

## **Land Transformation on the Northern Periphery of Planned City of Chandigarh: A Study Based on Remote Sensing and GIS Technology**

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### **Abstract**

“Land is the basic natural resources... it is perhaps regarded as a resource base rather than a resource itself” (Mather: 1986). It is infinite and fixed in place and most of the needs of humanity for food, clothing, shelter and energy come from the land (Davis: 1976). Only 29% of the earth’s total area is under land while the rest 71% is under water. Thus the percentage of fertile and productive lands, which are habitable and provide basic needs of human beings, is comparatively very small. Therefore, every inch of these lands has great importance for all of us. Land transformation is one of the most important fields of human induced environmental conversion, with an extensive history dating back to antiquity (Wolman: 1987). Since Neolithic times, the modification of the earth by human action mainly involved impacts on the soil and biotic resources. Land transformation did not abate but, rather, accelerated and diversified with the onset of the Industrial Revolution, the globalization of the world economy and the expansion of population and technological capacity. Forests were cleared, grasslands plowed or grazed, wetlands drained and crop lands and settlements expanded, yet never as rapidly as in the last few years. Almost all of the world’s lands are now used and managed, albeit in widely varying degrees of intensity (Richards: 1990). In the present paper the land transformation process have been studied in the northern periphery of the planned city of Chandigarh. Its objective is to study the land transformation process and to investigate the factors responsible for it. The satellite based remotely sensed data is used to generate the information about the land use patterns in the GIS environment of the past and the present, which is then verified through the field surveys to reach a desired level of accuracy. The study indicated the trend of the land transformation in two phases, phase one indicated the transformation of the forest land and vacant or marginal land into the agricultural land and slow growth rate of the settlements and the phase two registered high growth rate of settlements and transformation of the land from agricultural to non-agricultural or built-up land.

### **INTRODUCTION**

“Land is the basic natural resources... it is perhaps regarded as a resource base rather than a resource itself” (Mather: 1986). It is infinite and fixed in place and most of the needs of humanity for food, clothing, shelter and energy come from the land (Davis: 1976). Only 29% of the earth’s total area is under land while the rest 71% is under water. Thus the percentage of fertile and productive lands, which are habitable and provide basic needs of human beings, is comparatively very small. Therefore, every inch of these lands has great importance for all of us.

Land transformation is one of the most important fields of human induced environmental transformation, with an extensive history dating back to antiquity (Wolman: 1987). Since Neolithic times, the modification of the earth by human action mainly involved impacts on the soil and biotic resources. Land transformation did not

abate but, rather, accelerated and diversified with the onset of the Industrial Revolution, the globalization of the world economy and the expansion of population and technological capacity. Forests were cleared, grasslands plowed or grazed, wetlands drained and crop lands and settlements expanded, yet never as rapidly as in the last few years. Almost all of the world's lands are now used and managed, albeit in widely varying degrees of intensity (Richards: 1990).

Settlement refers to the occupation of land for human living space. As land cover, settlement represents the most profound human alteration of the natural environment through the imposition of structures, buildings, paved surfaces and compacted bare soils on the ground surface. Until quite recently, nearly everyone lived in rural areas. In 1800, only 3 per cent of the world's population lived in urban centers of 5,000 or more and many of these behaved like large villages in their socio-economic activities. By 1900, 14 per cent of the world's population was living in urban centers and this proportion increased rapidly after 1950 to reach close to 50 per cent today (United Nations: 1998).

The loss of agricultural land to human settlements is far more serious in India; about 1.5 million hectares of land (mostly agricultural) went to urban growth between 1955-1985 and a further 800,000 hectares were expected to be transformed between 1985 and 2000. With rapid urbanization and the extension of urban areas, combined with continuing population growth both agricultural and social scientists have long expressed a concern as to whether India will be able to feed its population (Chabra: 1985). The rapid increase in the pace of urbanization in India in recent years has brought to the forefront a number of problems in the field of 'Rural- Urban relations'. A large number of villages have come in direct contact with the city and its pattern of life either by being included in transport and communication network joining them to large cities and town or as a result of introduction of number of socio-economic and political changes leading to the gradual conversion of a number of large and medium sized villages into towns and cities (Verma: 1967).

Rural- Urban Transformation also takes place through the Urban Agglomeration, though it is a time taken process and this process counts various elements like travel cost, distance etc. but the agglomeration only happens on the urban fringe areas. In urban Agglomeration process is a continuous urban spread constituting a town and its adjoining urban outgrowths or two or more physical contiguous town together and any adjoining urban outgrowths of such towns. Examples of out-growth are railway colonies, university campus, port areas, military campus, etc. that may come up near a statutory town or city (Datta: 2006). Land uses are shifting from rural uses (agriculture purpose) to urban purpose (non-agriculture purpose). Large number of people is moving to cities, considerable acreages of land are converted from rural to urban uses. For urbanization most of land has been acquired on the periphery areas and rural land has been reshaped physically. Electric power lines, sewer lines, water supply pipes and numerous other physical improvements have drastically affected the use of the land. Sometimes new settlement will take place on these areas. This changing or converting of land uses are known as land transformation (Schmid: 1968).

Land use and land cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to be able to simulate changes (Prakasam: 2009). Land use and land cover (LULC) change is a major issue of global environment change.

From the begging of the human race, man has changed and modified its surroundings environment. As we begin to recognize the scope of human influence

on the surface of the earth as the environment. It is important to understand how specific form of human induced land transformation affects the dynamics of the earth's physical and biological system. Land transformation due to human activity has taken many forms historically starting with fire management, herding practice, and development of the agriculture and culminating with urbanization including industrial development.

The city beautiful Chandigarh over the years has grown as nuclei of urban growth in the region. When the foundation stone of the city was laid in 1952 at that time there were 54 villages which were selected as the site for the model city. It was completely a rural area mostly having agricultural land. In 1971 census there were 34 villages remaining in the jurisdiction of the city. In 1981 the number of villages was reduced to only 27. In 1991 the total number of villages in city boundaries was 24 and in 2001 census only 22 villages were recorded in the city. Most of these villages are located in the periphery of the city. Slowly the villages are affected by the outward growth of the city, which is converting these villages from rural to urban areas. there are many factors responsible for this change in the periphery of city such as increase in the total population of the city, development of the transportation network in the surrounding areas, increase in rural urban interaction, proximity of urban facilities, increasing interest of large scale builders in the periphery of the city, rise in the income of the villagers, etc.

The population of the Chandigarh is increasing very rapidly sever science the city started to take shape. It's not just that the total population of the city is increasing, but the relative share of the urban population is also increasing which demand more residential areas, put pressure on urban amenities and facilities. So the city starts growing in to the periphery to fulfill the demand and which change the land use pattern in the surrounding areas and transform the landscape of the periphery. So it becomes very important to know about the details about the expansion of the city. The proper study on the expansion of city and land transformation is very essential of the city. The study about land transformation is also important from environmental perspective as surrounding areas have most of the forested area of the city. The foothill zone of Shivalik hills is most sensitive part of the city from environmental point of view.

## **LAND TRANSFORMATION**

Dynamics of change of land with time is known as land transformation. Information on land use/land cover in the form of maps and statistical data is very vital for spatial planning, management and utilization of land. Land use change may influence many natural phenomena and ecological processes, including runoff, soil erosion and sedimentation and soil conditions. The Urban areas are changing due to various human activities, natural conditions and development activities. According to the user requirements, updating of land use mapping is required to various departments. Land transformation is about study of the direction of the change of the land from one type to another, which is basically from agricultural to urban or from waste land to urban. So land transformation is detecting the changes in the use of the land and its characteristics.

Temporal urban mapping develops a historical perspective of urban development by combining a variety of data sources into an integrated, multi-scale, and multi-resolution database. Temporal map and databases can be used to document human-induced land transformations in North-Eastern periphery of Chandigarh, where the human induced land transformation rate is very high. Two main features – Arial expansion and population increase characterize this land transformation

processes as well as growth. Rapid urbanization and land use change has resulted into impediment of the natural environment. This in turn alters the physical characteristics of the area resulting in a change of response of nature. Temporal urban map and database provides the baseline information for the planner and decision-makers to monitor and predict the patterns and future trends of urbanization. Temporal urban mapping relies on modern mapping techniques, such as remote sensing and geographic information systems (GIS), to capture information from both historical and modern records. The map and database highlights the profound changes to the landscape that have incrementally developed over time. In this research attempt has been made to develop several temporal databases based on historical maps/information and aerospace data to map and analyse the human induced land transformations for the study area. GIS and remote sensing (RS) were used to compile and create database that provided a visual and historical perspective of the urban expansion experienced in study area.

### **RELEVANCE OF THE STUDY**

Land use and land cover change play a crucial role in global environmental change. They contribute significantly to earth-atmosphere interactions and biodiversity loss, are major factors in sustainable development and human responses to global change, and are important for integrated modelling and assessment of environmental issues in general (IGBP , Report No. 35, Land-Use and Land-Cover Change Science/Research Plan).

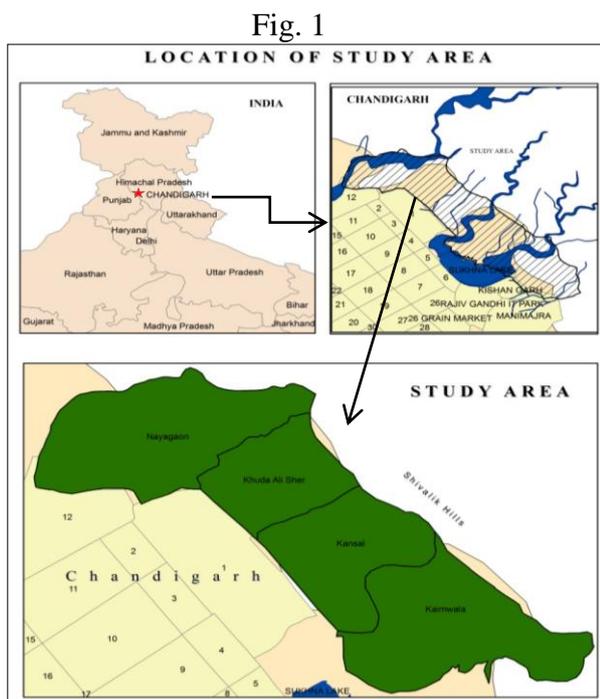
Land transformation is one of the foremost fields of human induced environmental transformation with an extensive history dating back to ancient times. The process of land transformation has not abated, but rather accelerated and diversified with the onset of industrial revolution, the globalization of the world economy and the expansion of population and technological capacity. Settlement refers to the occupation of land for human living, as land cover, settlements represent the most profound human alteration of the natural environment through the burden of structures, buildings, paved surfaces and compacted bare soils on the ground surface. The size and number of urban settlements is also increasing rapidly Monitoring and evaluating the growth of urban settlements is therefore essential for their proper planning and management. Especially in developing countries rapid urban population growth especially due to rural to urban migration is leading to unplanned growths of the urban settlements, vastly exceeding the capacity of local governments to provide basic infrastructure and services for these settlements, let alone to plan for their socially and economically viable, aesthetically pleasing and ecologically sustainable development. In this situation, it is of vital importance for urban planners to understand, the past and present urban growth patterns and to predict the future growth patterns. This is where the study of urban growth becomes important. These studies are not only useful for providing an understanding of urban dynamics, but also provide realizations of the numerous potential forms an urban system may take.

### **STUDY AREA**

The present study has been conducted in northern periphery of the city Chandigarh. The Patiali Rao choe mark the boundary of the study area on the northern side and the Sukhna choe marks the boundary from the South. The eastern side of the study area is marked by Shivalik range and the western side is bordered by Sector 1 and Sukhna Lake of Chandigarh (UT). The study area is located in the Foothill Zone of Shivalik range. It is environmentally very sensitive area as it is located in the close

proximity of the reserved forests. The region is nearly plain with very few undulations. The slope of the area is very gentle. The general slope of the area is from North–East to South–West direction.

The geographical extent of the area is from  $30^{\circ} 43' 09.95''$  N to  $30^{\circ} 47' 07.00''$  N Latitude and from  $76^{\circ} 45' 55.24''$  to  $76^{\circ} 51' 09.74''$  E Longitude. The total area is approximately 2425.73 Acres. There are presently 4 villages and 1 Notified Area Committee (NAC) in the Study area. The study area is bordered by Panjab, Haryana and Chandigarh. The district boundary of Mohali of Punjab and Panchkula of Haryana touches the study area. The study area is at present part of the Chandigarh Administration (Municipal Corporation of Chandigarh) and Punjab.



## OBJECTIVES

The present Study has been based on following objectives:-

1. To study the patterns of Land Use and Land Cover Patterns in the study area from year 1985 to 2010.
2. To study the Land Transformation patterns in the study area from 1985 to 2010.
3. To identify and investigate the Implications and factors responsible for the Land Transformation.

## RESEARCH QUESTIONS

1. How land transformation varies in time and space in terms of its extent and intensity?
2. What have been the driving forces behind this Land Transformation?
3. What are the implications of the Land Transformation?

## DATA SOURCES

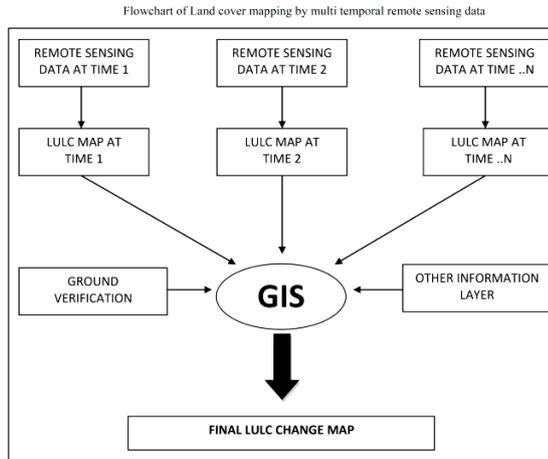
To study the transformation process and direction of transformation we need to study the satellite images of different time periods. In present study different data sources have been used from different agencies. The satellite data of Landsat satellite was downloaded from the official website of United States geological survey (USGS)

that is [www.landsat.org](http://www.landsat.org). The IRS P6 imagery was provided to Department of Geography, Panjab University, Chandigarh by National Remote Sensing Centre (NRSC). Apart from this the Survey of India (SOI) Toposheets (H43K9, H43K13, and H43K14) were also used. Further ground verification was conducted with the help of GPS to verify the signatures and to verify the results.

**METHODOLOGY**

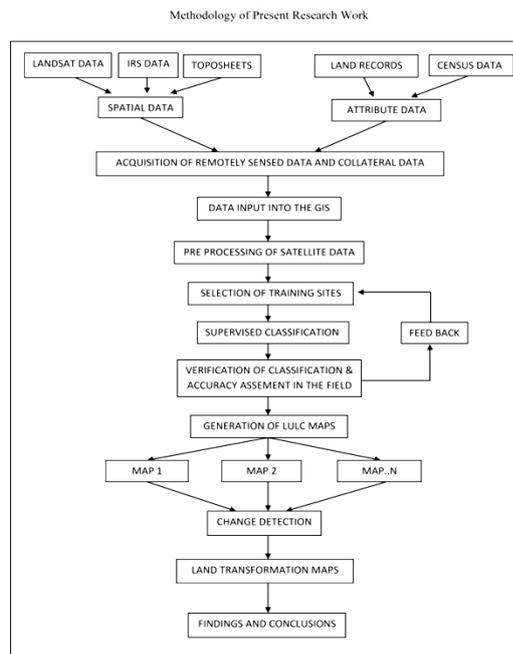
The present study is based on satellite data acquired from different sources of different periods of time. First IRS data was acquired from department, which was provided by NRSC. Then LandSat data was downloaded from official website of USGS. The SOI, Toposheets were also scanned and geo-referenced. Then the pre-processing was done on the data to bring it to the same and comparative scale.

Fig. 2



Then training sites were selected for supervised classification. After classifying the images accuracy was measured of classification by field visits. Then Interpretation (visual and automatic) was done to identify the built-up areas; lands are in the process of transformation from multi-resolution, multi-scale and multi-sensor of aerospace data and other historic data sets.

Fig. 3



Flow chart showing methodology to be followed in present study

An integrated GIS technique was developed to combine the data sets of different time spans (1990, 2000, 2005, and 2011) in order to reconstruct the past landscape. Then at last results and conclusions were drawn.

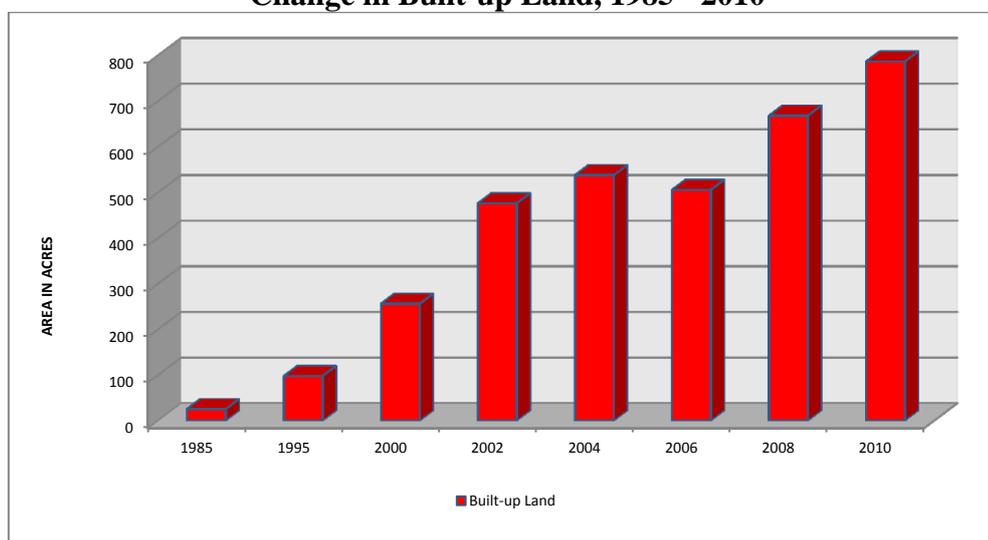
**LAND USE & LAND COVER PATTERN, 1985 – 2010:** The land use and land cover pattern in the study area have been totally changed from 1985 to 2010.

Table 1  
**Land Use and Land Cover  
 Northern Periphery of Chandigarh**

S. NO	CATEGORY	1985	1995	2000	2002	2004	2006	2008	2010
1	<i>Built-up Land</i>	25.6	98.1	256.2	476.3	538.0	505.7	668.3	786.8
2	<i>Vacant Land</i>	304.4	194.4	186.3	195.4	204.0	811.9	821.1	733.5
3	<i>Agricultural land</i>	1658.9	1789.2	1703.9	1497	1390.4	833.6	708.1	665
4	<i>Forest Area</i>	436.6	343.9	279.	256.9	293.2	274.3	228.0	240.3

In 1985 the area was having only 25.66 acres of built up land where in 2010 the built up land was 786.81 acres. The growth of built up land was constant. It rapidly grew in the year 2000. After 2000 the growth of built up land can be seen in following diagram:

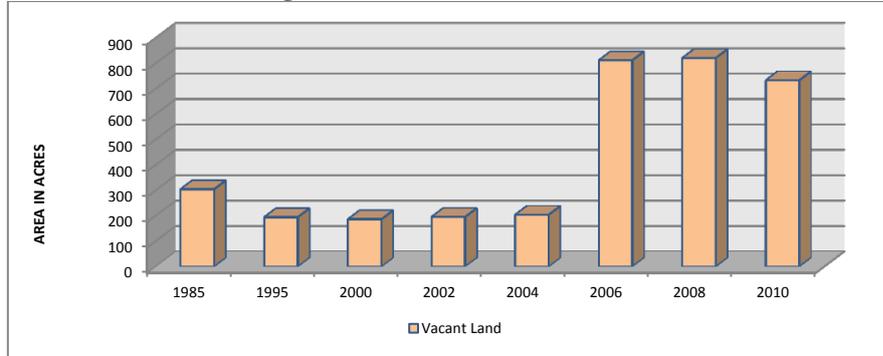
Fig 4  
**Change in Built-up Land, 1985 - 2010**



The proportion of vacant land remained same during the period of nearly 20 years but from year 2004 the proportion of vacant land raised dramatically. The vacant land was basically the land around the settlements which was vacant during that period for future developments. The vacant land also included the remnants of the historical choes in the study area. After 2004 the proportion of vacant land was rapidly increased.

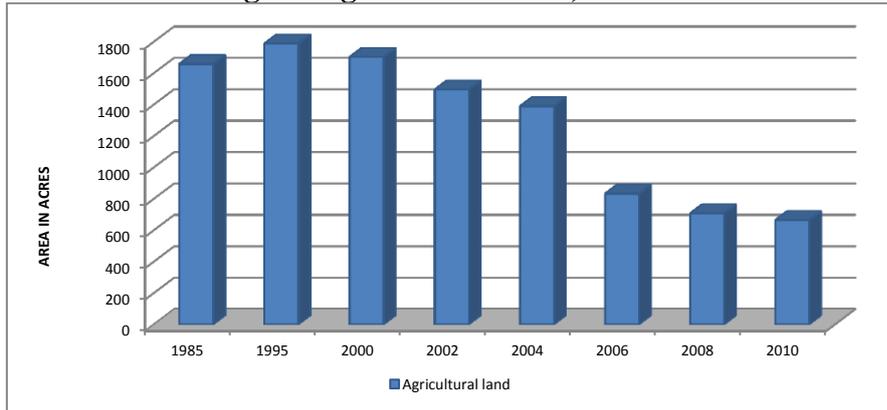
The area was initially an agricultural area where the major portion of land was under the agricultural land use. With the time passing the proportion of agricultural land is decreasing.

**Fig 5**  
**Change in Vacant Land, 1985- 2010**



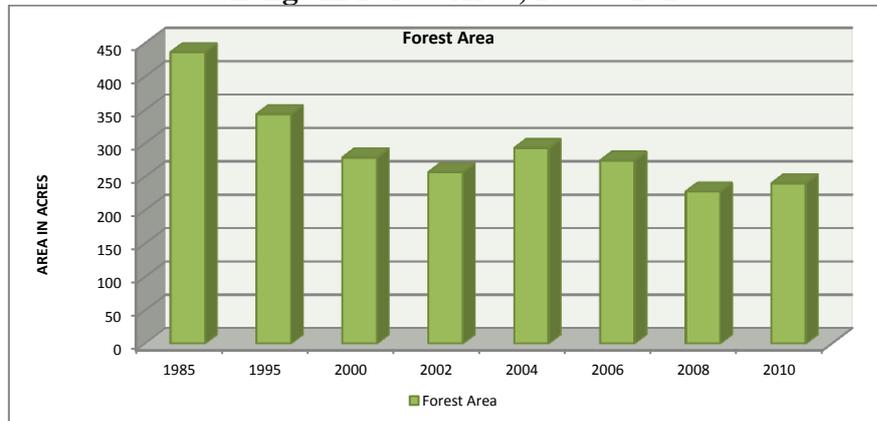
The further development of settlements is decreasing the share of agricultural land in the area. Major shift in agricultural land took place in 2004. After 2004 the agricultural land decreased rapidly. Slowly but surely the agricultural land is decreasing in the area.

**Fig 6**  
**Change in Agricultural Land, 1985 - 2010**



The area under the forest cover has been reduced to half of what it was in 1985. The forest area works as lungs to the city. It provides fresh air to the city. The declining pattern of forest land is a major issue of concern for the administrators.

**Fig 7**  
**Change in Forest Area, 1985 – 2010**



The land use and land cover changes are transforming the landscape of the northern periphery of the Chandigarh. It is slowly developing the periphery as the alternative place of developmental activities.

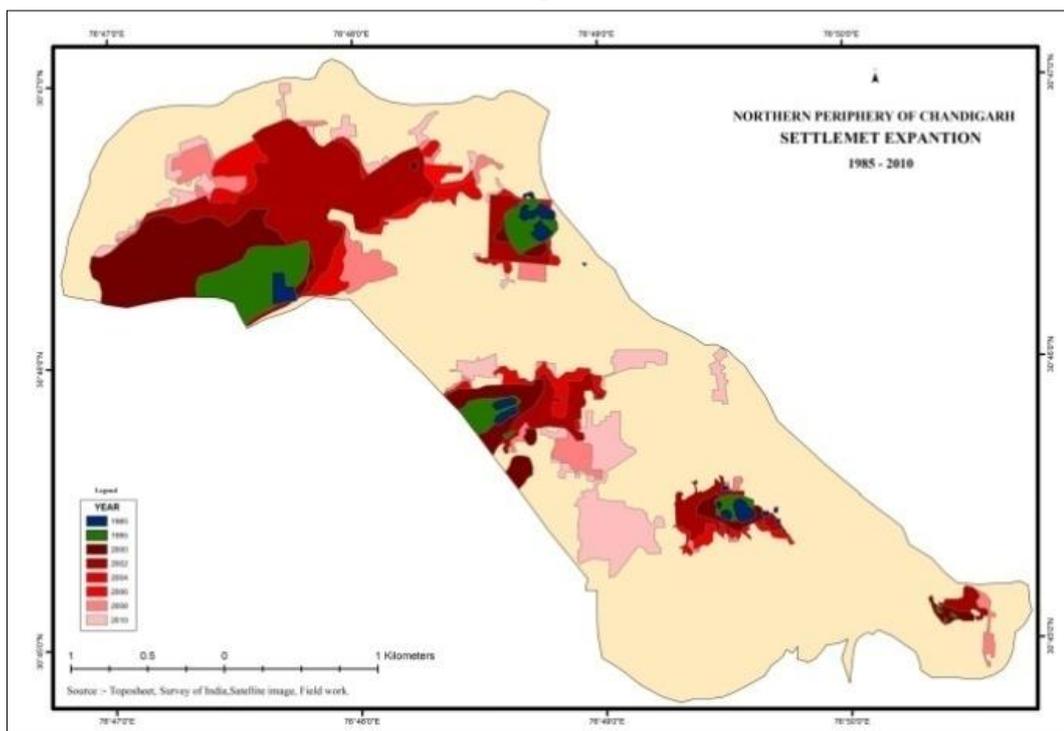
**LAND TRANSFORMATION, 1985 – 2010**

The land transformation is basically the process of change in land use of and area or of a land with a time from one category to another. In the present study area the process of land transformation was first governed by the agricultural land expansion and then with time it shifted to the expansion of settlements in the area. Time changes the land and use of land it changes from one category to other and then from other to another. Ultimately the land is converted into the built up land. The major force governing the land transformation in the area is expansion in the settlement area. The change of land into built up land can be seen in the following table.

Table 2  
**Settlement expansion  
 (Transformation into Built-up land )**

Year	Added area in acres	Total area in acres
1985	21.25	21.25
1995	83.75	105.00
2000	164.97	269.98
2002	241.55	511.53
2004	73.91	585.45
2006	12.54	597.99
2008	71.54	669.53
2010	128.65	798.19

Fig. 8



From the above table we can say that every year more and more built up land is added into the existing built up land. In the year 1985 there was only 21.25 acres of land under this category of built up land. In 1995 83.75 acres of land was added into it and it became 105 acres. In next five years the land brought under this category was 164.97 acres. Then in the period of only two years another 241.55 acres of land was added to it. In next two years that is in 2004 the total land added to built-up land was 73.91 acres which means there was in total 585.45 acres of land under this category at that point. Then in next two years the built up land added to the category was only 12.54 acres of land. Next two year also showed slow growth rate of settlements that is only 71.54 acres of land was added to the category. But in last two years that is from 2008 to 2010 the land conversion rate again picked up and the land transformed into the built up land was 128.65 acres.

So in short we can conclude that the area under the built up land is the major determinant or the major driving force of change in the area.

The following table shows the amount of change from one category to another at various points of time.

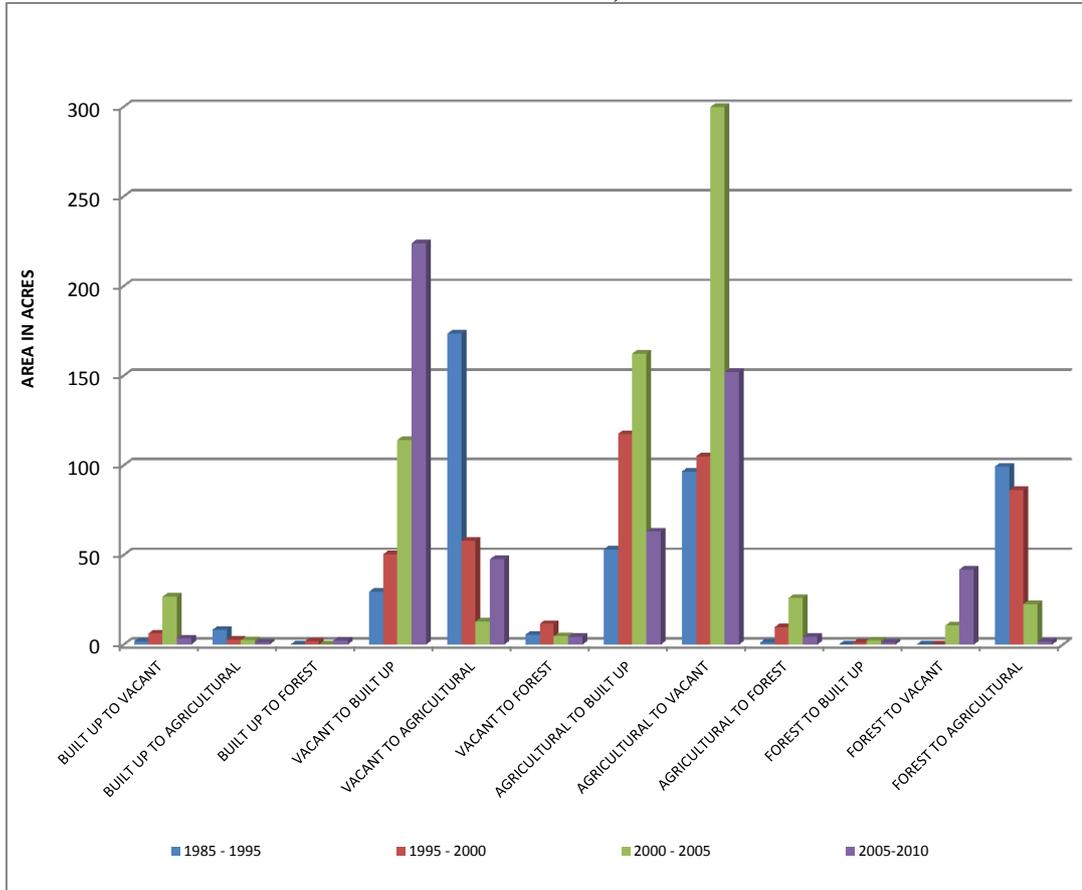
Table 3  
**Land Transformation, 1985 - 2010**

Category	1985 - 1995	1995 - 2000	2000 - 2005	2005-2010
Built up to built-up	15.24	86.93	226.63	498.53
Built up to vacant	1.90	6.31	26.83	3.55
Built up to agricultural	8.32	2.88	2.53	1.33
Built up to forest	0.19	1.98	0.27	2.35
Vacant to built-up	29.49	50.45	114.23	223.93
Vacant to vacant	94.03	74.31	54.34	535.89
Vacant to agricultural	173.5	58.04	13.04	47.71
Vacant to forest	5.68	11.63	4.75	4.43
Agricultural to built-up	53.18	117.6	162.39	63.08
Agricultural to vacant	96.60	105.14	720.11	152.12
Agricultural to agricultural	1506.71	1556.75	795.33	614.08
Agricultural to forest	1.24	9.71	26.11	4.32
Forest to built-up	0.00	1.28	2.50	1.25
Forest to vacant	0.20	0.20	10.67	42.00
Forest to agricultural	99.42	86.28	22.69	1.87
Forest to forest	339.97	255.76	243.22	229.24

The following chart shows the trend of transformation of land from one category to another with the time. It shows that in the period of 2000 to 2005 the agricultural to vacant land was the dominating change in the area. The land use change from one category to another is dependent on various factors such as population of the area, its numbers and density, demand for more residential as well

as work area. So with the time the need and demand for the built up land keep on increasing which ultimately changes the all over landscape of the area.

Fig.9  
Land Transformation, 1985 - 2010



At last it is evident that there is large scale land transformation in the northern periphery of the planned city of Chandigarh. With time the land use is changing in the periphery of the city. The major forces are raising demand for built up land which is shrinking the size of forest and agricultural land and increasing the size of vacant and built up land.

**IMPLICATIONS OF LAND TRANSFORMATION**

Land transformation is process of change in land use of an area from one type to another. With change in land use and land cover many changes are observed. The change in land use and land cover brings change in lifestyle of people of that area. This in return brings change in social, political, economic, demographic and environmental aspects. Present study area has various implications. The social structure has been affected by land transformation. The land prices increases with the development. So the local people start to sell their land to the local builders to gain profit from their land. In last few years Nayagaon is given the status of Notified Area Committee (NAC). The periphery of Chandigarh is developing as the hub of economic developments in the city. The property rates have been raised ten times of what they were last decade or so. IT Park is set up by the Chandigarh administration to cope up with the development. The population of the city is growing rapidly; following table shows us the trend of population from 1901 to 2011.

Table 4  
Demographic Composition, Chandigarh  
1901 - 2011

Year	Total population	Urban population	Rural population	% of urban population	% of rural population
1901	21967	-	21967	-	100
1911	18437	-	18437	-	100
1921	18133	-	18133	-	100
1931	19783	-	19783	-	100
1941	22574	-	22574	-	100
1951	24261	-	24261	-	100
1961	119881	99262	20619	82.8	17.2
1971	257251	232940	24311	90.5	9.5
1981	451610	422841	28769	93.6	6.4
1991	642015	575829	66186	89.6	10.4
2001	900635	808515	92120	89.7	10.3
2011	1054686	1,026,459	28,991	97.25	2.75

This has put pressure on the existing land, it work as a force to push people to go into the outer boundaries of the city. This has increased the density and total population of the periphery of the city. The northern periphery has also experienced the same.

Table 5  
Density of population, Chandigarh  
1971 – 2011

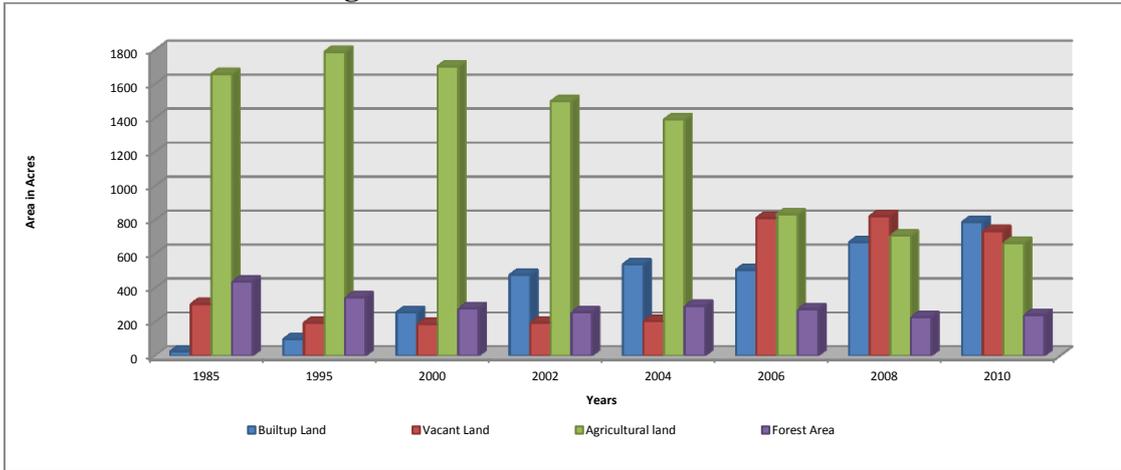
Year	Density (persons / km <sup>2</sup> )
1971	2257
1981	3961
1991	5632
2001	7900
2011	9252

The land transformation on the periphery of the city has changed the environmental landscape of the area. The total forest area have been decries to its half from 1985 to 2010.

Table 6  
Land use and Land cover Pattern  
Northern Periphery of Chandigarh  
1995 – 2010 (in Acres)

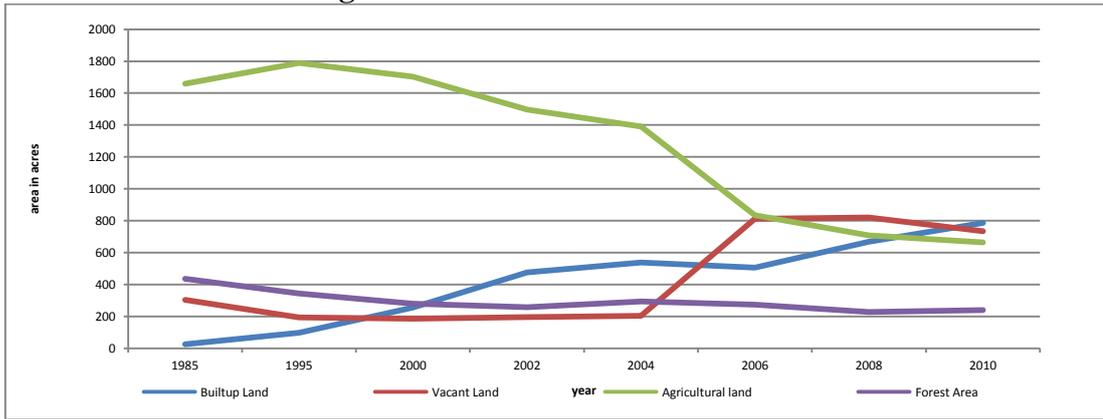
Year	Built-up Land	Vacant Land	Agricultural land	Forest Area
1985	25.67	304.48	1658.99	436.61
1995	98.13	194.44	1789.22	343.95
2000	256.29	186.38	1703.97	279.10
2002	476.36	195.43	1497.01	256.94
2004	538.02	204.06	1390.42	293.23
2006	505.77	811.98	833.61	274.38
2008	668.40	821.18	708.14	228.01
2010	786.81	733.57	665.01	240.35

**Fig. 10**  
**Change in Land use & Land cover Pattern**



The vacant land in first stage was the land remaining of the historical choes in the area. This initially was converted into the agricultural land.

**Fig. 11**  
**Change in Land use & Land cover Pattern**



The proportion of vacant land remained the same almost for the initial 15 years but as the demand for more residential areas increased in 2004 the developmental activities converted the agricultural land into the vacant land which ultimately gets converted into the built up land. The forest area remained almost same having slight decline every year in total area. The line graph showing the growth and decline in particular land use shows the rising area under built up land is increasing.

To conclude we can say that the study shows that the trend of land transformation have effects on all aspects of human society. It affects political, social, economic, demographic as well as the environment surrounding people in the area. The growth of population has raised economic status of the area, changed social values, and has degraded the environmental standard of the area.

**SUMMARY AND CONCLUSIONS**

Information on land use/land cover in the form of maps and statistical data is very vital for spatial planning, management and utilization of land. Study has shown that the land use and land cover pattern has changed to great extent in last 25 years. The built up land has increased from 25.67 acres to 786.81 acres. The forested area has decreased from 436.61 acres to 240.35 acres. The agricultural land has decreased

from 1658.99 acres to 665.01 acres. The vacant land has initially remained same for the period of twenty years from 1985 to 2005 but now has increased from 304.48 acres in 1985 to 733.57 acres in 2010.

The present study is showing the rapid growth of built up land in the area. The area under agriculture initially expanded due to conversion of vacant land that is of remnants of choes in the middle of the study area. But with the time the agricultural area decreased to great extent. The growing population in the area is major factor contributing the land transformation process. The legal and illegal construction is shaping the present day landscape.

The study was conducted to study the land transformation in the northern periphery of the planned city of Chandigarh. The study revealed many facts. The land use and land cover pattern in 1985 was basically almost all agricultural in nature where the settlements were only a few locations and very small one. But with the introduction of regional development plan in 1985 and central government policy of L.P.G. in 1991, the land use and land cover pattern started to change after 1995. In 2000 the settlements started to grow into the surrounding area and the vacant land and surrounding agricultural land was converted into the built up land. In 2005 the growth of settlements grew drastically and the expansion of settlements into surroundings of existing settlements took place, apart from these settlements also started to take place at intermediate places or between two settlements. In 2010 most of the landscape was dominated by the built up land the share of built up land in total land raised from 1 per cent in 1985 to 33 per cent in 2010. To conclude the study shows signs of land transformation of the present study area initially from agricultural to vacant and from vacant to built-up.

## BIBLIOGRAPHY

- Land Transformation: Philosophy and Technique, P.C. Raheja, Bhartiya Vidya, Bhawan, 1962
- Past Industrial Land Transformation: An approach to socio-cultural aspects as catalysts for urban redevelopment, Luis and Jhon burley.
- Land Transformation in Agriculture, edited by M.G. Wolmen and P.G.A Fournier, 1987, Published by Jhon Willy & Sons Ltd.
- The consequences of Urban Land Transformation on net Primary Productivity in USA. Marc L. Imhoff, Lahousri Bounoua, Ruth Defries, (Remote Sensing & Environment).
- Land Use and Land Transformation, Geo Journal, Volume-8, number-1.
- Anderson, et al. 1976. A Land Use and Land Cover Classification System for Use with Remote Sensor Data. Geological Survey Professional Paper No.964, U.S. Government Printing Office, Washington, D.C. P.28
- Arvind C. Pandey and M.S. Nathawat 2006. Land Use Land Cover Mapping Through Digital Image Processing of Satellite Data- A case study from Panchkula, Ambala and Yamunanagar Districts, Haryana State, India.
- Khullar. D.R. (2005): Land Utilization; India, A comprehensive Geography, Kalyani Publisher, Delhi.
- Meyer, W.B. 1995. Past and Present Land Use and Land Cover in the USA Consequences.
- Prakasam. C and Biplab Biswas (2009). Land use, Land Cover Change Study in Ausgram I&II Blocks, Burdwan Dist, West Bengal Using Remote Sensing and GIS. Indian (2009) Journal of Landscape Systems and Ecological Studies Vol. 32 (2).

- PetronJ.H. (2006): Land work and Resources an Introduction to Economic Geography.
- Robinson, A.H., Morrison, J.L., Muehrcke, P.C., Guphill, S.C., Elements of Cartography, Sixth Edition, John Willy & Sons, Inc.