struggling for the most basic human needs. The *Sustainable Development Goals* (SDG) is a bold commitment towards poverty eradication by targeting the most vulnerable group of the population to make accessibility of basic resources and service to improve the quality of life and supporting communities affected by conflicts.

The present study emphasised on the poverty alleviation and environmental concerns with the respect of ecosystem services. SDG goal number first and seven states 'to end poverty in all its forms and dimension by 2030' and 'Environment Sustainability' respectively. Present time India is also facing many related problems on a large scale like poverty, inequality, and environmental problems and also trying hard to remove through implementing many policies and programs. To turn these programs into actions the SDGs will guide with the ways for the policy implementation with a clear vision within the time frame.

7.4 Policy Inferences based on study Area

Urban area recognised as the engines of inclusive economic growth. Urbanisation is a rapidly growing phenomenon at present time in many developing countries in the world including India. Urbanisation in India, after independence, gave the rise of the private sector in the country. India is a large country in terms of area; this vastness gives a reason for the development of many urban centers throughout the country. National Capital Region (NCR) is one of the most important regions of the country experiencing urbanisation at very fast rate especially after new economic reforms during 1991.The study area which consists two villages named Kheri Kalan of Faridabad (Haryana) and Bishada of Gautam Budh Nagar (Uttar Pradesh) of NCR.

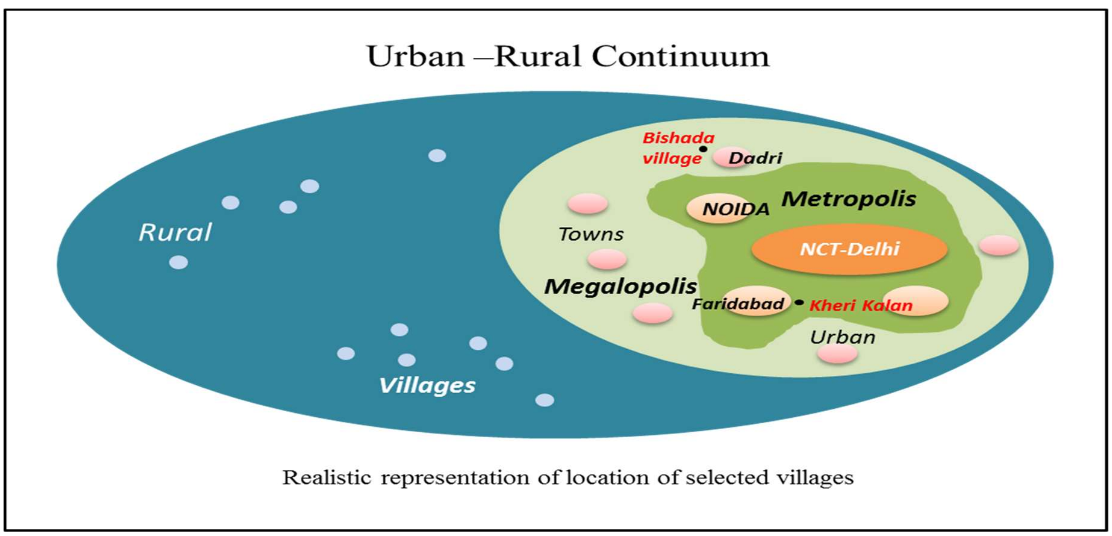


Figure 7.1 Location of selected villages in Urban-Rural Continuum

Within the rural urban continuum of NCR, village Kheri Kalan located on the periphery of million plus city Faridabad while village Bishada located on the periphery of class I town Dadri (one lakh population and above). As this study area is the part of NCR megalopolis

As these villages are located in the fringe area of the mentioned districts, therefore the overall ecosystem is very disturbed due to urban expansion and peri-urban activities on the outer belt of the villages. Many developmental activities like real estate, development of road network lead to loss of fertile agricultural land as well as changes in the livelihood pattern of the people. A large number of government policies and programs also implemented in the area but it is not enough to sustain the livelihood security of the people as well as poverty.

Plate 7.1 Conversion of agriculture land into built-up land

In the case of environmental conditions which are also badly affected by such activities and deteriorate the ecosystem services like fisheries, livestock, water services, and crop production etc. The loss of ecosystem services in terms of conversion of fertile land into waste land leads to decrease the quality of land, depletion of groundwater, polluted surface water bodies results in unfortunate consequences in thelivelihoodof the people, health, and education of the people. To consider these types of problems in the area the Government started many policies which provide compensation and support to enhance the quality of their life as well as to search for other livelihood option.

7.4.1 Analysis of policy and its implementation regarding study area

The overall condition of the study area observed through the field survey that both the villages benefited through some of the important policies and programs initiated by the government in the NCR. Those policies somehow bring some positive impacts and prosperity in the villages as well as enhance livelihood options for the people such as **horticulture, apiculture, fishing, dairying activities** resulting into enhancing the quality of life and secure their livelihood. In 1983, one of the most important initiatives of government by establishing ***NTPC*** plant in Bishada village which provides employment to the villagers and also brings prosperity in the region.

Plate 7.2 Horticulture, fishing practices and dairying activities as a livelihood options in a village

As per the flagship program of Indian government started in 2005 by the name ***Bharat Nirman*** focused on infrastructure development in rural areas, resulting a lot of positive changes such as the development of **canal network, increase rural connectivity** with the major urban center of the village. These infrastructural activities provide employment to villagers under *Mahatma Gandhi National Rural Employment Guarantee Act* **(MNREGA).** The total number of worker benefitted under MNREGA in Bishada village is 580 and in Kheri Kalan is 75 (Ministry of Rural Development). MNREGA is a demand driven program, therefore, women are also get benefitted through it and get an opportunity to participate in labour work force which leads to their financial independence and security. 35% women workers in Bishada village and 41% in Kheri Kalan engaged under MNREGA, provide an opportunity to combat poverty as well as make them empowering.

Plate 7.3 Development of Roads and Canal in Kheri Kalan & Bishada Village

In NCR the village Kheri Kalan of Faridabad experienced more urban features in comparison to village Bishada (UP). A number of peri-urban activities such as land converted into the built-up area, plots and development of highways on the fringes of village resulting changes in the occupational structure of the people which leads to the development of **social infrastructure** like school, medical college, banking facilities etc. On the other hand, the number of people engaged in agricultural activities is high in Bishada due to well-developed canal network as well as the good availability of groundwater resource, therefore, a large number of the population engaged in the agricultural activities. Peri-urban activities also experiencing in this village but the rate of urbanisation is slow in different features such as a bank, electric sub-station, small industrial units, farm houses but the engagement of private developers is less. Social infrastructure development is also limited.

Plate 7.4 Private School at Kheri Kalan whereas only one government school in Bishada village showing developmental gap

Both villages come under **KCC** scheme for the **BPL** farmers to provide short term loans as well as to ensure their participation in the financial system of the country guided by the concept of **financial inclusion**. The main purpose of KCC is to purchase fertilizer, seeds and other inputs with the security of crop insurance. As per the survey of SECC 2011 number of KCC issued in Bishada village is 99 to small and marginal farmers which are quite low in Kheri Kalan (only 2).

In the case of ecosystem services both the villages are very much dependent on it but the dependency of Bishada is higher on ecosystem services. Most of the activities such **as crop residue** used as fodder for livestock, agriculture, and practice of **agro forestry** practiced in the village provide an alternate way to secure their livelihood. On the other hand, the dependency on ecosystem services of villagers in Kheri Kalan is much diversified because of more impact of urban expansion and occupational structure of the people is shifting from agricultural to non-agricultural activities such as **livestock, small entrepreneurs** on the farm land etc.

Kheri Kalan village experienced many conversions into urban phenomena in the western side of the village from agricultural to non-agricultural uses and remaining area continues increasing and rest of agricultural land is contracting. This increasing pressure on the ecosystem resulting depletion of ecosystem services in the village by degrading the quality both of land and water. If this trend will be same in the future most of the chances that this agricultural land may disappear in the future. On the other hand, the high dependency on ecosystem services in Bishada village is also generating pressure on the ecosystem services. In both the villages, peri-urban agriculture plays a vital role in sustaining livelihood and food security of the people. On the basis of this study can be concluding that the ecosystem services in both villages are under high pressure in the different ways.

Plate 7.5 a) crop residue used for fodder for livestock, b) Farmers in Bishada growing spinach crop

7.5 Issues and Challenges

In the study area, on one side a lot of positives changes have experienced regarding developmental activities as well as livelihood security of the people but on the other hand, some of the issues and challenges are there which can be categorized into challenges regarding policy implementation and challenges regarding the attitude of the people. In both circumstances, the quality of life as well as quality, and availability of resources is degrading. The same conditions are also observed in the case of the study area which clears that there are also some of the important gaps in the policy implementation which can be discussed under following heads.

7.5.1 Lack of regional approach and comprehensive management

One of the important aspect of policy in terms of implementation is lack of regional approach and comprehensive management in the implementation of the government policies resulting many loopholes, as the requirements can be changed in the region according to the as per its conditions. Therefore, policies should be region specific so that impact of policy implementation may be up to the mark, like in both the villages, the population dependence on the ecosystem services is much higher in Bishada village, therefore, the focus on the environment should be high in this village so that it can make sure both livelihood security and environmental sustainability. On the other hand, urban expansion is high in Kheri Kalan, therefore, the focus should be high on the peri-urban activities like agriculture and livestock so that it can reduce the pressure on the environment.

7.5.2 Absence of District Development Plan

No District Developmental **Plans** as per 73 and 74 Constitutional Amendment Act has been prepared in NCR (NCR Regional plan 2021-Rural Development). According to the policy makers that the adjoining districts of NCR come under the developmental plans which framed for NCR and there is no any specific developmental program has been prepared for those districts, even socio economic conditions and environmental requirements are totally different.

7.5.3 Problem of Land Acquisition

The problem of land acquisition is also affecting villagers' livelihood; India is a country where the land holding size is already very small. The agricultural land of the people has acquired for the developmental plan like road network and railway line, the establishment of NTPC and real estate without proper compensation and sometimes there is no compensation is due to corrupt practices of the officials. Hence people lost their land without finding the alternate source.

7.5.4 Shortage of Basic Services

Those rural settlements which are close to NCR are undergoing rapid physical and socio-economic changes further resulting haphazard development leads shortage of basic essential services such as water supply, sanitation, and decreasing enormous pressure on the ecosystem and its services. Establishment of NTPC on one side provides employment opportunity to the people but on the other hand also responsible for the environmental degradation and also increase the pressure on the ecosystem services, water, and land degradation due to absence or waste management practices and waste recycling system. Construction activities are also responsible for increasing vulnerability of the existing ecosystem services.

7.5.5 Unawareness among Villagers

Lack of awareness and knowledge among the people regarding sanitation practices as well as the environment is another important reason for the concern. It can clearly say that population does not engage themselves in the sanitation related activities may be they dependent on the government. A lot of dumping sites are open along the roads. Streets in the villages are full of water throughout the year further resulting in many health problems. This large numbers of health problems leads to the loss of working hours of the people again resulting poverty which generates avicious cycle of poverty.

Plate 7.6 Open dumping sites along the roads and sanitation issues

7.5.7 Poor Waste Management Practices

Water pollution, poor solid, and liquid waste management are some of the most important concerns of the area. Groundwater and surface water both are highly polluted which further resulting aquifer pollution. The area alongside the main canal in the Bishada is experiencing infertile user land due to alkalinity and salinity of the soil. If this expansion would not be controlled, then the situation can be worse in the future and there are high chances that groundwater aquifer can be highly polluted which is the main source of drinking may affect with the heavy metals like arsenic and fluoride.

7.6 The Way Forward

Agriculture is a primary sector and major activity as the majority of the population of the country depends on it. Therefore, this is the most important concern any type of negative impact on agriculture in the form of loss of fertile land due to encroachment and conversion of fertile land into waste land leads a decrease in both production and productivity which further result into the problem of livelihood security of people as well as food security problem. In order to meet SDG goal number one to make the country free from hunger and malnourishment, the sustainable agriculture is the most important measure and SDG goal number seven environment sustainability.

7.6.1 Integrated Planning

Integrated planning of urban development plans and environmental policies should be integrated with the major consideration of sustainability of ecosystem and livelihood of the people. Most of the master plans in the metropolitan cities did not include agriculture as a separate category of land use while it recognises agricultural land as a green belt which is not aright prediction of the land. Therefore, any plan regarding development in NCT or even any urban area agricultural land should be marked as a separate category in both formal and informal.

7.6.2 Region Specific Policies

The developmental policies of the government should be region specific according to the requirement of that area in terms of the need of the existing population and environment. Programs should be implemented with the consideration of reduction of disparity by supporting employment and economic activities. In the study area, both the villages have some differences. Therefore, the policy implementation should target for the villages and adjoining peri-urban area.

7.6.3 Community Participation

The participation of community and decision making in the development process is one of the most important measures to improve the overall condition of the village. The communities should work together with local government through monitoring and ensure for environmental protection measures. To make people aware of the monitoring of environment and sanitation practices role of Anganwadi and self-help group can play an important role.

7.6.4 Conservation of resources

There should be the proper conservation of existing resources such as fertile agriculture, groundwater, and surface resources are should be conserved and promote sustainable use. Because the degradation of these resources results in adevere impact on the life of people in long term. Waste water released by domestic use and other activities can be used for the agricultural purpose to conserve the water. To improve the quality of land and water should promote organic farming in the internal part of the village, crop diversification instead of monoculture, use sustainable new methods of irrigation to conserve water, and promote peri-urban agriculture in on the fringes of the villages. Apart from this, promotion of agro-forestry and horticulture can generate a good alternate source of livelihood as well as promote environmental sustainability.

7.6.5 Priorities based programs

The focus should be targeted on the basis of priorities such as the expansion of urban area on the fringes can be the cause of damaging of local ecosystem and livelihood. Therefore, development should be prioritized according to the requirement. In both the villages of the studyarea, the first priority should be environmental sustainability followed by livelihood security to make them self-empowered and improve the quality of their life.

7.6.6 Vulnerability mapping

Vulnerability mapping for the ecosystem services and poverty affected area will help to determine the priorities and provide information for the suitable policy and planning. To prepare the mapping and monitoring of the area community participation can play an important role.

7.6.7 Land as a Resource

The land is the essential resource for all the economic and developmental activities for both survival and prosperity of humanity. In the rural areas, most of the population is highly dependent on land through many primary activities such agricultural production, fodder, livestock etc. Therefore, the sustainability and maintenance of land become necessary due to increasing demand of land. In the case of the study area, most of the land hasbecome waste which cannot be used for any purpose but on the other hand pressure on existing agricultural land continues increasing further resulting declining crop production and degradation of both land quality and quantity.

7.6.8 Promote Women Participation

Another important aspect of the social and economic development is women participation in the different areas like wage employment through MGNREGA, promotion of self-employment and women entrepreneurs with the engagement of self-help groups through Anganwadicenters. Here this is necessary to make them aware of their empowerment as well as financial assistance schemes to promote women participation in all the economic activities. This is further providing not only an alternate source of livelihood in the villages but also make women economically empower. Women entrepreneurship can help to maintain and sustain the ecosystem services in villages.

7.6.9 Follow Guideline

Ministry of Environment, Forest, and Climate Change, the Environmental Protection Act 1986 states that prohibition of following activities in NCR such as location of any industry including expansion and modernisation, all new mining operation and liner project development in protected areas like wild life sanctuary, national parks and tiger reserves, deforestation, electrification laying new transmission line, construction of any cluster including road and real estate in the outer belt of villages etc. These guidelines were not followed in NCR, generating over pressure which leads degradation of the ecosystem. To sustain long term quality of ecosystem one of the important measure that the implementation of the policies should be under the framework of the guidelines.

7.6.10 Private participation

Engagement of private sectors should be promoted and motivated those to get involved in the developmental and planning process of the region so that it can enhance the competitiveness as well as the quality of services provided further helping to bridge inequality.

7.6.11 Restructuring and re-visioning of policies

The existing programs focusing on development should be restructured and reformed to increase the efficacy of the policies instead to implement a new one. Introduction of new policies will create a multiplicity of the policies and reduced its efficiency.

7.6.12 Policies for peri-urban areas

There is no any policy focusing particularly on the peri-urban areas in the country. In the present era urbanisation as well as urban expansion on the fringes of rural area is increasing very fast, this disturbed the total ecosystem of the rural areas. Especially peri-urban agriculture activities which plays very important role to secure the livelihood source and ecosystem services for the people. Present policies regarding urban development experienced complete neglect of prei-urban agriculture. Hence there should be an aspect of peri-urban agriculture as the important component of the developmental polices on which large population dependent on their basic needs.

All these measures and its effective implementation will help to achieve the SDGs, before this the *Millennium Development Goals* initiated by UN signed by India during 2000 with the target of 2015. These goals could not be completed only because of the absence of implementing in a sustainable way. Now to achieve the MDG replaced by SDG set the target by 2030, which can be achieving only through the policy implementation in the sustainably and effectively. In the study area, the poverty conditions have improved a little bit but this is not up to the mark, flagship programs like MGNREGA and KCC were not implementing in the transparent manner which faces the problem like delayed in wages and ghost beneficiary.

This study is focusing SDGs one and seven to eliminate poverty in all its form by 2030 and sustainability of environmental respectively. To achieve these targets, it's necessary to ensure the effective policy implementation, as well as work, should be on grassroots level, here local and municipal government have great opportunity to conserve and protect both rural and urban areas and enhance the efficacy of the resources, ecosystem services and impact of urbanisation over it and help towards to conserve and sustain SDG in the long run.

Chapter-8

SUMMARY AND CONCLUSION

8.1 Summary

This study has made an attempt to approach the impact of ecosystem serives on livelihoods in the National Capital Region from the view point of sustainability of human life. While recognising the fact that the effect of urbanisation may be high around the pheripherial zone of NCT-Delhi as compared to the other regions of NCR, such effect, nonetheless is crucial to the region's sustainable environment and livelihood aspect and needs special attention.

The Natural Capital Region has vast endowments of ecosystem services like soil and water, favourable for crop production, which makes agriculture the chief livelihood option of the people in this region. Due to such immense importance being given to agroecosystems it seems worthwhile to make study of the changing land use land cover and ecosystem services senario ever since the concept of National Capital Region come into being. Along with ecosystem services the urbanisation trend has been viewed to see if the growth in later exerts any influence over the former.

The region has experienced a rapid urban growth in which Delhi contributed substantially. Apart from being India's Capital, Delhi happens to be the nucleus of intellectual actvity in technology and management and has great potential for industrial development. These factors attract lot of migrants which added to the already huge population base, create high population growth rate and expansion towards its peripheries which further influence the distribution of ecosystem services. It is with this background the conclusion derived from the present study has been summed up in the following text systematically as per objective scheme, followed in the present study.

Objective 1: To understand the process of urban growth in NCR and exploring its effects on ecosystem services, chapter 3 comes out with some findings and conclusion given below:

For fulfilling objective one, chapter 3 is a study of urbanisation and their process and pattern in Natioanal Capital Region. It also attemped to study the urban growth effects on ecosystem services. Therefore this chapter was divided into two sections. First with the study of urban growth, process and pattern from 1991 to 2011 in the NCR. And another section deals with the effects of urbanisation on ecosystem services in NCR.

Urbanisation in NCR is taking place at a very fast rate. It has been found that the level of urbanisation in NCR is 62.5% in 2011 which has been increased from 56% in 2001 and it was 50.31% in 1991 that means from 1991 to 2011 there is a 12 % growth rate in urban population. According to the census 2011 in whole NCR, Uttar Pradesh sub-region shows higest urbanisation (48.3%) followed by Haryana (43.1%) and rajasthan sub-region (17.18%). The district wise analysis of level of urbanisation shows that Faridabad is the most urbanised district from 1991 to 2011. In 2011 Faridabad is 79.44% urbanised followed by Gurugram (68.42%), Ghazizbad (7.46%) and Gautam Budh Nagar distict of UP (59.56%). And at tehsil level, urbanisation was highest in Gurugram tehsil (93.1%) followed by faridabad tehsil (89.9%), Ghazizbad tehsil(89.12%), Dadri tehsil (70.54%) and Merrut tehsil (69.45%). The lowest level of urbanisation at tehsil level found in the Kishangarh bas tehsil of Alwar and nuh tehsil of Mewat. Decadal urban population growth rate in NCR pertains that in Haryana sub-region , Gurugram (182.5%) has highest urban population growth rate and in Uttar Pradesh sub-region , Gautam Budh Nagar has highest growth rate (93%). The analysis of concentration of urban population shows the densification of population in a region which is found highest in Faridabad distict followed by Gurugram, Ghaziabad and Gautam Budh Nagar in 2011.

To understanding the urban growth process in NCR, the region divided into core and rings. Core was identified based on location of old and new Central Business District (CBD) in Delhi, Ring 1 was identified as remaining districts of NCT-Delhi, Ring 2 was identified with the help of buffer of 50 kilometers from the core NCT-Delhi and has been treated as Central National Capital Region or Delhi Metropolitian Area, and finally Ring 3 was identified as the remaining part of the NCR apar from Ring 1 & Ring 2 which more or less rural character. Landsat imageries has been used for identifying expansion in urban buit up area. Built up area expansion has been confirmed in NCR from 1991 to 2011. It showed that buit up area density was highest at core and sprwaling has been confirmed in rings which is taking NCR in suburbanisation process. The process of urbanisation in different regions of NCR resulting in the different forms and parrten of urban expansion. It gone through different stages of urban phenonmena, first densification of the core region after independece, second spreading of urban sttelements towards its pheriphery due to the decentralization policy of NCRPB which confirms starting of the suburbanisation stage and yet it prevails to some regions and thrid, according to Jain et. al 2013 NCR will most likely to skip counterurbanisation stage and go directly to reurbanisation due to prevalent deficient infrastructure environment and institutional capacity in the NCR.

In the second section, an attempt has been made to assess the impact of urbanisation on ecosystem services in NCR. For this assessment firstly with the help of land use land cover maps, different ecosystems were identified then further with the help of Costanza et al. 2014 methodology, different ecosystem services were identified. The analysis of this section also based on core and rings. Land use land cover analysis showed decline in agricultural land and an increase in built up area as a whole. In assessment of ecosystem services, it shows that there is a loss in food production services (which is mainly depended on cropland). It was decreased by $359.5 million from 1991 to 2011. Although cropland is the largest land use category in NCR but the decreasing rate of cropland ecosystem (including fallow land) from 1991 to 2011 is 2.18 percent per year which is highest loss among other land use category. At core, Ring1, Ring 2 & Ring 3 the rate of change in ecosystem services value from 1991 to 2011 was $ 0.18 million per year, $0.22 million per year, $ 0.05 million per year & $ 0.06 million per year respectively. As in whole region of NCR, the rate of decline in ecosystem services value from 1991 to 2011 was $ 0.03 million per year. The influence of land use change on indvidual ecosystem functions indicated the decline in the food production services was maximum followed by genetic resources, soil formation, water supply, waste treatment, raw materials, habitat/refugia, erosion control, biological control, and gas regulation. On the other hand, contribution of recreation, climate regulation, disturbance regulation, water regulation and nutrient cycling functions has increased from 1991 to 2011 in NCR.

Over all, due to urbanisation and land transformation from agricultural land to non-agricultural land resulted into the intensification of agriculture in NCR. Cropping intensisty has increased in NCR which positively resulted in high crop yields but its negative consequenses impacting the ecosystem in other ways such as degradation of soil nutrients, water contamination, eurthofication of river and lakes, increased erosion, and reduced biodiversity (Maston et al 1997; Nagendra et al. 2014; Sharma et al. 2016).

Objective 2: To assess the loss of provisioning ecosystem services, chapter 4 comes out with following findings given below:

This chapter is an assessment of loss of provisioning ecosystem services mainly focused on food and further an assessment of water also been analyzed. For doing this, InVEST model has been used for assessment of crop production and water yield modeling in the National Capital Region. The modeling part of the study is significant for the purpose to enables decision makers to assess quantified trade-offs associated with alternative management choices and to identified the areas where investment in natural capital can enhance human development and conservation.

Crop yield model shows increase in crop yield in tons per hectare in various parts of NCR that includes Ghaziabad, Faridabad, Meerut, Gautam Budh Nagar, Baghpat, Panipat, Sonipat etc from 2002-03 to 2011-12. However, production of sugarcane has declined whereas production of wheat has increased, followed by mustard crop, millets and rice crop. The output results from the model indicates that percentage of total cost, total revenue and total returns in production of sugarcane crop is decreased which further indicating, possible change in the cropping pattern in NCR. Further, the validation of this model has been compared with the Directorate of Economics & Statistics (DES) crop production data which reveals high degree of association between InVEST derived crop production values and DES crop production values. The analysis of variance results showed, InVEST crop production values explains that the computed R^2 value 0.76 is significant at 0.01 significance level which infers the suitability of InVEST model with the DES data and shows reliability for predicting future scenario of the region for evaluating ecosystem services.

Water yield model based on InVEST depicts that water yield has increased at many regions of NCR namely Alwar, Bulandshar, Gautam Budh Nagar, Ghaziabad and Faridabad that shows high level of water yield per pixel as compare to other regions of NCR. The total volume of water yield has increased from 1578919885.11 m^3 to 1736219072.20 m^3 in all the watersheds in NCR from 2001 to 2011. Watershed based results showed increase in the water yield in Yamuna river watershed from 46.52 mm in 2001 to 63.44 mm in 2011 that may be attributed to the increase in impervious surface in the Yamuna watershed region. Further, pixel based results showed relative increase in minimum water yield from 0.1 million m3 in 2001 to 1.2 million m^3 in 2011 at watershed level. Whereas maximum water yield varies from 310 million m^3 in 2011 to 282 million m^3 in 2001. This could be attributed to the changes in LULC and possible increase in surface run-off. However, there were limitations in quality as well as the availability of input data.

Both models illustrate that land use and land cover change is a possible driving factor for increase in both, crop yield and water yield. Overall, we can say that water yield and crop yield calculation and mapping are of great importance to water and land resource planning and management.

Objective 3: To study the impacts of loss in ecosystem services on livelihoods, chapter 5 & 6 come out with following results:

National Capital Region is urbanising very fast with expansion of its urban settlements. Land use and land cover analysis of Faridabad and Gautam Budh Nagar districts indicating the reduction in the agricultural land and expansion of the urban settlements to its peripheries. High urbanisation growth rate has been detected in Gautam Budh Nagar district whereas Faridabad showing slowed down in this process. The establishment of urban industries at the Noida, Greater Noida and Faridabad regions attracts the huge masses for the getting numerous facilities and employment. In Gautam Budh Nagar district, Noida and Greater Noida are urbanising very fast due to availability of different means of earning livelihoods. Noida is emerged as an industrial centre of this region which attracts huge masses due to availability of various necessary facilities such as educational facilities, shopping complexes, utilities and services, other recreational services along with employment.

For analysis of impacts of loss in ecosystem services on livelihoods, socio-economic profile of the Kheri Kalan village reveals that most of the households with land are got engaged into the other occupation other than cultivation due to reduction in the agricultural land whereas in Bishada village, cultivators are mostly landless but still they are practicing agriculture for their livelihood option that further elaborating dependency on ecosystem services were higher in Bishada village. The pooper class have been found more in the elementary occupation category from both villages which showing the high level of socio-economic vulnerabilities to these communities. On the other hand, high level of socio-economic vulnerability also found in the farming category of Bishada village.

ES has developed livelihood strategy to support the farmers in the Bishada and Kheri Kalan, which includes small scale agriculture, in terms of growing food crops (wheat, rice, bajra, pulses and vegetables etc) with the aim to use it as domestic consumption as well as sale of cash crops (spinach, potatoes, cauliflower, etc) in local scale. Not only that, the excess milk from domestic cattle is sold and thus become important source of another income. Fish, caught from ponds in Bishada are sold to Mandi. Groundwater is the only source of domestic water and used as drinking purposes as well; most of the households have submersible. Mostly irrigation source is tube wells, but existence of canal in Bishada provide some relief to farmers but in Kheri Kalan dependency on groundwater source is maximum. Agro forestry is considered to be an important strategy especially when it uses traditional tree species in the above mentioned villages which includes localized planting in-between private plots. Soil erosion and resulted fertility decline are the key issues there, along with increasing dependency on manure as a fertilizer caused by increase in prices of commercial fertilizers. Various cultural services are widely common in both villages, along with the connection of indigenous trees with recreational uses and thus traditional cultures. Thus, aesthetic values nonetheless prefer ordered farmland, rather than 'natural' landscapes.

As cited by respondents in Bishada and Kheri Kalan village, the critical livelihood linkages has been identified there in terms of population increase, caused by natural growth rates and influx from surrounding areas as well which has in turn resulted into issues related to land scarcity as well as diminishing plot sizes; water level gone down in wetlands caused by siltation and over abstractions; food insecurity and in general water scarcity for domestic purposes and livestock. On the other hand, poor transportation facilities in the study area have favored far-flung reliance on middlemen thus low retail value of crops which has been identified as key facet to poor livelihoods.

Objective 4: To examine the urban policy gaps and suggestions, chapter 7 comes out with following results:

The present objective would provide an explicit illustration of rural urban continuum development policies in relation to ecosystem services, livelihood security and peri-urban area development. Evidence from the study that there is impact of lot of developmental activities in the study area in terms of infrastructural development which somehow make secure the livelihood of the people as well as to provide alternate options for livelihood. But in case of policy implementation there is minimal interaction with environmental sustainability and limited empowerment of local bodies and their participation in the development process and decision making resulting failure of policies.

In the review of existing measures of the government for the development of NCR are mainly responsible for the transformation in overall as well as peri-urban agriculture practice and provide one of the major source to access to affordable and nutritious produces for peri-urban, urban and rural population. Therefore, there is an urgent need to integrate the developmental and environmental policies as well as to engage the local residents, which would help to develop an agro ecological way by merging traditional and technological methods.

8.2 Conclusion

Urbanisation and land change are interrelated however it's difficult to interpret different processes on ground regarding immediate consequences. This study can be concluding with the change in land use and land cover in urban fringes are the development linked sustainability challenges, leading to loss of ecosystem services and further impacted the productivity capacity (via intensification and land degradation) of ecosystem. It has also impacted the socio-ecological sustainability and livelihood security in the studied region and thus exacerbating existing social and economic vulnerability.

8.3 Suggestions

This study has suggested numerous opportunities to integrate planning for productive landscape into peri-urban region planning:

- ✓ Resilient city system including peri-urban areas want be built without resilient communities to rely directly or indirectly on ecosystem services. This neglect of peri-urban environment is impacting on food production and livelihoods of peri-urban vulnerable communities.
- ✓ PES (Paying for Ecosystem Services) approach should be adopted for farmers to attain multiple goals of amplifying the farm incomes, which could further decrease rural-urban migration, and also reduce burden on urban infrastructure.

Moreover, at the same time, it provides sustainable livelihood options to the farmers. (Devi et al., 2017).

- ✓ There is need to incorporate rethinking of the city planning with consideration of environment and reemphasis on the perspective of livelihoods.
- ✓ There is also need to incorporate direct interventions to support peri-urban ecosystem services which involve peri-urban communities in environmental monitoring.
- ✓ Engagement of private sectors should be promoted and motivated those to get involved in the developmental and planning process of the region so that it can enhance the competitiveness as well as the quality of services provided further helping to bridge inequality.
- ✓ Vulnerability mapping for the ecosystem services and poverty affected area will help to determine the priorities and provide information for the suitable policy and planning. To prepare the mapping and monitoring of the area community participation can play an important role.
- ✓ Integrated planning of urban development plans and environmental policies should be integrated with the major consideration of sustainability of ecosystem and livelihood of the people.

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